REVISED DRAFT

Final Feasibility Study

West Lake Landfill Operable Unit-1

Prepared for

The United States Environmental Protection Agency Region VII

Prepared on behalf of

The West Lake Landfill OU-1 Respondents

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EXECUTIVE SUMMARY

This Final Feasibility Study (FFS) for Operable Unit-1 (OU-1) of the West Lake Landfill (the Site) was prepared at the direction of the U.S. Environmental Protection Agency (EPA) to present further evaluation of potential remedial alternatives to address the presence of radiologically impacted materials (RIM) contained within portions of some of the landfill units at the Site. This FFS was prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), relevant EPA guidance documents (including, but not limited to, EPA's 1988 Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA), EPA's December 9, 2015 Statement of Work (SOW) for the Remedial Investigation Addendum (RI Addendum) and FFS, the May 6, 2016 Abbreviated Work Plan for the RI Addendum and FFS, EPA's clarification letter dated August 4, 2016, and EPA's November 28, 2017 letter request to incorporate an on-site disposal alternative.

The Site is a 200-acre, inactive solid waste disposal facility that accepted wastes for on-site landfilling from approximately the 1950s through 2005. OU-1 consists of two landfill disposal areas (Areas 1 and 2), a 1.78-acre parcel of land known as the Buffer Zone, and the adjacent Lot 2A2 of the Crossroads Industrial Park where radionuclides have been identified within the soil and solid waste materials. Operable Unit-2 (OU-2) consists of the remainder of the Site, including areas never used for landfilling, several inactive fill areas containing sanitary waste or demolition debris (which were closed prior to state regulation), and a permitted, inactive sanitary landfill (the Bridgeton Landfill). This FFS does not address remedial options for the portions of the Site that comprise OU-2.

RIM at the Site consists of soils containing radium and thorium isotopes intermixed with and interspersed within an overall matrix of municipal solid waste (MSW) and non-radionuclide bearing soil in portions of two areas of the West Lake Landfill. These two areas have been identified as Areas 1 and 2 (Figure ES-1). Disposal of MSW within the majority of these areas ended in 1974, but for some portions ended later in the 1970s, at which time MSW disposal was shifted to other portions of the Site. The distribution of the RIM within the landfilled areas has been impacted by both natural and anthropogenic processes, such as the original discontinuous nature of the placement of soil cover over the top of the uneven surface of the landfill waste during the period of active operations and the subsequent 40-plus years of decomposition, consolidation and differential settlement of the MSW, resulting in the occurrences of radionuclides in soil being irregularly interspersed within the larger overall matrix of the MSW in Areas 1 and 2. In addition, although the Buffer Zone and Lot 2A2 were never used for landfilling, radionuclides have been documented as being present on this portion of the Site – likely as a result of historical soil erosion from adjacent, sloped portions of Area 2. Additional information regarding the nature and extent of the occurrences of radionuclides and other aspects of the surface and subsurface conditions at the Site can be found in the 2000 Remedial Investigation (RI) and the 2017 RI Addendum.

Consistent with the NCP, an RI and Feasibility Study (FS) were previously completed for OU-1 and approved by EPA in 2006. Based on those reports, EPA developed a Proposed Plan for OU-1 and, after an extended public comment process including three public meetings, issued a Record of Decision (ROD) in 2008. The ROD-selected remedy called for containment of the RIM and solid waste materials within a new multi-layered engineered landfill cover system, long-term operation and maintenance and environmental monitoring, and land use controls (including deed restrictions).

In January 2010, EPA directed Respondents to prepare a Supplemental Feasibility Study (SFS) for OU-1 to evaluate two additional potential remedial alternatives. Specifically, EPA directed the OU-1 Respondents to perform an updated engineering and cost analysis of the ROD-selected remedy, and to conduct a similar analysis of two new alternatives to excavate RIM in excess of a specified cleanup level from OU-1 and either send the excavated materials to a permitted, out-of-state landfill for disposal ("complete rad removal" with off-site disposal) or re-dispose of the excavated material in a new engineered landfill cell to be built within the boundaries of the Site ("complete rad removal" with on-site disposal).

In December 2015, EPA directed Respondents to perform additional investigation and monitoring and to prepare an addendum to the RI, as well as this FFS, which expands on and augments the prior SFS completed in 2011 and the original FS completed in 2006 (both of which were previously reviewed and approved by EPA) and evaluates additional remedial alternatives identified by EPA. Specifically, this FFS:

(1) provides further evaluation of the containment remedy that was previously evaluated in the original FS and subsequently selected by EPA in 2008 as the remedial action for OU-1, as documented in the ROD (ROD-selected remedy), with some modifications;

and also presents additional evaluations of:

(2) a containment remedy alternative with an engineered cover designed to meet the Uranium Mill Tailings Radiation Control Act (UMTRCA) performance standards;

(3) a full excavation with off-site disposal alternative;

(4) a partial excavation alternative that would remove RIM containing either combined radium or combined thorium activities above 52.9 pCi/g and located within 16 feet of the 2005 topographic surface;

(5) a partial excavation alternative that would remove RIM containing either combined radium or combined thorium above 1,000 pCi/g, regardless of depth;

(6) a risk-based partial excavation alternative to remove RIM such that the remaining materials would be protective of industrial land uses (the reasonably anticipated future land use) without consideration of the presence of an engineered cover system; and

(7) per EPA's November 28, 2017 letter, a full excavation alternative with the option to re-dispose the excavated material in an on-site engineered cell (originally evaluated in the SFS).

In accordance with the NCP, this FFS also includes discussion of a No Action Alternative (which operates as a baseline against which all the remedial alternatives are evaluated).

In this FFS, the seven developed remedial alternatives are evaluated using the nine criteria set forth in CERCLA and the NCP: two threshold criteria, (1) overall protection of human health and the environment, and (2) compliance with applicable or relevant and appropriate requirements of other environmental regulations (ARARs); and five primary balancing criteria, including (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility or volume through treatment; (5) short-term effectiveness; (6) implementability; and (7) cost. The two remaining criteria – State and community acceptance – will be evaluated by EPA as part of any future decision process. In addition to the nine CERCLA/NCP criteria, at EPA's direction, the long-term effectiveness and permanence of each remedial alternative was evaluated relative to the potential effects of climate change, the potential impacts of a tornado, the potential impacts of a subsurface reaction, and the potential construction of a thermal isolation barrier. At EPA's direction, environmental justice considerations relative to the long-term effectiveness and permanence of each alternative and potential short-term impacts associated with each remedial alternative were also evaluated.

Overall, the results of the FFS evaluations indicate the following regarding the seven remedial alternatives fully evaluated:

1. Protection of Human Health and the Environment

   - All of the remedial alternatives -- the ROD-selected remedy, the UMTRCA cover alternative, the full excavation with offsite or on-site disposal alternatives, and the three partial excavation alternatives -- meet EPA's criteria for overall protection of human health and the environment.

   - The No Action alternative is not protective of human health and the environment (see the updated Baseline Risk Assessment (Auxier, 2018).

2. Compliance with ARARs

   - All of the alternatives, except the No Action alternative, would comply with ARARs. The on-site cell may not meet some of the location-specific ARARs for proximity to the airport.

Because the No Action alternative did not meet the threshold criteria of protection of human health and the environment and compliance with ARARs, it is not discussed as part of the evaluation of the primary balancing criteria below.

3. Long-Term Effectiveness and Permanence

    - With the exception of the No Action alternative, all of the remedial alternatives would result in long-term risks below the health risk range that EPA uses to assess the protectiveness of remedial alternatives at Superfund sites (see Table ES-1 and Appendix H).

    - All of the alternatives would rely on engineering measures and institutional controls that have been used and demonstrated as being effective and permanent at numerous municipal solid waste sites and other Superfund sites.

    - None of the alternatives are expected to result in measurable, long-term impacts to plants or animals.

    - The effectiveness of the remedial alternatives is not expected to be significantly impacted by possible climate change or a tornado, or by installation of a thermal isolation barrier, provided that such a barrier was installed prior to or concurrent with implementation of a remedial action, and none of the remedial alternatives would present unacceptable risks if a subsurface heating event were to occur.

    - If any environmental justice concerns had been identified, the potential effects of each remedial alternative on any environmental justice communities would have been evaluated as part of the long-term permanence and short-term impact criteria; however, a screening-level analysis did not identify any environmental justice concerns relative to the Site.

4. Reduction in Toxicity, Mobility or Volume Through Treatment

    - Because radionuclides are naturally-occurring elements that cannot be fully modified or destroyed by physical, chemical, or thermal processes, most treatment technologies are not considered effective or applicable for radionuclides. In-situ solidification/chemical stabilization is potentially applicable to soil containing radionuclides, but has never been applied to MSW. Ex-situ solidification treatment may be required prior to placement of MSW or debris into any offsite disposal facility. Physical separation of large items and debris from finer-grained soil and decomposed MSW will likely be required for all of the alternatives. Due to the presence of thorium-230, which does not emit a measurable gamma signature, radionuclide segregation based on gamma emissions is not considered to be effective for most of the alternatives. Owing to the co-occurrence of radium-226, a strong gamma emitter, with thorium-230, radiological segregation may potentially be effective for the 1,000 pCi/g partial excavation alternative by setting the gamma level low enough (*e.g.*, corresponding to a radium-226 level of for example 500 pCi/g) to ensure that all of the thorium-230 above 1,000 pCi/g is identified during radiological screening.

- The excavation alternatives would reduce the volume of the materials left onsite.

- All of the alternatives include installation of a low-permeability cover that would reduce infiltration of precipitation and therefore reduce the mobility of the radionuclides.

5. Short-Term Effectiveness

- None of the remedial alternatives are expected to pose risks to the general public above EPA's accepted risk range during remedy implementation (Table ES-1).

- The short-term risks to on-site workers associated with the full excavation alternatives and the 52.9 and 1,000 pCi/g partial excavation alternatives are projected to exceed EPA's acceptable risk range; however, these risks may be mitigated through use of personal protective equipment and appropriate health and safety procedures.

- The 52.9 and 1,000 partial excavation alternatives are expected to result in radiation doses to workers above the limits established by OSHA and NRC. However, a properly designed health and safety program can be implemented such that exposures would be controlled/limited.

- The full excavation alternatives would remove all of the RIM from Areas 1 and 2; the 1,000 pCi/g partial excavation alternative would remove a smaller amount of RIM but would focus on removal of RIM with the highest activity levels. The risk-based partial excavation alternative would remove any RIM that poses a potential risk to future on-site workers. Removal of all or some of the RIM would reduce potential uncertainty regarding long-term effectiveness of the remedy.

- Implementation of either of the full excavation alternatives would require removal, temporary stockpiling, and subsequent relocation of approximately 1.5 million in-place cubic yards (approximately 2.4 million loose yards) of non-RIM MSW overburden. Implementation of the 1,000 pCi/g partial excavation alternative would require relocation of approximately 645,000 in-place cubic yards (approximately 968,000 loose yards) of non-RIM MSW overburden. The other alternatives require relocation of approximately 100,000 to 200,000 in-place yards of non-RIM MSW overburden, with the least amount associated with the Risk-Based Partial Excavation Alternative.

- All of the alternatives are expected to result in measurable, short-term impacts to plants or animals as a result of removal of existing habitat. Much of the habitat has already been removed under the non-combustible cover (NCC) work.

- The time required to achieve the remedial action objectives (RAOs) would be shortest for the ROD-selected remedy and UMTRCA cover alternative. Implementation of the partial excavation alternatives would take approximately 50% longer for the risk-based partial excavation alternative, approximately twice as long for the 52.9 pCi/g partial excavation alternative, and three times as long for the 1,000 pCi/g partial excavation alternative (as compared to the ROD-selected remedy and UMTRCA cover alternative). Implementation of either of the full excavation alternatives would take over five times longer than the ROD-selected remedy and UMTRCA cover alternative.

6. Implementability

- All of the remedial alternatives are considered to be implementable.

- The full excavation and partial excavation alternatives likely will pose a greater potential bird or other wildlife hazard to aircraft and airport facilities than the ROD-selected remedy or UMTRCA cover alternative because performing the excavation remedies would: (1) open up larger areas of the landfilled waste to excavation, particularly in the case of the full excavation and 1,000 pCi/g partial excavation alternatives, which would require opening up and temporarily relocating large amounts of relatively younger waste in the above-grade part of the North Quarry portion of the Bridgeton Landfill; (2) require the excavation, handling, and relocation of larger volumes of waste material; and (3) take significantly longer to complete and result in landfill waste that will be exposed to the environment for a longer period than if the ROD-selected remedy or the UMTRCA cover alternative were implemented.

- The full excavation and the 52.9 pCi/g and 1,000 pCi/g partial excavation alternatives may require the existing MSW transfer station building to be relocated due to the potential for impact to the structural integrity of the building from excavation of material near the foundation of the building. Relocation of the existing transfer station could require relocation of other operations currently being conducted at the Site to provide space for the relocated transfer station building. Shoring of the area adjacent to the transfer station foundation wall may be a potential alternative to relocation, if some RIM in the area of the building could remain in place.

7. Cost

- Of the seven remedial alternatives (excluding the No Action alternative), the cost estimate for the ROD-selected remedy is the lowest, followed by UMTRCA cover alternative, the risk based partial excavation, the 52.9 pCi/g partial excavation, the 1000 pCi/g partial excavation, the full excavation with on-site disposal, and finally, the full excavation with off-site disposal alternative (Table ES-1).

Table ES-1 summarizes in numerical format the results of the FFS evaluation of long-term risks, short-term risks, time to achieve the RAOs, volumes of RIM to be excavated, and the estimated costs of each of the alternatives.

Table ES-1: SUMMARY OF POTENTIAL RISKS, IMPLEMENTATION SCHEDULES AND ESTIMATED COSTS - WEST LAKE LANDFILL FFS REMEDIAL ALTERNATIVES[1]

	ROD-Selected Remedy	UMTRCA Cover Alternative	52.9 pCi/g to a 16-ft depth Partial Excavation Alternative	1,000 pCi/g Partial Excavation Alternative	Risk-Based Partial Excavation Alternative	Full Excavation with Off-Site Disposal	Full Excavation with On-Site Disposal
Long-term residual cancer risk after 1,000 years	1.2×10^{-6} (1.2 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 5-ft)	7.3×10^{-6} (7.3 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 5-ft)	2.3×10^{-6} (2.3 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 5-ft)	2.7×10^{-7} (0.27 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 5-ft)	9.3×10^{-9} (0.009 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 7.2-ft)	5.38×10^{-8} (0.054 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Storage Yard Worker) (Cover thickness 3-ft)	2.3×10^{-6} (2.3 extra cancer incidences in 1,000,000 people) Within EPA's acceptable range (Receptor: Groundskeeper) (Cover thickness 5-ft)
Short-term risks during cleanup	Waste excavation volume: 112,000 bcy RIM Excavation volume: 15,750 bcy Percent of RIM removed 0% RIM consolidated on site No disturbance of North Quarry	Waste excavation volume: 112,000 bcy RIM Excavation volume: 15,750 bcy Percent of RIM removed 0% RIM consolidated on site No disturbance of North Quarry	Waste excavation volume: 274,000 bcy RIM Excavation volume: 83,900 bcy Percent of RIM removed 27% RIM disposed off site No disturbance of North Quarry	Waste excavation volume: 684,000 bcy RIM Excavation volume: 38,700 bcy Percent of RIM removed 12% RIM disposed off site Removal of part of North Quarry	Waste excavation volume: 105,000 bcy RIM Excavation volume: 15,580 bcy Percent of RIM removed 5% RIM disposed off site No disturbance of North Quarry	Waste excavation volume: 1,821,000 bcy RIM Excavation volume: 309,700 bcy Percent of RIM removed 100% RIM disposed off site Removal of part of North Quarry	Waste excavation volume: 1,821,000 bcy RIM Excavation volume: 309,700 bcy Percent of RIM removed 100% RIM disposed in on-site cell Removal of part of North Quarry
	On-Site Workers Industrial accidents: 5.1 Cancer risk: 2.8×10^{-5} (28 extra incidences in 1,000,000 people) Hazard Index 27.0 Worker dose: 60.2 mrem/yr	On-Site Workers Industrial accidents: 5.6 Cancer risk: 2.8×10^{-5} (28 extra incidences in 1,000,000 people) Hazard Index 27.0 Worker dose: 60.2 mrem/yr	On-Site Workers Industrial accidents: 11.1 Cancer risks: 2.2×10^{-3} (2,200 extra incidences in 1,000,000 people) Hazard Index 27.1 Worker dose: 6,940 mrem/yr	On-Site Workers Industrial accidents: 15.5 Cancer risks: 1.1×10^{-2} (11,000 extra incidences in 1,000,000 people) Hazard Index: 27.2 Worker dose: 13,400 mrem/yr	On-Site Workers Industrial accidents: 8.7 Cancer risks: 5.0×10^{-5} (50 extra incidences in 1,000,000 people) Hazard Index 27.1 Worker dose: 108 mrem/yr	On-Site Workers Industrial accidents: 25.5 Cancer risks: 3.7×10^{-3} (3,700 extra incidences in 1,000,000 people) Hazard Index 27.0 Worker dose: 1,820 mrem/yr	On-Site Workers Industrial accidents: 25.7 Cancer risks: 3.7×10^{-3} (3,700 extra incidences in 1,000,000 people) Hazard Index 26.9 Worker dose: 1,820 mrem/yr
	Community Transportation accidents: 0.6 Cancer risk: 1.9×10^{-7} (0.2 extra incidence in 1,000,000 people)	Community Transportation accidents: 0.6 Cancer risk: 1.9×10^{-7} (0.2 extra incidence in 1,000,000 people)	Community Transportation accidents: 7.5 Cancer risks: 9.7×10^{-7} (0.97 extra incidence in 1,000,000 people)	Community Transportation accidents: 16.1 Cancer risks: 2.5×10^{-6} (2.5 extra incidence in 1,000,000 people)	Community Transportation accidents: 2.4 Cancer risks: 3.8×10^{-7} (0.38 extra incidence in 1,000,000 people)	Community Transportation accidents: 41.1 Cancer risks: 5.5×10^{-6} (5.5 extra incidence in 1,000,000 people)	Community Transportation accidents: 1.4 Cancer risks: 8.1×10^{-5} (81 extra incidence in 1,000,000 people)
Time to reach RAOs	2.8 years	2.8 years	5.0 years	8.3 years	4.1 years	14.6 years	14.8 years
Estimated Costs	Capital construction: $75,000,000 OM&M per year: $176,000 to $389,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 71 79 80 200 years 71 95 113 1,000 years 71 101 265	Capital construction: $96,000,000 OM&M per year: $176,000 to $389,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 90 100 102 200 years 90 116 134 1,000 years 90 123 287	Capital construction: $274,000,000 OM&M per year: $176,000 to $389,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 236 275 280 200 years 237 290 312 1,000 years 237 297 464	Capital construction: $379,000,000 OM&M per year: $176,000 to $389,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 287 372 384 200 years 288 388 417 1,000 years 288 394 569	Capital construction: $187,000,000 OM&M per year: $176,000 to $389,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 165 189 192 200 years 165 205 225 1,000 years 165 211 377	Capital construction: $695,000,000 OM&M per year: $176,000 to $340,000 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 455 667 699 200 years NA NA NA 1,000 years NA NA NA	Capital construction: $591,000,000 OM&M per year: $182,100 to $444,100 Present Worth (millions $) Discount rate 7% 0.7% 0% 30 years 391 568 596 200 years 392 585 631 1,000 years 392 592 788

[1] The No Action Alternative is evaluated in the FFS but because it was found to not be protective of human health and the environment, it is not included on this summary table.

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List of Acronyms

ACM	asbestos containing materials
AEC	Atomic Energy Commission
ALI	Annual Limits on Intake
amsl	above mean sea level
AOA	Air Operations Area
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
ARRA	American Recovery and Reinvestment Act
ASAOC	Administrative Settlement Agreement and Order on Consent
bcy or BCY	bank cubic yard
BDAT	Best Demonstrated Available Technology
bgs	below ground surface
Bi	Bismuth
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
BRA	Baseline Risk Assessment
CCDF	Conditional cumulative density function
CCL	Compacted clay/silt liner
ccy or CCY	Compacted cubic yard
C&D	Construction and demolition
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
cf	cubic feet
CFR	Code of Federal Regulations
cm	centimeter
CM	Construction Manager
cm/sec	centimeter per second
COCs	Chemicals of concern
COPC	Constituent of Potential Concern
CQAO	construction quality assurance officer
CSR	Code of State Regulations
cy, or cu yd	cubic yard
DAC	Derived air concentration
DCGL	Derived concentration guideline level
DOD	Department of Defense
DOE	United States Department of Energy
DOT	United States Department of Transportation
DQO	data quality objective
dtrs	daughters
ea	Each
ECY	Embankment cubic yard
EDTA	ethylenediaminetetraacetic acid
EJ	Environmental Justice
EMSI	Engineering Management Support, Inc.

List of Acronyms (continued)

ENRCCI	Engineering News Record Construction Cost Index
E.O.	Executive Order
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FS	Feasibility Study
FFS	Final Feasibility Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft or Ft	feet
GCL	Geosynthetic clay liner
gm, or g	gram
GRA	General Response Action
HAZMAT	Hazardous Materials
HDPE	high density polyethylene
HEB	Heat extraction barrier
HP	health physicist
hr	hour
IB	Isolation barrier
IBAA	IB Alternatives Analysis
IC	Institutional Control
IK	Indicator kriging
IM	Intermodal
INEEL	Idaho National Engineering and Environmental Laboratory
IP	industrial packaging
IRBL	Industrial Land Use Risk-Based Levels
K	Potassium
kg	kilogram
L	liter
LAACC	Large Area Activated Charcoal Canisters
LBSR	Leached barium sulfate residues
lbs	pounds
lcy or LCY	loose cubic yard
LDR	Land Disposal Restrictions
LF	Linear foot
LFMR	Landfill mining and reclamation
Li	Lithium
LLRW	Low level radioactive waste
LoMR	Letter of Map Revision
LPGAC	Liquid Phase Granular Activated Carbon
LSA	low specific activity
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum contaminant level
MCLG	MCL goal

List of Acronyms (continued)

MDNR	Missouri Department of Natural Resources
MDOT	Missouri Department of Transportation
MDWTP	Michigan Disposal Waste Treatment Plant
MECA	Missouri Environmental Covenants Act
MED	Manhattan Engineering District
MeV	Million electron volts
m	meter
mg	milligram
mm	millimeter
mo `	month
MOU	Memorandum of Understanding
Mrem	millirem
MSD	Metropolitan St. Louis Sewer District
MSF	Thousand square feet
MSW	Municipal solid waste
MSWLF	Municipal Solid Waste Landfill
N	Nitrogen
Na	Sodium
NARM	NORM and Accelerator – Produced Radioactive Material
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMOC	non-methane organic compound
NOAA	National Oceanic and Atmospheric Administration
NORM	Naturally occurring radioactive material
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NS	Norfolk Southern
NWS	National Weather Service
O	Oxygen
O&M	operation and maintenance
OM&M	operation, maintenance, and monitoring
OSHA	Occupational Safety and Health Administration
OSR	Off-Site Rule
OSTRI	Office of Superfund Technology Research and Innovation
OU	Operable Unit
Pb	Lead
PCB	Poly-chlorinated biphenyl
PCF	Pounds per cubic foot
pCi	pico Curie
PFLT	Paint Filter Liquids Test
Po	Polonium
POTW	Publicly-Owned Treatment Works
PPE	Personal protective equipment

List of Acronyms (continued)

PRG	preliminary remediation goal
RA	Remedial action
Ra	Radium
RACM	Regulated asbestos-containing material
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RAR	Relevant and Appropriate Requirement
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDWP	Remedial Design Work Plan
RG	Remediation Goal
RI	Remedial Investigation
RIM	Radiologically Impacted Material
RMC	Radiation Management Corporation
RML	radioactive material license
ROD	Record of Decision
RSMo	Revised Statutes of Missouri
RTO	Regenerative Thermal Oxidation
SAP	Sampling and Analysis Plan
sec, or s	second
SEC	Securities and Exchange Commission
sf or sq ft	square feet
SF Flr	Square foot of floor
SFS	Supplemental Feasibility Study
SGS	Segmented gate system
Si	Silicon
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SOW	Statement of Work
SSE	Subsurface Smoldering Event
SSP&A	S.S. Papadopoulos & Associates
SSR	Subsurface reaction
STLAA	St. Louis Airport Authority
SVOC	Semi-Volatile Organic Compound
SWMP	Solid Waste Management Program
SWPP	Stormwater Pollution Prevention Plan
SY	Square yards
t	ton
TAL	Target Analyte List
TBC	To-be-considered
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
	Thorium

List of Acronyms (continued)

TDS	Total dissolved solids
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
Th TPH	Total Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
TSDF	Treatment, storage, and disposal facility
U	Uranium
µg	microgram
UMTRCA	Uranium Mill Tailings Radiation Control Act
Unat	Natural Uranium
µR/hr	microRoentgens/hr
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEI	US Ecology Idaho
UTS	Universal Treatment Standards
VCA	verification of current acceptability
VOCs	Volatile Organic Compounds
WAC	Waste Acceptance Criteria
WL	Working Level
yr	Year

1 INTRODUCTION

In an October 9, 2015 letter to Cotter Corporation (N.S.L.), Laidlaw Waste Systems (Bridgeton) (n/k/a Bridgeton Landfill, LLC) and Rock Road Industries and the U.S. Department of Energy (Federal Respondent), collectively, the West Lake Landfill Operable Unit-1 (OU-1) Respondents ("Respondents" or "OU-1 Respondents"), the United States Environmental Protection Agency (EPA) informed Respondents that additional work was necessary to accomplish the objectives of the Remedial Investigation/Feasibility Study for OU-1 (EPA, 2015a). EPA also provided a Statement of Work (subsequently revised on December 9, 2015) (EPA SOW) (EPA, 2015b) that identified the additional work that needed to be performed, including preparation of a Final Feasibility Study (Final FS or FFS). In accordance with the EPA SOW, the OU-1 Respondents prepared an Abbreviated Work Plan for a Remedial Investigation Addendum and Final Feasibility Study (RI Addendum/FFS Work Plan) (EMSI, 2016a) that was approved by EPA on May 18, 2016 (EPA, 2016a). EPA provided additional guidance concerning the status of various studies' work plans and related deliverables developed to support EPA's evaluation of a remedy decision for OU-1 by letter dated August 4, 2016 (EPA, 2016). On behalf of the OU-1 Respondents, Engineering Management Support, Inc. (EMSI) has prepared this FFS to address the requirements set forth in the EPA SOW as further described in the RI Addendum/FFS Work Plan. This FFS has been revised in response to EPA's comments dated June 23, 2017.

1.1 Background

The West Lake Landfill Site (the Site) is located within the western portion of the St. Louis metropolitan area on the east side of the Missouri River. The Site has an address of 13570 St. Charles Rock Road, Bridgeton Missouri. The Site consists of an approximately 200-acre parcel of land that includes six identified waste disposal areas or units, including Radiological Area 1 (Area 1), Radiological Area 2 (Area 2), a closed demolition landfill, an inactive sanitary landfill, and the North Quarry and South Quarry portions of the permitted Bridgeton Landfill. These six identified areas were used for solid and industrial waste disposal from approximately the 1950s through 2004.

The areas of the West Lake Landfill where radiologically-impacted materials (RIM) are present have been designated by EPA as OU-1. The radionuclides within OU-1 include materials generated by the Manhattan Engineering District (MED) and Atomic Energy Commission (AEC) activities resulting from extraction and concentration of uranium from various ores, as further described in the RI Addendum (EMSI, 2016b). OU-1 comprises Radiological Area 1 and Radiological Area 2 (or more simply Area 1 and Area 2). In addition to RIM, these two areas also contain municipal solid waste (MSW), industrial waste and construction and demolition (C&D) debris, which may contain other non-radionuclide constituents such as trace metals and volatile organic compounds (VOCs) typically found in MSW landfills. OU-1 also includes a 1.78-acre parcel of land adjacent to Area 2 known as the Buffer Zone and the adjacent Lot 2A2 of the Crossroads Industrial Park. Although the Buffer Zone and Lot 2A2 were never used for landfilling, radionuclides were found to be present in surface soil in these areas. Investigations and evaluations of non-radioactive constituents in other parts of the Site outside of Areas 1 and 2 are being performed by Bridgeton Landfill, LLC under a separate operable unit (OU-2) RI/FS.

In 1990, EPA listed the Site on the National Priorities List (NPL) under the Comprehensive Environmental, Response, Compensation and Liability Act of 1980 (CERCLA). EPA designated Areas 1 and 2 as OU-1 and the remainder of the Site as OU-2. In 2016, EPA publicly announced that it will be designating a third operable unit, OU-3, to address groundwater conditions at the Site.

In accordance with a 1993 Administrative Order on Consent (AOC) (EPA, 1993a), and over the period from 1994 to 2008, the OU-1 Respondents conducted numerous Site investigations that included the collection and analysis of waste/soil samples and monitoring of the quality of surface water, sediment, groundwater and air at the Site. During this same time period, the OU-1 Respondents also performed numerous evaluations and prepared various comprehensive reports, including a Remedial Investigation (RI) report (EMSI, 2000), a Baseline Risk Assessment (BRA) report (Auxier & Associates, Inc. 2000), and a Feasibility Study (FS) report (EMSI, 2006). These studies and evaluations were considered by EPA in the development of a Proposed Plan for OU-1 (EPA, 2006a) and the subsequent selection of a remedial action as described in the Record of Decision (ROD) for OU-1 (EPA, 2008).

After issuance of the ROD, and as a result of internal deliberations and further consideration of certain comments provided by interested community members, EPA determined in 2010 that additional investigation was warranted, and in January 2010 directed the OU-1 Respondents to perform a Supplemental Feasibility Study (SFS) (EPA, 2010a). Work on the implementation of the ROD Remedial Design Work Plan and negotiation of the associated Consent Decree was accordingly suspended while the OU-1 Respondents performed the necessary evaluations and prepared the SFS report (EMSI et al., 2011) to assess potential remedial alternatives for removal of the RIM from the Site. EPA also requested, and the OU-1 Respondents performed, additional environmental monitoring of groundwater (EMSI, 2012a, 2013a, 2013b and 2014a) and air quality (Auxier and EMSI, 2016a, 2016b, and 2016c), as well as additional characterization of Areas 1 and 2 (including additional drilling, logging, sampling and laboratory analyses). The additional site data were incorporated into an RI Addendum (EMSI, 2017a) and updated BRA (Auxier & Associates, Inc. 2017).

In the EPA SOW, EPA stated that the FFS shall be a comprehensive document incorporating the elements of and updating as appropriate the June 2006 FS (EMSI, 2006) and the 2011 SFS (EMSI et al., 2011). The FS evaluated six containment (capping) alternatives (Table 1-1) that were considered in EPA's selection of a containment remedy for OU-1 as documented in the OU-1 ROD (EPA, 2008). The SFS evaluated two "complete rad removal" alternatives: excavation of the RIM and offsite disposal, and excavation and disposal of the RIM in a new engineered landfill cell at the Site. The SFS also included additional evaluation of the ROD-selected remedy, including more detailed estimates of the potential risks, costs, and schedule commensurate with the level of additional detail developed for the excavation alternatives. For additional information about the specific evaluations and conclusions provided in the 2006 FS and 2011 SFS, please see Section 5 and Table 1-1.

1.2 ROD-Selected Remedy

A description of and reasons for selection of the final remedy for the Site are presented in EPA's ROD for OU-1 (EPA, 2008). In particular, EPA reached the following conclusions:

- The ROD-selected containment remedy for OU-1 would protect human health and the environment by providing source control and institutional controls for the landfilled waste materials.
- The source control and institutional control methods would prevent human receptors from contacting the waste material.
- The source control method would mitigate contaminant migration to air and restrict infiltration of precipitation into the landfill, which contributes to protection of groundwater quality.

The components of the ROD-selected remedy include the following:

1. Installation of landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills, including enhancements consistent with the standards for uranium mill tailing sites, *i.e.*, armoring layer and radon barrier;
2. Consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroads Property to the containment area;
3. Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills;
4. Surface water runoff control;
5. Gas monitoring and control, including radon and decomposition gas as necessary;
6. Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides; and
7. Long-term surveillance and maintenance of the remedy.

Performance standards for each of the remedy components are described in Section 12 of the ROD.

A memorandum dated May 21, 2009 from EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) Acting Deputy Director identified four additional measures or performance standards to apply to the 2008 ROD-selected remedy:

- The proposed cover should meet Uranium Mill Tailings Remediation Control Act (UMTRCA) guidance for a 1,000-year design period including additional thickness as necessary to prevent radiation emissions.

- Air monitoring stations for radioactive materials should be installed at both on-site and off-site locations.

- Groundwater monitoring should be implemented at the waste management unit boundary and also at off-site locations. The groundwater monitoring program needs to be designed so that it can be determined whether contaminants from the Site have migrated across the waste management unit boundary (i.e., the boundary of OU-1) in concentrations that exceed drinking water Maximum Contaminant Levels (MCLs). The groundwater monitoring program needs to measure for both contaminants that have historically been detected in concentrations above MCLs (e.g., benzene, chlorobenzene, dissolved lead, total lead, dissolved arsenic, total arsenic, dissolved radium and total radium) and broader indicators of contamination (*e.g.*, redox potential, alkalinity, carbonates, pH and sulfates/sulfides).

- Flood control measures at the Site should meet or exceed design standards for a 500-year storm event under the assumption that the existing levee system is breached.

Evaluation of these measures has been incorporated into this RIA/FFS process.

The SFS analysis incorporated these additional performance standards and refined the description and evaluation of the containment remedy that was selected in the ROD to document that the proposed measures were designed to be protective for projected increases in both gamma radiation and radon emissions anticipated to occur over the next 1,000 years.

EPA implemented a program of offsite air quality monitoring in 2014 and 2015 (TetraTech, 2014, 2015a, 2015b, 2015c, 2015d and 2015e). A comprehensive program for monitoring air quality around the perimeter of Areas 1 and 2 was implemented in 2015 (Auxier and EMSI, 2014) and continues to be conducted through the date of this FFS. The results of this air monitoring are presented in various quarterly monitoring reports (Auxier and EMSI, 2016a, 2016b, and 2016c and 2017a, 2017b and 2017c) and were described in the RI Addendum (EMSI, 2017a).

Four comprehensive, Site-wide groundwater monitoring events were conducted in 2012-2013. The results of the additional groundwater monitoring activities are presented in various monitoring reports (EMSI, 2012a, 2013a, 2013b and 2014a) and also in the RI Addendum (EMSI, 2017a.

Additional measures to prevent impacts in the unlikely event of flooding were also included as part of the additional evaluation of the ROD-selected remedy; however, it should be noted that subsequent evaluations by the Federal Emergency Management Agency (FEMA)[1] have determined that landfilled materials contained within Areas 1 and 2 are located outside of the Missouri River floodplain.

1.3 National Remedy Review Board Consultation

Because the anticipated costs of the alternatives evaluated in the SFS were greater than $25 million, on February 29, 2012, EPA Region VII consulted with the EPA National Remedy Review Board (NRRB). That consultation and subsequent feedback from NRRB members resulted in EPA Region VII directing the Respondents to perform additional investigations and studies, culminating in this FFS.

The NRRB provided the following suggestions to Region VII (as articulated in its February 28, 2013 memorandum)[2]:

- "Consider adding wells at the site to better delineate the vertical and lateral extent of potential site-related contamination previously identified from limited sampling in Areas 1 and 2. These additional wells would be instrumental in clarifying the presence of isolated groundwater contamination versus a groundwater plume in the complex subsurface geologic setting, and would help inform a decision about whether CERCLA response authority is warranted to address any additional contamination";

- The available data and information (including specifically the information contained in the RI and NRC reports) should be examined to "ensure that the location and volume of RIM is accurately characterized and if necessary consider conducting further investigations possibly using test trenches. Furthermore, the range of alternatives should

[1] FIRM Flood Insurance Rate Map, St. Louis County, Missouri and Incorporated Areas, Panel 39 of 445, Map Number 29189C0039K, February 4 – see Figure 2-9 and additional discussion in Section 2.1.6.

[2] The memorandum describing the conclusions and recommendations from the NRRB consultation was not provided to the OU-1 Respondents until June 16, 2016.

include options for addressing the likely volume and location (including hot spots) of RIM at the Site";

- "Use a more reasonable future use assumption of industrial/commercial and based on this land use, recalculate the volume of RIM to be removed" under a "complete rad removal" alternative;

- The Region should "carefully consider the range of alternatives developed for this site and explain in its decision documents how the preferred alternative, when selected, will be consistent with CERCLA and NCP, or publish an explanation as to why not. In particular, the Region should more fully explain how its approach to treatment is consistent with the statute and the NCP, including specifically CERCLA § 121(b)(1)'s preference for treatment "to the maximum extent practicable;" CERCLA § 121(d)(l)'s requirements regarding protectiveness and applicable or relevant and appropriate requirements; 40 CFR § 300.430(a)(1)(iii)(A)'s expectation that "treatment [be used] to address the principal threats posed by a site, wherever practicable"; and 40 CFR § 300.430(f)(1)(ii)(E)'s preference for treatment "to the maximum extent practicable" while "protecting human health and the environment, attaining ARARs identified in the ROD, and balancing the five primary criteria listed in the NCP";

- "Consider developing an alternative that includes sorting and removing the RIM in a precise manner using performance standards for the excavation process and includes treatment to the maximum extent practicable," and that the "cleanup levels reflect the fact that the site is zoned industrial/commercial and is most likely to stay that way given the reasonably anticipated future land use";

- Noting "that 'treatment' can include measures taken to reduce volume," the NRRB suggests that the Region "reconsider treatment alternatives or provide more explanation for ruling out an in-situ or ex-situ solidification/stabilization process that is specifically designed for both the high sulfate content and saturated conditions found at this site";

- The short-term effectiveness comparison be re-evaluated to include:
    - consideration of engineering controls to limit short-term exposures and risks,
    - "focusing on the extent to which accidents expose workers or the community to possible releases resulting from such accidents, and considering 'mitigative measures during implementation'",
    - inclusion of an "analysis of both short-term and long-term effects on the community (including any sensitive or potentially high-exposure subpopulations)", and
    - elimination of funding constraints,

- "Consider examining additional information on alternative cap designs plus fate and transport of groundwater that supports long-term protectiveness";

- "Evaluate whether the alternatives under consideration for Area 2 will meet the UMTRCA standards as ARARs, as well as any NRC standards (and guidance that might serve as TBCs) that exist for licensed facilities storing or disposing of radiological waste";

- "Consider the appropriateness of using RCRA Subtitle D regulations for RIM, where radium- 226 activity will increase by a factor of thirty-five 1,000 years from now, as an ARAR for this site";

- Acknowledge that FAA guidance and Executive Orders, while important, are not ARARs, and the list of ARARs citations included in the ARARs tables should be enhanced to provide more detail pursuant to EPA/540/G-89/006, August 1988, CERCLA Compliance With Other Laws Manual;

- The cost analysis should include a 7% interest rate and, if an interest rate based on OMB Circular A-94 is used, an explanation and sensitivity analyses should be provided in accordance with EPA guidance, OSWER Directive No. 9355.0-75, July 2000, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. In addition, the cost estimates for containment alternatives should include costs for perpetual operation and maintenance, including repair and replacement, for all of the components of an engineered cap.

The following actions have been taken to address these comments:

1. Groundwater monitoring – EPA required four rounds of groundwater sampling of all wells at the Site, identified a third operable unit (OU-3) to address groundwater, and will be requiring a RI/FS be performed for OU-3;

2. EPA required additional characterization of the RIM occurrences in Areas 1 and 2 and these data have been used in conjunction with prior data to define the lateral and vertical extent of RIM at the Site and an alternative that looks at removal of "hot spots" (1,000 pCi/g) is evaluated in this FFS;

3. A partial excavation alternative developed using risk-based levels for industrial land use is evaluated in this FFS;

4. Additional evaluations of potential treatment technologies were performed as part of this FFS;

5. Additional evaluation of physical separation and radiological segregation of material containing radionuclides from municipal solid waste and a partial excavation alternative developed using risk-based levels for industrial land use were evaluated in this FFS:

6. Additional evaluation of in situ and ex situ treatment technologies was performed for this FFS;

7. The evaluation of short-term impacts includes consideration of engineering controls to limit exposures and risks, evaluation of potential impacts to workers or the community from potential releases during off-site transport, evaluation of short-term and long-term impacts to the community including an evaluation of environmental justice considerations, and elimination of funding constraints;

8. This FFS includes evaluation of an alternative cap design;

9. Evaluation of UMTRCA requirements for all alternatives that include radiologically-impacted material remaining on Site and for radiological occurrences in soil on the Buffer Zone and Lot 2A2;

10. This version of the FFS now focuses on UMTRCA regulations, as opposed to RCRA Subtitle D regulations, as the primary ARARs;

11. The ARARs evaluation has been revised to identify FAA guidance as TBCs, Executive Orders related to floodplains and wetlands as ARARs, and to provide additional detail; and

12. The present worth cost calculations include use of a 7% interest rate.

1.4 Scope of the FFS

This FFS has been prepared to provide additional evaluation of a select group of potential remedial alternatives for OU-1 specified by EPA in the SOW, as described below. The FFS also addresses various additional evaluations identified by EPA in the EPA SOW, and which are further set forth in the RI/FFS Work Plan.

1.4.1 Remedial Alternatives

The EPA SOW and the RI/FFS Work Plan identified six remedial alternatives to be evaluated in the FFS:

1. No Action (2006 FS Former Alternative L1)– Required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and RI/FS guidance to provide a baseline against which all of the other alternatives are evaluated;

2. Partial Excavation 1,000 picoCuries/gram (pCi/g) (2006 FS Former Alternative L6 and Alternative F4) – Excavation of all soil/waste containing combined radium (radium-226 plus radium-228) or combined thorium (thorium-230 plus thorium-232) with activity levels greater than 1,000 pCi/g;

3. Partial Excavation 52.9 pCi/g to 16 feet bgs – Excavation of all soil/waste containing combined radium or combined thorium with activity levels greater than 52.9 pCi/g down to a total depth of 16 feet beneath the 2005 topographic surface;

4. Partial Excavation Based on Expected Land Use – Partial excavation of all soil/waste containing combined radium or combined thorium with activity levels greater than a risk-based level to be developed based on the reasonably anticipated future land use of the Site;

5. Full Excavation with Offsite Disposal – Excavation of all soil/waste containing combined radium or combined thorium with activity levels greater than 7.9 pCi/g; and

6. 2008 ROD-Selected Remedy (2006 FS Former Alternative L4 and Alternative F4) – Containment consisting of regrading and installation of a new landfill cover and other remedial components for the landfill, as described in Section 1.2, and consolidation of any radiologically-impacted soil that may remain on the former Ford Property (now known as the Buffer Zone and Lot 2A2) into the containment areas in Areas 1 and 2 prior to placement of additional fill and construction of the new landfill cover.

EPA subsequently (EPA, 2017) identified an additional, seventh alternative for inclusion in the FFS: full excavation with on-site disposal in a new, engineered UMTRCA disposal cell ("Full Excavation with On-site Disposal").

The EPA definition (EPA, 2010a) of the full excavation alternative is based on the unrestricted land use criteria for combined radium and combined thorium activities as specified in OSWER Directives No. 9200-4.18 and 9200-4.25 (EPA, 1997a and 1998). Although uranium is a contaminant of concern at the Site, uranium was not found to be a driver for identification of RIM, because any locations/depth intervals that contained uranium above its criterion for full excavation (54.5 pCi/g) also contained radium and/or thorium activity levels greater than their respective criteria for unrestricted land use. A comparison of this criterion to risk-based levels determined that this level would be protective of human health (see Section 3.3.2). Therefore, these alternatives are based solely on the combined radium and combined thorium activity levels. As noted above, use of the combined radium and combined thorium activity levels to define the materials to be included in the scope of the partial excavation alternatives should also result in inclusion of any materials with commensurate uranium activity. Additional evaluation of potential cleanup standards is presented in Section 3.3.

1.4.2 Additional Evaluations Required by the SOW

The EPA SOW required (and the RI/FFS Work Plan describes) various additional engineering and other types of evaluations to be performed as part of the FFS.

1.4.2.1 Additional Technology Evaluations

The EPA SOW requires additional evaluations of several technologies, including:

- Volume separation techniques and other physical and/or chemical treatment technologies as they relate to partial and full excavation alternatives;
- Evaluation of the long-term effectiveness of proposed landfill caps/covers in addressing both humid region conditions and long-term shielding of the RIM;
- Evaluation of the long-term effectiveness of a landfill cap/cover on potential migration of chemicals-of-concern (COCs) to leachate and groundwater;
- Evaluation of apatite/phosphate based treatment technologies as appropriate to solid matrices[3]; and
- Additional evaluation of potential technologies to control bird populations based on the methods described in the draft Bird Mitigation Plan (LGL, Ltd., 2015) as part of the Isolation Barrier Alternatives Assessment (EMSI et. al., 2014a and EMSI, 2015a).

1.4.2.2 Other Additional Evaluations

The EPA SOW required several other additional evaluations to be performed as part of the FFS, including the following:

- Discussion and consideration of the occurrence of an exothermic subsurface reaction (SSR)[4] and evaluation of an Isolation Barrier (IB), including a brief discussion of pending/ongoing IB-related design and field work;

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[3] Evaluation of these technologies relative to possible groundwater applications may be further considered and/or implemented under the pending new operable unit, OU-3.

- Acknowledgement of any environmental justice communities in the potentially affected area and modifications, as appropriate, to the evaluation and implementation of remedial alternatives;

- Updates to the discussion of potentially applicable or relevant and appropriate requirements of other environmental regulations (ARARs), and in particular, additional detailed assessment of the requirements associated with the UMTRCA and the Resource Conservation and Recovery Act (RCRA) Subtitle C landfill cover design requirements, as appropriate;

- Discussion of climate change and vulnerabilities associated with extreme weather events (such as potential impacts associated with possible flooding or tornadoes) and any system vulnerabilities to potential climate change in accordance with EPA's "Climate Change Adaptation Technical Fact Sheet: Landfills and Containment as an Element of Site Remediation (EPA, 2014a) and the EPA Region 7 Climate Change Adaption Implementation Plan (EPA, 2014b); and

- Potential impacts of an SSR within OU-1 and the effects of an IB on the remedial alternatives presented in this FFS.

The EPA SOW also requires the FFS to include information associated with (and results of) the following studies that have been performed by the Respondents since 2006 (including revisions made to these documents based upon EPA comments):

- Supplemental Feasibility Study (EMSI et al., 2011);

- Discount Rates and Cost Estimates Evaluation (EMSI, 2014b and 2013c);

- Phase 1 RIM Investigation (EMSI et al., 2016a);

- Area 1 and Area 2 Additional Characterization (EMSI, 2015b);

- Alternate Cover Designs Evaluation (EMSI, 2015c and 2014c);

- Partial Excavation Alternatives (EMSI, 2014d, 2015d, and 2015e);

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[4] This reaction has previously been called a "subsurface smoldering event" (SSE). However, the current understanding of the reaction is that it is occurring in the absence of oxygen, which indicates that it is not the result of a fire or smoldering (combustion). Accordingly, current references are to an "SSR," or subsurface reaction, rather than the prior SSE terminology.

- Evaluation of the Use of Apatite/Phosphate Treatment Technology (EMSI, 2013d);
- Evaluation of Possible Effects of a Tornado on Integrity of the ROD Selected Remedy (EMSI, 2013e and 2013f);
- Evaluation of Risks Associated with Subsurface Smoldering Events (EMSI, 2014d and 2013g);
- Radon Flux Calculations (Auxier and EMSI, 2016d); and
- Bird Mitigation Analysis (LGL, Ltd, 2015).

1.4.3 NCP Required Evaluations of Remedial Alternatives

All of the remedial alternatives are to be evaluated using the threshold and primary balancing criteria set forth in the NCP, 40 CFR § 300.430 (EPA, 2009a). These criteria include the following:

- Threshold Criteria:
  - Overall Protection of Human Health and the Environment; and
  - Compliance with ARARs.
- Primary Balancing Criteria:
  - Long-term Effectiveness and Permanence;
  - Reduction of Toxicity, Mobility, or Volume through Treatment;
  - Short-term Effectiveness;
  - Implementability; and
  - Cost.

These evaluations have been performed in this FFS consistent with the requirements set forth in the NCP and EPA's RI/FS guidance (EPA, 1988a) using the same methodologies that were previously used and described in the SFS and FS reports (EMSI et al., 2011 and EMSI, 2006). Additional descriptions of these criteria are presented in Section 6 of this FFS.

The NCP also requires remedial alternatives to be evaluated in terms of "Modifying Criteria," which include State and community acceptance. State acceptance will be evaluated by EPA based on comments and feedback provided by the Missouri Department of Natural Resources (MDNR) on the FFS and subsequent Proposed Plan. State and community acceptance will be evaluated by EPA as part of any decision process that may be undertaken by EPA after completion of the FFS and are not considered in this document.

A comparative analysis of the results of the evaluations of the alternatives against the No Action alternative was also performed. The relative performance of each of the alternatives was evaluated against the performance of the other alternatives for each of the threshold and primary balancing criteria during the comparative analysis. This comparative analysis is intended to identify the advantages and disadvantages of each alternative.

1.5 FFS Approach

This FFS has been developed pursuant to an October 9, 2015 letter from EPA to the OU-1 Respondents (EPA, 2015a), the EPA SOW (EPA, 2015b), and the EPA-approved Abbreviated Work Plan for an RI Addendum and FFS (EMSI, 2016a). This report has been prepared to address the requirements of the EPA SOW, EPA-approved Work Plan, and the NCP, in accordance with EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9355.3-01 (EPA, 1988a), "Guidance for Data Usability in Risk Assessment", OSWER Directive 9285.7-09A (April 1992) (EPA, 1992a), "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER Directive 9200.4-18, (August 1997) (EPA, 1997a), "Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA," OSWER Directive 9200.4-23 (August 1997) (EPA, 1997b), "Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites," OSWER Directive 9200.4-25 (February 1998) (EPA, 1998), "Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6)," OSWER Directive 9200.4-35P (April 2000) (EPA, 2000a), and other EPA FS-related guidance documents (*e.g.*, EPA, 1991a and EPA, 2000b).

This FFS includes:

- A summary discussion of Site conditions and other information presented in the RI Addendum for OU-1 (EMSI, 2017a), including addressing the findings in United States Nuclear Regulatory Commission (NRC) reports (NRC, 1988 and RMC, 1982 and 1981) that evaluated the radiological disposal areas at the West Lake Landfill Site;

- The nature and extent of RIM in Areas 1 and 2 and the Buffer Zone and Lot 2A2 property and information regarding the occurrence of non-radiological hazardous substances in Areas 1 and 2;

- A summary of the characterization of potential Site risks presented in the updated BRA for OU-1 (Auxier, 2017);

- Further information and evaluation pertaining to a negative easement on the property held by the City of St. Louis, and its potential impacts on remedy implementation for OU-1;

- Additional information about environmental monitoring during remedy implementation and long-term maintenance and operations;

- Evaluation of potential treatment technologies for the RIM; and

- Evaluation of potential ARARs and remedial technologies, descriptions of the seven remedial alternatives to be evaluated, evaluation of the seven alternatives using the threshold and primary balancing criteria, and a comparative analysis of the alternatives.

Where necessary for the evaluation of the alternatives, or as otherwise appropriate for completion of the FFS, brief summaries or tabulations of the results of prior Site evaluations are provided; however, the prior reports should be reviewed or consulted for additional details and specific information relative to those evaluations.

1.6 Report Organization

This report is organized as follows:

Section 1: Introduction – Presents information regarding the scope and approach used to complete the FFS.

Section 2: Site Conditions – Summarizes information regarding Site conditions as they relate to the alternatives evaluated in the FFS. Detailed information about Site conditions was presented in the [draft] RI Addendum report for OU-1 (EMSI, 2017a) and a summary discussion of Site conditions related to the development and evaluation of remedial alternatives was presented in the FS and SFS reports for OU-1 (EMSI, 2006 and EMSI et al., 2011). This section provides a description of occurrences of radionuclides in soil/waste, air, surface water, sediment, and groundwater at the Site. In addition, this section describes the nature, general locations, and overall lateral and vertical extent of RIM. This section also provides a summary of the occurrences of chemical constituents in soil/waste and groundwater. Finally, this section provides a brief summary of the results of the updated BRA (Auxier, 2017a).

Section 3: ARARs – Summarizes information regarding potential ARARs and remedial action objectives (RAOs) as they relate to the remedial alternatives evaluated in the FFS. Additional, detailed information about potential ARARs and RAOs was presented in the FS and SFS reports (EMSI, 2006 and EMSI et al., 2011).

Section 4: Remedial Technologies – Summarizes information regarding additional remedial technologies that may be potentially applicable to the partial excavation and full excavation alternatives evaluated in the FFS. Additional, detailed information about potentially applicable technologies was presented in the FS and SFS reports (EMSI, 2006 and EMSI et al., 2011).

Section 5: Remedial Alternatives – Provides descriptions of the partial excavation alternatives, the full excavation with off-site disposal alternative, a full excavation with on-site disposal alternative, the ROD-selected remedy alternative and the UMTRCA cap remedy alternative that are the subject of the detailed evaluations presented in Sections 6 and 7. Descriptions of other remedial alternatives previously developed and evaluated for OU-1 that were not included in the list of alternatives identified by EPA for evaluation in this FFS were presented in the FS and SFS reports (EMSI, 2006 and EMSI et al., 2011) and are not repeated in this FFS report.

Section 6: Detailed Analysis of Alternatives – Presents a detailed analysis of the six of the seven remedial alternatives relative to the threshold and balancing criteria defined by the NCP, and provides an overview of the seventh proposed alternative, an industrial land use risk-based partial excavation alternative.

Section 7: Comparative Analysis of Alternatives – Presents a summary comparison of the six of the seven remedial alternatives in terms of the threshold and balancing criteria defined by the NCP, and provides a summary of the seventh proposed alternative, an industrial land use risk-based partial excavation alternative.

Section 8: References – Provides a list of references cited in this report.

This FFS also includes the following appendices:

Appendix A: Existing Institutional Controls, City of St. Louis Negative Easement and Restrictive Covenant on West Lake Landfill, FAA ROD, MOU and Advisories, and St. Louis Airport Authority Letters

Appendix B: Cross-Sections and Horizontal Slices of the Extent of RIM in Areas 1 and 2

Appendix C: Off-site Disposal Facilities – Waste Acceptance Criteria

Appendix D: Additional Evaluation of Selected Technologies

Appendix E: Supplemental Radon Flux Evaluation

Appendix F: Cover Thickness Calculations

2 SITE CONDITIONS

The purpose of this Section 2 is to provide information necessary to support the evaluation of remedial technologies and alternatives presented in Sections 4, 6, and 7. This section summarizes the site conditions at the West Lake Landfill. It is divided into five subsections:

- Section 2.1 provides information regarding the Site and the surrounding area, including discussions and/or descriptions of historical landfill operations and disposal areas; Superfund Operable Units (OUs) on the Site; current Site uses; Site zoning, use restrictions and easements; surrounding land uses; and proximity to the Missouri River floodplain.

- The nature and extent of radionuclide occurrences in OU-1 are discussed in Section 2.2, including the source of the radionuclides; general locations of RIM in Areas 1, 2, and the Buffer Zone/Lot 2A2; lateral and vertical extent of RIM; estimated volume of RIM; radiological characterization of the RIM in Areas 1 and 2; projected radionuclide decay and in-growth of the RIM; and the evaluation of principal threat wastes. Section 2.2 also includes information regarding the occurrence of non-radiological hazardous substances (trace metals, petroleum hydrocarbons, volatile and semi-volatile organics, pesticides and PCBs) in soil samples collected from Areas 1 and 2, as well as discussions regarding the potential for occurrences of hazardous wastes and asbestos-containing materials in the landfill matrix.

- The presence of radionuclides in air is discussed in Section 2.3.

- Occurrences of radionuclides in stormwater, surface water and sediment are discussed in Section 2.4.

- Brief descriptions of the Site geology and hydrogeology and the nature and extent of radionuclide and chemical occurrences in groundwater near Areas 1 and 2 are provided in Section 2.5.

- Finally, Section 2.6 includes summaries and conclusions from the baseline human health and screening-level ecological risk assessments.

2.1 Site Location and Surrounding Area

The West Lake Landfill Superfund Site is located within the western portion of the St. Louis metropolitan area on the east side of the Missouri River (Figure 2-1). The Site is located approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the city limits of the City of Bridgeton in northwestern St. Louis County. The Site has an address of 13570 St. Charles Rock Road, Bridgeton, Missouri.

The Site is bounded to the north and east by St. Charles Rock Road (State Highway 180) and by the Crossroads Industrial Park to the northwest (Figures 2-2 and 2-3). Taussig Road, commercial properties, and agricultural land are located to the southeast. The Site is bounded to the southwest by Old St. Charles Rock Road (now vacated) and the Earth City Industrial Park (Earth City) stormwater/flood control pond. The Earth City commercial and industrial complex continues to the west and north of the flood control pond and extends from the Site to the Missouri River. Earth City is separated from the river by an engineered levee system owned and maintained by the Earth City Flood Control District.

The Site is divided into six areas:

- Radiological Area 1, which is adjacent to (and in part overlain by) waste material within the North Quarry portion of the Bridgeton Landfill;
- Radiological Area 2;
- The Closed Demolition Landfill;
- The Inactive Sanitary Landfill;
- The Bridgeton Landfill (including the North Quarry portion and the South Quarry portion); and
- The Buffer Zone and Lot 2A2.

These areas are discussed further below.

2.1.1 Historic Landfill Operations and Disposal Areas

The West Lake Landfill Superfund Site is an approximately 200-acre parcel of land containing multiple areas of differing past operations. The Site was used agriculturally until a limestone quarrying and crushing operation began in 1939. The quarrying operation continued until 1988 and resulted in shallow excavation areas and two quarry pits, the North Quarry Pit and the South Quarry Pit (Figure 2-3), which were excavated to maximum depth of 240 feet below ground surface (bgs) (Herst & Associates, 2005). The relationship between the quarries and Area 1 is shown on Figure 2-3.

The Site contains several areas where solid wastes have been disposed. The date on which landfilling activities started at the West Lake Landfill is not known with certainty and has been variously cited as beginning in or around the early 1950s (EMSI, 2000), or as starting in 1952 or possibly 1962 (Herst & Associates, 2005). The Site was not officially permitted for use as a sanitary landfill until 1952. EPA has reported that “from 1941 through 1953 it appeared that limestone extraction was the prime activity at the facility; however, as time passed the focus of the activity appeared to shift to waste disposal" (EPA, 1989). EPA has reported that historical aerial photography from 1953 indicates use of a landfill had commenced (EPA, 1989). Mine spoils from quarrying operations were deposited on adjacent land immediately to the west of the quarry (Herst & Associates, 2005). Portions of the quarried areas and adjacent areas were subsequently used for landfilling municipal refuse, industrial solid wastes and construction and demolition debris. EPA has reported that liquid wastes and sludges were also disposed of at the Site (EPA, 1989). These operations, which predated state and federal laws and regulations governing such operations, occurred in areas that subsequently have been identified as Area 1, Area 2, the Closed Demolition Landfill, and the Inactive Sanitary Landfill (Figure 2-3).

The early landfilling activities at the Site (prior to 1974) were not subject to state permitting (although they were still subject to an authorization issued by the county), and the portion of the Site where these activities occurred has been referred to as the "unregulated landfill." Waste disposal in St. Louis County was regulated solely by county authorities until 1974, when the Missouri Department of Natural Resources (MDNR) was formed. Landfill activities conducted after 1974 were subject to permits obtained from the Missouri Department of Natural Resources (MDNR).

Additional discussion of the history of landfill operations, including a discussion of permitted disposal operations at the Site, is presented in Section 3.3 of the RI Addendum (EMSI, 2017a).

2.1.2 Superfund Operable Units

Superfund-program remedial action at the Site is currently divided into two operable units (OUs). OU-1 includes the solid wastes and RIM disposed in Areas 1 and 2. Area 1, which encompasses approximately 17.6 acres, is located immediately to the southeast of the Site entrance. Area 2, which encompasses approximately 47.8 acres, is located in the northwestern part of the Site. On the west side of Area 2 is the property referred to in the OU-1 RI (EMSI, 2000) as the Ford Property because it was previously owned by Ford Motor Credit, Inc. In 1998, the majority of the Ford Property was sold to Crossroad Properties, LLC and has since been developed into the Crossroads Industrial Park. Ford initially retained the 1.78 acres immediately adjacent to the western boundary of Area 2, but subsequently transferred ownership of this parcel of land to Rock Road Industries, Inc. in order to provide a buffer between the Site and the adjacent property, and therefore this parcel has been identified as the Buffer Zone (Figure 2-3). Due to the presence of radionuclides in surface soils, the Buffer Zone and Crossroads Lot 2A2 are also included as part of OU-1.

OU-2 consists of the other landfill areas at the Site, including the Inactive Sanitary Landfill located adjacent to Area 2, the Closed Demolition Landfill, and North and South Quarry portions of the Bridgeton Landfill. OU-2 also includes a surface water retention pond, abandoned leachate lagoons, a closed leachate retention pond, a former soil borrow area, a current soil stock pile area, a current stormwater retention basin, and an active leachate treatment facility associated with the Bridgeton Landfill. Regulatory authority for the Closed Demolition Landfill and the Bridgeton Landfill has been deferred to the MDNR pursuant to the OU-2 Record of Decision. To the extent that the presence of, or activities associated with, these OU-2 areas potentially impact OU-1 and the remedial alternatives considered by this FFS, those impacts are discussed in the appropriate FFS sections.

EPA has indicated that it intends to designate a third Operable Unit, OU-3, to evaluate groundwater conditions at the Site.

OU-1 Area 1 is situated on the northern and western slopes of a topographic high within the overall Site. Ground surface elevation in Area 1 varies from 490 feet above mean sea level (AMSL) on the south side of Area 1 to 452 feet AMSL at the roadway near the Site access road along the north side of Area 1 (Figure 2-4). OU-1 Area 2 is situated between a topographic high of landfilled materials to the south and east, and the Buffer Zone/Crossroads Property to the west. The highest topographic level in Area 2 is about 500 feet AMSL on the southwest side of Area 2, sloping to approximately 470 feet AMSL near the top of the landfill berm (Figure 2-4). The upper surface of the berm along the western edge of Area 2 is located approximately 20 to 30 feet above the adjacent Buffer Zone/Crossroads Property and approximately 30 to 40 feet higher than the water surface in the flood control channel located to the southwest of Area 2. A berm on the northern portions of Area 2 helps control runoff to the adjacent properties to the north; however, in other portions of Area 2, storm and surface water have been documented to flow through various stormwater outfalls that are monitored during and/or following any storm event that exceeds 0.10 inches. Although storm events of 0.10 inches do not produce flow at these outfalls, the outfalls are monitored after each storm event, and are sampled if sufficient flow occurs during a given month for collection of a sample.

2.1.3 Current Site Uses

The Site is located in a predominantly industrial area. The entire Site area, including the areas investigated as part of OU-1 and OU-2, has been the site of historic limestone quarrying operations, as well as landfill operations. Other activities on the OU-2 portion of the property currently include a solid waste transfer facility, a leachate treatment facility, and an asphalt batch plant operation (Figure 2-3).

With the exception of the Buffer Zone, all of the Site has previously been developed and has been used for, or in conjunction with, disposal of solid wastes at the Site or is currently being used in conjunction with the various industrial operations conducted at the Site. Areas 1 and 2, the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the North and South Quarry portions of the Bridgeton Landfill (Figure 2-3) were all used for disposal of solid wastes. Current activities in these areas consist of maintenance of the landfill covers and environmental monitoring. Extraction of groundwater/leachate and landfill gas continues to be performed on an ongoing basis from the North and South Quarry portions of the Bridgeton Landfill.

In addition to the area containing the Site access road and an office trailer/weigh station, there are areas located outside of the solid waste disposal units in which industrial activities are conducted at the Site. These include the area in the central portion of the Site where the solid waste transfer station, leachate treatment facility, and the asphalt batch plant are located (Figure 2-3). The asphalt batch plant operates at the Site pursuant to a long-term (99-year) lease. The OU-2 stormwater retention pond and OU-2 on-site soil borrow, and stockpile area are also located at the Site (Figure 2-3).

2.1.4 Site Zoning, Use Restrictions, and Easements

Current owners of the land encompassed by the Site and of adjacent properties are shown on Figure 2-5. The land use zoning for the Site and adjacent properties is shown on Figure 2-6. The southern portion of the Site is zoned M-1 (manufacturing district, limited). Although the northern portion of the Site is zoned R-1 (one family dwelling district), this area has never been used for residential purposes, is bounded on all sides by industrial and commercial uses, and has been used for industrial purposes for more than 50 years.

In addition, various restrictions on land use have been implemented at the Site (Figure 2-7) to reflect: (1) use of the Site as a solid waste disposal facility; (2) the presence of radiologically-impacted materials in Areas 1 and 2; and (3) the proximity of the Site to the Lambert-St. Louis International Airport. In particular, an institutional control in the form of a “Declaration of Covenants and Restrictions” was recorded on June 30, 1997, and a supplemental “Declaration of Covenants and Restrictions” was recorded on January 20, 1998, prohibiting residential use and groundwater use on any of the landfill property and restricting construction of buildings and underground utilities and pipes within Areas 1 and 2. On October 31, 2016, the prior institutional controls were modified by a further supplemental “Declaration of Covenants and Restrictions” recorded against nearly all of the OU-1 Areas (Areas 1 and 2 and the Buffer Zone) and the OU-2 landfill areas to include the OU-1 areas not included under the prior institutional controls, and to prohibit use of the premises for commercial and industrial purposes including but not limited to use as a storage yard, and to prohibit placement of water wells for agricultural purposes. The covenants grant EPA, the MDNR, and the owners the right to enforce the covenants’ restrictions and cannot be terminated without written approval of their respective owners, MDNR and EPA. Copies of these land use covenants are included in Appendix A to this report. Consequently, even though a portion of the Site is zoned residential, as a practical matter, the only reasonable future use of the Site is commercial-industrial, not residential.

The Site is located northwest of the Lambert-St. Louis International Airport (Lambert Airport). The northwest end of Lambert Airport runway 11 is located approximately 8,450 feet from the nearest point of the landfill mass (east corner of the South Quarry portion of the Bridgeton Landfill). The northwest end of runway 11 is located approximately 9,350 feet from the nearest point of Area 1 and approximately 11,000 feet from the nearest point of Area 2. Therefore, portions of both the Bridgeton Landfill and Area 1 are located at distances that are less than the FAA siting guidance of a 10,000-foot separation radius (Figure 2-8). Numerous flight tracks pass over the West Lake Landfill Site (Figure 2-8). In 2005, the City of St. Louis entered into an Negative Easement and Declaration of Restrictive Covenants Agreement with Bridgeton Landfill, LLC (among other entities) to prohibit depositing or dumping of new or additional putrescible waste on the entirety of the Bridgeton Landfill after August 1, 2005 (City of St. Louis, 2005). This negative easement stemmed in part from an earlier determination by the Federal Aviation Administration (FAA) and the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA) that the Site was a hazardous wildlife attractant for the Lambert-St. Louis International Airport (City of St. Louis, 2010). In particular, the proximity of the airport to the Site presents a risk of bird strikes. Certain types of scavenging birds (e.g., gulls, crows) are attracted to exposed putrescible wastes at landfills, and accordingly can present a bird strike risk to passing aircraft.

2.1.5 Surrounding Land Uses

Land use in the area surrounding the Site is commercial and industrial. The Crossroads Industrial Park is located on the north and west of the Site. The property to the north and east of the Site, across St. Charles Rock Road, is moderately developed with commercial, retail and manufacturing operations. The Earth City Industrial Park is located adjacent to the Site on the south and west, across Old St. Charles Rock Road. Various manufacturing facilities are located to the east of the Site, across St. Charles Rock Road. The Republic Services area office and refuse collection vehicle parking and repair facilities are located on the southeast side of the Site and the Boenker farm (agricultural property) is located to the south of the Site.

Two residential communities are present within approximately one mile of the Site. The Terrisan Reste mobile home park is located on the east side of St. Charles Rock Road approximately one-half mile to the southeast of Area 1 and approximately one mile to the southeast of Area 2 (near the intersection of St. Charles Rock Road and Interstate 270) (Figure 2-2). The Spanish Village neighborhood, which contains single family residential units surrounded by a larger area of commercial and industrial facilities, is located to the south of the Site just north of I-70, approximately one mile from Areas 1 and Area 2 (Figure 2-2).

2.1.6 Missouri River Floodplain

The limits of the geomorphic floodplain of the Missouri River were delineated based on information obtained from the MDNR, as further described in the RI Addendum (EMSI, 2017a). Portions of the Site, including all of Area 2 and much of Area 1, are located within the geomorphic floodplain of the Missouri River. However, Areas 1 and 2 are located outside of the 100-year floodplain and outside of 500-year floodplain that is protected by levees (see additional discussion in Section 3.1.2.1).

Historically, there was flooding in the area of the Site; however, changes in both the site topography and construction and operation of the Earth City levee and stormwater management system have resulted in the majority of the Site being located outside of flood-prone areas. The topography of the Site area has been significantly altered by quarry activities and by placement of quarry spoils and landfill materials. Consequently, although portions of the Site were built over the historic (geomorphic) floodplain, landfilling activities have significantly increased the topographic elevation of much of the Site (Figure 2-4) such that with the exception of the stormwater retention basin and the soil borrow and stockpile area (Figure 2-3), the majority of the surface of the landfill property, including Areas 1 and 2, is now located above and outside of the 500-year floodplain of the Missouri River (Figure 2-9).[5] The Buffer Zone and Lot 2A2 are located on the Missouri River floodplain within the area protected by the Earth City Flood Control district levee system from a 0.2% chance of flooding.

The Earth City Flood Control and Levee District operates and maintains a levee and stormwater management system in order to protect the Earth City development from Missouri River floods with a recurrence interval greater than 500 years (commonly referred to as a 500-year flood). As the Earth City levee system is located between the Missouri River and the Site, this levee system also acts to protect the Site from a 500-year flood.

No flooding of the Site or the adjacent former Ford property occurred in 1993 or 1995 during the 500- and 300-year flood events that occurred in those years, respectively. The USGS identifies the 1993 flooding as "The Great Flood of 1993" and indicates that the flood crest set a new record for the Missouri River at St. Charles (Johnson, Holmes and Waite, USGS, Great Flood of 1993.pdf, undated). USGS Water Supply Paper 2499 and Circular 1120 indicate that the 1993 river flow and flood stage of the Missouri River at Hermann, MO exceeded the prior records and was associated with a recurrence interval of greater than 100 years. MDNR Water Resources Report 54 indicates that flood stage records were broken at nearly every Missouri recording location along the Upper Mississippi and Missouri rivers and states in many places, the magnitude of the flood was what had been predicted as a "once-in-five-hundred-year flood". The Missouri Department of Conservation indicates that local gauges showed the 1995 flood was actually inches higher than the 1993 flood and described both as 500-year floods (MDEC, Jim Aukley, August 1995 issue of the Conservationist). EPA's 2008 ROD for OU-1 states "Four major flood events have occurred since the [Earth City] levee was completed in 1972, including the record level flood of August 1993 when the Missouri River crested at 14.6 feet above flood stage and remained above flood level for about 110 days."

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[5] The Federal Emergency Management Agency (FEMA) prepares Flood Insurance Rate Maps (FIRM) for many portions of the country. These maps are available online through FEMA's Map Service Center site (http://msc.fema.gov). The area of the West Lake Landfill is on FIRM Map Number 29189C0039K dated February 4, 2015 (FEMA, 2015). The FIRM map (Figure 2-9) indicates that the majority of West Lake Landfill Site is outside the 0.2-percent annual chance (500-year) floodplain.

In the event of a breach in the levee system, EPA estimated that the flood level associated with a 500-year recurrence interval (i.e., annual exceedance probability of 0.2%) would result in a project flood elevation of about 453 feet amsl adjacent to the levee (EPA, 2008). Flooding of areas adjacent to the landfill (i.e., areas outside of the levee system) would only occur as a result of a failure of the levee system. Spreading of floodwaters into areas outside of the levee system would result in lower flood elevations than those projected to occur within the levee system. Therefore, the actual elevations of any floodwaters that may extend into areas adjacent to the landfill would be less than 453 feet. The result would be no more than a foot or two of water at the northwestern toe of the landfill (EPA, 2008). Although the majority of the RIM in Area 2 is located at elevations above 453 feet, potential deeper intervals of RIM, for example, at boring locations WL-210 (AC-24), Wl-214, AC-13, -24, and 26, and NRC borings 6 and 7 (also identified as PVC-6 and -7) are located below this elevation (see Table 2-2).

2.2 Nature and Extent of Radionuclide and Chemical Occurrences in OU-1

This section summarizes the origin and general nature and extent of occurrences of RIM in waste materials in Areas 1 and 2 and the Buffer Zone/Crossroads Property. The occurrence, distribution and volume of RIM in Areas 1 and 2 has been the subject of extensive field investigations, sampling and laboratory analyses, and engineering evaluations, as summarized in the OU-1 Soil Boring/Surface Soil Investigation Report (McLaren/Hart, 1996a), the OU-1 Remedial Investigation Report (EMSI, 2000), the OU-1 Feasibility Study (EMSI, 2006), EPA's Record of Decision for OU-1 (EPA, 2008), the Supplemental Feasibility Study (EMSI et al., 2011), the Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report (FEI et al., 2014), the Comprehensive Phase 1 Report (EMSI et al., 2016a), and the RI Addendum (EMSI, 2017a). Information regarding the nature and extent of non-radionuclide chemical occurrences in soil/waste material in OU-1 is also presented to assess the potential for occurrences of hazardous waste within the landfill materials.

2.2.1 Occurrences of Radionuclides in Areas 1 and 2

Radiological constituents in OU-1 Areas 1 and 2 occur in soil materials that are intermixed with and interspersed within portions of the overall matrix of landfilled refuse, debris and fill materials and unimpacted soil and quarry spoils in Area 1 and Area 2. As discussed in Section 6.5 of the RIA (EMSI, 2017a), in some portions of Areas 1 and 2, RIM is present at the surface; however, the majority of the radiological occurrences are present in the subsurface beneath these two areas. At the Buffer Zone/Lot 2A2, radionuclides were found in surface soil that had been carried by erosion from the Area 2 berm prior to growth of the current onsite vegetation. See additional discussion in Section 2.2.10, below.

The primary radionuclides detected at levels above background concentrations at the Site are radium-226 and thorium-230, which part of the uranium-238 decay series (see RIA Section 6.6).

Thorium-232 and radium-224 isotopes from the thorium-232 decay series are also present above background levels but at a lesser frequency and at much lower activity levels.

2.2.2 Potential Sources of Radionuclides in Areas 1 and 2

It was reported that leached barium sulfate residues (LBSR) mixed with soil was brought to the West Lake Landfill in 1973. (NRC, 1976 and 1988). The LBSR was derived from uranium ore processing for the production of uranium beginning in 1942 by Mallinckrodt Chemical Works (Mallinckrodt) under contracts with the Manhattan Engineering District (MED) and the Atomic Energy Commission (AEC) at the Mallinckrodt Chemical Works facility in St. Louis, known today as the St. Louis Downtown Site (SLDS). Most of the uranium and radium had previously been removed from the LBSR in multiple extraction steps (EPA, 2008 and NRC, 1988).

Prior to 1966, the LBSR (along with other materials processed by Mallinckrodt) were stored by the AEC on a 21.7-acre tract of land (now known as the St. Louis Airport Site or SLAPS) in what was then an undeveloped area of north St. Louis County (EPA, 2008, NRC, 1988, and RMC, 1982). The LBSR, along with certain uranium processing residuals, reportedly were moved from SLAPS to the nearby Latty Avenue Site in 1966 (NRC, 1988).

Placement of the LBSR mixed with soil within Areas 1 and 2 in conjunction with placement of garbage resulted in the materials being intermixed with MSW within portions of the overall matrix of landfilled solid waste materials, debris and fill materials, and unimpacted soil and quarry spoils in portions of Area 1 and Area 2. According to a report prepared by the NRC, "The manner of placing the 43,000 tons of [soil mixed with LBSR] in the landfill caused it to be mixed with additional soil and other material so that now an appreciably larger amount is involved." (NRC, 1988). In light of the standard MSW operating procedures at that time, it is assumed that the soil mixed with LBSR was most likely used as landfill cover material. Operation of MSW landfills requires placement of soil cover over exposed waste at the end of each day; soil is placed over the compacted but still irregular, non-uniform surface of the disposed waste, resulting in a relatively discontinuous layer of variable thickness. Furthermore, the surface of an active landfill is not flat, but rather is sloped to allow for better compaction of the waste material. Consequently, soil cover material placed over waste materials in an MSW landfill is not a discrete definable layer even when it is initially placed, but rather, consists of small areas of irregular sloping surfaces of variable soil thickness. The initial discontinuous nature of the soil cover material is further disrupted during the placement and compaction of additional MSW and other soil material over the top of and adjacent to previously placed waste materials. Subsequent decomposition of the organic fraction of the MSW results in further compaction and settlement, resulting in further intermixing of the radiological materials with the decomposed MSW. Over the years, the resultant mixture has become interspersed within the overall larger masses of MSW in Areas 1 and 2 (i.e., it is present within some but not all of the MSW in these areas).

2.2.3 Criteria for Defining RIM Occurrences

EPA previously determined for purposes of evaluating "complete rad removal" alternatives (EPA, 2010a) that RIM would be defined based on the criteria set forth in EPA's regulations (40 CFR Part 192) promulgated pursuant to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) as modified by subsequent EPA guidance on the use of these regulations at CERCLA sites. Specifically, EPA's Scope of Work for the Supplemental Feasibility Study (EPA, 2010a) indicated that full excavation (referred to in that Scope of Work as "complete rad removal") was defined to mean attainment of risk-based radiological cleanup levels specified in OSWER Directives 9200.4-25 and 9200.4-18 (EPA, 1998 and 1997a). These directives provide guidance as to the use of the UMTRCA soil cleanup criteria as remediation goals at CERCLA sites.

Based on these criteria, EPA has established a conservative definition of RIM at the Site based on the application of criteria for unrestricted (*i.e.,* residential) land use.[6] Criteria were developed for the primary radionuclides of concern at the Site including radium, thorium and uranium isotopes. Specifically, EPA determined that RIM at the Site will be defined as any material containing combined Ra-226 plus Ra-228 or combined Th-230 plus Th-232 at levels greater than 5 pCi/g above background (EPA, 2010a). The EPA previously identified that this criterion would allow for unrestricted (*i.e.*, residential) use of the Site relative to radionuclide occurrences for purposes of identifying RIM at the Site. The uranium remediation goal of 50 pCi/g above background has been proposed as one criteria for identifying RIM for West Lake Landfill OU-1 because it was a cleanup goal established in the RODs for SLDS and SLAPS FUSRAP sites (USACE, 1998, and EPA, 2005, respectively). For the SLDS, EPA determined that this level would be protective of human health in that it corresponds to a risk of less than 2×10^{-5} without regard to the presence of clean soil cover that would be placed over the excavation areas. Evaluation of background levels and the associated criteria that would allow for unrestricted use was previously performed for the SFS (EMSI et al., 2011) and was also discussed in detail in the RI Addendum (EMSI, 2016b). Additional evaluation of potential cleanup standards is presented in Section 3.3.

Based on the Site background values presented in the RI Addendum and the SFS, the criteria to be used to identify RIM are as follows:

- Ra-226 plus Ra-228 = 7.9 pCi/g[7]
- Th-230 plus Th-232 = 7.9 pCi/g

[6] As noted in Section 2.1.4, above, use of the Site for residential purposes is inconsistent with the presence of municipal solid wastes within a landfill, regardless of the presence (or absence) of radionuclides within those wastes.

[7] Total radium Derived Concentration Guideline Level (DCGL) = 1.3 pCi/g Ra-226 + 1.6 pCi/g Ra-228 + 5 pCi/g radium cleanup level = 7.9 pCi/g total radium

- Combined uranium (U-234 plus U-235 plus U-238) = 54.5 pCi/g

These values were used to identify the Site soil/waste that would be included within the definition of RIM for purposes of the RIA. Additional discussion of these criteria, including evaluation of the protectiveness of these levels, is presented in Section 3.3.2 relative to the cleanup levels for the full excavation remedial alternatives.

Although the site-specific BRA is not being used to justify the cleanup values presented above, comparisons between the BRA results and the cleanup levels derived from the UMTRCA regulations as described above do provide an additional qualitative line of evidence that the cleanup levels will be protective of human health. The highest cancer risk levels calculated in the BRA for uranium were for a future storage yard worker at Area 2 and corresponded to 6.6×10^{-6} for total uranium (1.5×10^{-6} for uranium-238, 2.0×10^{-6} for uranium-234, and 3.1×10^{-6} for uranium-235). These risk estimates were based on 95% upper confidence limit (UCL) values for uranium-238, uranium-234, and uranium-235 activity levels of 42.2, 51.5, and 2.64 pCi/g, respectively, which together are approximately twice the value of the proposed cleanup criteria of 50 pCi/g plus background. Therefore, the risk level associated with the proposed cleanup level would be within EPA's acceptable risk range. Note that because site samples contain natural uranium, the activity concentration of uranium-235 in the samples must be approximately 5% of the activity concentration of either uranium-238 or uranium-234. The BRA determined that uranium did not pose a non-carcinogenic risk to the maximally exposed individual (MEI), which consists of potential future outdoor storage yard workers in Areas 1 and 2.

2.2.4 Occurrences of RIM in Areas 1 and 2

Radionuclides have been identified as primarily present in MSW in two distinct and separate disposal areas at the Site. These two areas have been designated by EPA as Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2) (Figure 2-3). Area 1 encompasses an approximately 17.6-acre portion of the Site located immediately to the southeast of the main access road to the Site. Area 2 encompasses an approximately 41.8-acre portion of the Site along the northern boundary of the West Lake Landfill property (Figure 2-3). Radionuclides have also been detected in surface soil in the Buffer Zone and Lot 2A2 (these areas do not contain MSW) as a result of erosional transport of soil containing radionuclides from the adjacent Area 2.

Procedures used to initially identify RIM occurrences based on review of the results of the field investigations and laboratory testing are detailed in Section 6.3 of the RI Addendum (EMSI, 2017a). Specifically, the downhole gamma logging, core sample gamma scan, and core sample alpha scan data were evaluated to identify intervals of elevated gamma or alpha counts (relative to instrument background and the base level gamma or alpha counts for borehole or core material from each boring) that likely reflect occurrences of RIM. The RIM occurrences identified in Areas 1 and 2 based on review of the field and laboratory data are summarized in Tables 2-1 and

2-2, respectively. The results of the geostatistical evaluation of the extent and volumes of RIM in Areas 1 and 2 are described in the next subsection of this report.

The top and bottom of the intervals interpreted to contain combined Ra-226 plus Ra-228 and/or combined Th-230 plus Th-232 greater than 7.9 pCi/g based on review of analytical laboratory data, or that are inferred to contain such levels based on interpretation of the downhole gamma logs and/or the core scans, are identified on the Borehole Summary Sheets presented in Appendix L of the RIA (EMSI, 2017a). Since RMC did not log the materials encountered during drilling of its borings and no laboratory analytical results were developed, the only data available for the RMC borings[8] are the downhole gamma measurements and, for some borings, intrinsic germanium (IG) logging that was used to estimate the activities of individual radionuclides. Therefore, borehole summary sheets were not prepared for these borings, but the results of the downhole and IG logging (presented in Appendix D-1 of the RIA report) and any re-logging performed by McLaren/Hart (presented in Appendix C-1 of the RIA report) were reviewed to identify RIM occurrences in these borings.

The results of the evaluations of RIM occurrences based on review of the field and laboratory data are summarized on Tables 2-1 and 2-2. The thickness of the RIM intervals was primarily identified based on the results of the downhole gamma logging which indicated zones with elevated gamma readings. Elevated gamma readings reflect occurrences of radium and other gamma emitters but provide no direct indication of the presence or absence of thorium-230. The intervals of elevated gamma levels reflect intervals where radium is interpreted to be present in soil intermixed with refuse. Where occurrences of thorium above the levels used to define RIM were identified without any corresponding elevated gamma or alpha levels, an approximation of the thickness of the RIM occurrences was used based on the thorium activity; specifically, for thorium occurrences between 1 and 10 times the RIM criteria, a two-foot thick interval (1 foot above and 1 foot below the sample depth with elevated thorium) was assumed, and for thorium occurrences greater than 10 times but less than 100 times the RIM criteria, a four-foot-thick interval (2 feet above and two feet below) was assumed. These assumptions were only used for those occurrences of thorium above the RIM criteria that were not associated with elevated radium, gamma or alpha levels. Thorium levels greater than 100 times the RIM criteria were associated with radium levels above the criteria and with elevated gamma levels, and therefore no assumption was used for these occurrences.

The minimum, average and maximum identified thickness of the RIM intervals in Areas 1 and 2 based on the results of the field investigations and laboratory testing were as follows:

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[8] The RMC borings are identified by the designated prefix of "NRC" or, in the case of those borings for which the PVC casing was subsequently found by McLaren/Hart during the 1995 OU-1 field investigation and the location was surveyed, by the designated prefix of "PVC".

	Area 1	Area 2
Minimum RIM thickness (ft)	0.2	1
Average RIM thickness (ft)	4.3	7.3
Maximum RIM thickness (ft)	19	25

The thickness of RIM is highly variable throughout Areas 1 and 2 as demonstrated by the wide variation in thickness listed on Tables 2-1 and 2-2. Overall, the values of RIM thickness display an exponential distribution with 93% of the values from Area 1 being less than 9.5 feet thick and 76% of the values from Area 2 being less than 10.4 feet thick (Figure 2-10).

In some locations, such as at borings 1D-9, AC-1, AC-2 and AC-3 in Area 1 and NRC (PVC), -4, -5, -6, -7, -10, -21, -22, and -40, WL-209, -210, -214, and -235, and AC-24, and AC-26A in Area 2, evaluation of the downhole logging and/or laboratory analyses of samples resulted in identification of more than one interval of RIM within a single boring. There are also a few locations in Area 2, such as NRC-16, WL-226, WL-234 and AC-21, where the results of the downhole gamma logging indicated that potentially thicker occurrences of RIM (20 feet or more) may be present.

The depths to the top of the identified intervals containing RIM in Area 1 average approximately 27.8 ft bgs (average elevation of 450.0 ft amsl), ranging from 0 (at the surface) to 89.4 ft bgs (elevations ranged from 425.4 to 470.5 ft amsl). The base of the RIM intervals occurs at an average depth of 31.9 ft bgs (average elevation of 446.0 ft amsl), ranging from 5 to 96 ft bgs (elevations ranging from 420.3 to 462.3 ft amsl). Part of the reason for the larger depths is that the landfill materials in the southern portion of Area 1 were buried beneath additional landfilled waste that was placed in that area in approximately 2002-2003 in conjunction with disposal in the above-grade portion of the North Quarry portion of the Bridgeton Landfill. In addition, inert fill was placed over portions of Areas 1 and 2 during the period from April 2007 through May 2008 (see discussion in Section 5.5.2 of the RIA report) which would also have increased the relative depth to top and bottom of the RIM occurrences in some parts of both Areas 1 and 2.

The average depth to the top of the intervals identified as containing RIM in Area 2 is approximately 6.6 feet (average elevation of 466.2 ft amsl) ranging from 0 (at the surface) to 42.5 ft bgs (elevations ranged from 434.9 to 486.5 ft amsl). The base of the RIM intervals in Area 2 occurs at an average depth of 13.9 ft bgs (average elevation of 458.6 ft amsl) ranging from 1 to 49.5 ft bgs (elevations from 428.3 to 484.5 ft amsl).

2.2.5 Estimated Extent and Volume of RIM and Overburden Material

Evaluations of the extent of RIM in Areas 1 and 2 were performed using geostatistical methods in support of the RIA and the evaluation of potential remedial alternatives for the FFS. Specifically, the extent of RIM within OU-1 Areas 1 and 2 was estimated in three dimensions (3D) using indicator kriging (IK) at multiple concentration levels. The indicator kriging method is commonly used to identify regions of the subsurface that exhibit properties that exceed one or more defined threshold criterion – typically a concentration - and as such is well-suited to delineating RIM. In the case of a single threshold, sample results are indexed according to whether they exceed (index=1) or fall below (index=0) the threshold concentration. The transformed indicators are interpolated using kriging, resulting in a continuous 3D distribution of values that range between zero and one that, in the simplest case, reflect the probability that the threshold concentration is exceeded at each interpolation grid location. When more than one activity concentration threshold is being simultaneously evaluated, indicator kriging at multiple activity concentration thresholds is used to obtain a cumulative distribution function (CDF) for the probability of occurrence above each threshold. A complete description of the methods used, data incorporated in the analysis, and the assumptions and limitations of the analysis is provided in the report titled "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri*" (S.S. Papadopulos & Assoc., Inc. [SSP&A], 2017), which was submitted as a separate report in support of both the RIA and this FFS.

The data available to estimate the extent of RIM include concentrations of thorium and radium obtained from laboratory analysis of surface and subsurface samples, plus a large number of vertically piecewise-continuous gamma and alpha recordings obtained within boreholes or by scanning retrieved core material. The reported activity concentrations of thorium and radium comprise direct measurements of the quantity of interest, and are referred to here and by SSP&A (2017) as "hard" data. In contrast, measurements of gamma emissions and alpha radiation are indirect indicators of the presence and likely concentration of radiological constituents, including (but not limited to) thorium and radium. These counts of radioactivity are referred to here and by SSP&A (2017) as "soft" data. The indicator kriging method enables such soft data to be incorporated into the estimation of the extent of the primary hard variable under the assumption that the soft data exhibit a correlation with the hard data. Given the preponderance of gamma emission versus alpha radiation recordings from previous investigations, the geostatistical analysis focused on the utility of existing gamma emission data for inferring the presence and concentration of radium and thorium. As detailed by SSP&A (2017), correlations can be demonstrated between gamma emissions and activity concentrations of both radium and thorium, although the relationship between gamma emissions and thorium concentrations is weaker than that with radium concentrations.

The interpolation grid used for kriging was designed on a vertical and horizontal discretization suitable for providing estimates of the extent and volume of RIM in terms of concentrations of combined radium *or* combined thorium exceeding 7.9 pCi/g. The discretization of the interpolation grid was initially selected based upon UMTRCA guidance, resulting in a grid defined by square blocks of side-length 10 meters (32.8 feet) and thickness 0.15 meters (0.5 feet) consistent with the criteria specified in 40 CFR § 192.12a for cleanup of land containing residual radioactive materials. However, to provide greater precision for estimates of the volume of RIM associated with the various remedial alternatives evaluated in this FFS, final calculations were made on a refined horizontal grid comprising square blocks of side-length 5 meters (16.4 feet) and thickness 0.15 meters (0.5 feet).

Estimates of the areal extent of RIM, defined above as material containing combined radium *or* combined thorium concentrations greater than 7.9 pCi/g, obtained using IK are shown on Figures 2-11 (Area 1) and 2-12 (Area 2). The estimated extent of RIM shown on these figures is based upon indicator kriging of both laboratory analytical data that are considered direct measurements of RIM occurrences and the field measurements of gross gamma or alpha radiation that provide an indirect indication of potential RIM occurrences. Based on the results of the indicator kriging evaluations, the composite areal extent where RIM is present (at any activity level greater than 7.9 pCi/g for combined radium and/or combined thorium) in Area 1 is approximately 8.4 acres. The composite areal extent where RIM is present (at any activity level greater than 7.9 pCi/g for combined radium and/or combined thorium) in Area 2 is approximately 26.8 acres. These maximum areal extents represent projections of *any* regions where RIM is present at *any* depths within Areas 1 and 2. Accordingly, the two-dimensional depictions of the extent of RIM shown on Figures 2-11 and 2-12 should not be construed to indicate that RIM is present at *all* depths beneath all areas within the outer RIM boundary. Rather, these figures illustrate only that RIM, possibly as little as 6 inches thick, is *likely* (meaning, a greater than 50% probability based on the indicator kriging evaluation) to be present at *some* depth beneath the areas outlined on Figures 2-11 and 2-12.

Depictions of the extent of RIM as a function of depth (elevation) beneath Areas 1 and 2 are presented in Appendix B. Appendix B-1 contains cross-sections through Areas 1 and 2 that portray the vertical extent of RIM occurrences in Areas 1 and 2. Appendix B-2 presents horizontal “slices” of RIM occurrences that display from a different perspective the RIM extent at various elevation intervals. Both of these depictions display the variability of the presence and extent of RIM occurrences as a function of depth. Review of these cross-sections and horizontal “slices” demonstrates that the RIM in Areas 1 and 2 does not consist of a continuous layer, but rather, as numerous discrete or disconnected bodies of material (See Appendices B-1 and B-2).

The best-estimates for the volume of RIM within Area 1 and Area 2 are approximately 56,700 cubic yards for Area 1 and approximately 251,000 cubic yards for Area 2. However, as described by SSP&A (2017), there is significant uncertainty associated with the estimated extent and volume of RIM in Areas 1 and 2. Specifically, SSP&A indicated that these estimates are likely biased low and therefore underestimate the actual volume of RIM in Areas 1 and 2.

The base-case estimates for the volume of RIM within Area 1 and Area 2 are approximately 56,700 cubic yards for Area 1 and approximately 251,000 cubic yards for Area 2. As detailed by SSP&A (2017), there is significant uncertainty associated with the estimated extent and volume of RIM in Areas 1 and 2, and there is also likely to be bias associated with the estimates. With regard to uncertainty, calculations presented by SSP&A (2017) suggest that depending upon the level of confidence that is associated with the estimates, the calculated RIM volume may range over by a factor of 3 or greater. With regard to bias, SSP&A (2017) suggest that for a variety of reasons – including the results of cross-validation calculations; the possible tendency toward false-negative estimates from low-valued but widely-spaced gamma measurements; and the presence of some regions beyond the convex hull of the sample data for which estimates cannot reasonably be made – the base-case RIM volume estimates are likely to be biased low, and therefore underestimate the actual volume of RIM in Areas 1 and 2.

RIM has also been independently identified at the ground surface. The extent of RIM at the current ground surface was evaluated through review of the analytical results of the surface soil samples, the results of the 1995 overland gamma survey, and identification of boreholes for which the downhole gamma or core scans indicated the potential for RIM to be present at the ground surface (i.e., not based on the results of the IK evaluation). These data were combined on Figures 6-10 and 6-11 and were used to define the approximate extent of RIM occurrences at the ground surface. Based on this evaluation, RIM was previously present at, or very near, the ground surface in 1.15 acres (6.6%) of Area 1 (total area 17.6 acres). 100% of the surface RIM in Area 1 is covered by the non-combustible cover installed in 2016, the inert fill that was placed in 2007-2008, or the asphalt parking lot that was installed sometime after 1978. RIM was previously present at the ground surface in 9.46 acres (22.6%) of Area 2 (total area of 41.8 acres), of which 93% is currently covered by the non-combustible cover or inert fill. Most of the remaining surficial RIM is located in the two steeply sloped areas that are planned to be covered by the non-combustible cover once the results of geotechnical testing and slope stability evaluations are completed.

2.2.6 Distribution of RIM

The overall distribution of RIM can be characterized based on the results of the various investigations and the geostatistical evaluation (SSP&A, 2017). Overall, the RIM is found to occur predominantly in relatively thin lenses and layers that are intermixed and interspersed within the overall matrix of decomposing solid waste (see Appendix B). This intermixed RIM and solid waste occurs throughout much, but not all, of Areas 1 and 2 (see Appendix B). As illustrated in Appendix B, the occurrence of RIM does not represent a continuous layer within a specific depth or elevation interval. Rather, the RIM represents thin layers of variable occurrence through much, but not all, of Areas 1 and 2.

Such occurrences are consistent with use of soil material containing radionuclides as daily cover material which would have been placed primarily on inclined, irregular surfaces of the working face of the disposed refuse. Such material would have been subject to displacement from initial compaction of the material and further displacement as additional refuse and additional cover material was placed and further compacted these areas. Furthermore, subsequent decomposition, consolidation and settlement of the emplaced refuse would have resulted in further differential displacement of the cover material layers. The presence of RIM intervals reported to be thicker than the nominal 6-inches of daily cover or 12-inches of intermediate cover may reflect disposal of additional soil material at the time of placement (*i.e.*, placement of more than the minimum required thickness or direct disposal of soil containing radionuclides), larger vertical thicknesses present on inclined (*e.g.*, working face) surfaces, vertical redistribution of the emplaced cover materials as a result of decomposition, consolidation and settlement of the refuse over the past 40 years, erosion of cover materials prior to burial, or gamma signatures that extend above and below the actual intervals of radionuclide occurrences in the subsurface (*i.e.*, "shine").

2.2.7 Radiological Characterization of the RIM

The primary radionuclides detected in Areas 1 and 2 at levels above background concentrations are part of the U-238 decay series. The uranium decay series includes Th-230, Ra-226, and Rn-222, which are the primary radionuclides of concern at the Site. Th-232 and Ra-228 isotopes from the thorium decay series were also present above background levels but at a lesser frequency and relatively lower activity levels than the radionuclides in the U-238 decay series. A total of 218 radium analyses and 213 thorium analyses (including investigative samples, field duplicate samples, and laboratory duplicate analyses) are available for Area 1, and 144 radium and thorium results are available for Area 2, from the OU-1 RI, Phase 1, and Additional Characterization investigations. Table 2-3 summarizes the radium, thorium and uranium results for samples obtained from Area 1, and Table 2-4 summarizes the results for samples obtained from Area 2.

The total number of results, and the average, maximum, and estimated 95% UCL values (based on results for a non-parametric distribution as calculated using ProUCL 5.0 – see additional discussion below) for the radium and thorium data sets are provided on Table 2-5. For purposes of these calculations, lab replicate samples, which are laboratory internal QA/QC samples, were not considered. Also, in order to be consistent with EPA direction, only the maximum reported value for any pair or more of sample results from the same sample interval (*i.e.*, field duplicate samples, EPA split samples, or EPA verification samples) were utilized in the preparation of the risk assessment. In addition, certain data were determined to be unusable based on comparability and representativeness criteria (see Appendix D-12 of the RI Addendum) and therefore are not included in the sets of data used to calculate the radium and thorium statistical values provided on Table 2-5.

It should be noted that although an average value is presented in Table 2-5, the data sets were not composed of a single population but appear to be best represented as a bimodal population, and therefore are not normally distributed. Therefore, an arithmetic average is not an appropriate measure of central tendency for such data sets. The 95% UCL values listed on Table 2-5 is based on non-parametric distribution and estimation techniques. Regardless of whether the data are treated as a single population or as bimodal mixture of two populations, the values provided on Table 2-5 support the conclusion that the RIM is primarily characterized by elevated levels of Th-230 and Ra-226, and that, with the exception of a few values, most of the Th-232 and Ra-228 values are close to or similar to background values.

2.2.8 Radionuclide Decay and In-Growth

Review of the data indicated that for all of the results that are greater than the unrestricted use criteria (*i.e.*, 7.9 pCi/g combined Ra-226 + Ra-228 or combined Th-230 + Th-232), the Th-230 activities are greater than the Ra-226 activities. These analytical data indicate that the Ra-226 activities are not in equilibrium with the Th-230 activity levels and consequently the levels of Ra-226 at the Site will increase over time. Over time, the activity concentrations of Ra-226 will grow into that of its parent, Th-230.

The 95% upper confidence limit values of the Th-230 and Ra-226 data for the Area 1 and Area 2 soil/waste samples were used to estimate the anticipated in-growth of Ra-226 from decay of Th-230 over time. Accounting for the in-growth of Ra-226 due to the decay of Th-230 results in an estimated Ra-226 activity level of 1,323 pCi/g in Area 1 and 1,476 pCi/g in Area 2 in 1,000 years (Tables 2-6 and 2-7). The expected increases in the Ra-226 levels in Areas 1 and 2 owing to decay of Th-230 over time are graphically presented on Figure 2-13 and 2-14. Peak radium levels are expected to occur in approximately 9,000 years at which time Ra-226 activities are estimated to be 1,979 pCi/g in Area 1 and 2,253 pCi/g in Area 2.

The projected increase in Ra-226 levels over time will result in both increased radiation levels and increased radon gas generation over time. Design of a landfill cover included within the scope of the ROD-selected remedy, or a cover associated with any of the other remedial alternatives, will need to consider the projected increase in radium over time and the associated increases in gamma radiation and radon emanation that will also occur over time. The projected increase in radiation and radon levels over time was addressed as part of the risk characterization included in the BRA and Updated BRA (Auxier & Associates, 2000 and 2017), and was considered as part of the conceptual design of the remedial alternatives and potential long-term risks evaluated in the prior SFS and in this FFS, as described further in Sections 5 and 6.

2.2.9 Principal Threat Wastes

In accordance with the NCP, EPA expects that treatment will be the preferred means by which to address the principal threats posed by a site, wherever practicable. Because one of the purposes of the FFS is to provide a thorough evaluation of potential full excavation and partial excavation alternatives relative to the ROD-selected remedy, it is conservatively assumed (for purposes of this evaluation) that principal threat wastes may be present within OU-1. Therefore, potential treatment technologies are evaluated in Section 4 of this FFS. As discussed in Section 4, the evaluation of potential treatment technologies takes into account both the presence of the RIM and the expected further in-growth of radionuclides in the RIM due to radioactive decay and disequilibrium.

2.2.10 Radiological Occurrences on the Buffer Zone and Lot 2A2

During the RI (EMSI, 2000), radionuclide occurrences in surface soil were identified in the southern portion of what at that time was property owned by Ford Motor Credit (referred to in the RI as the Ford Property and now known as the Buffer Zone and Lot 2A2), located immediately to the west of Area 2 (Figure 2-3).

Reportedly, after completion of landfilling activities in Area 2, but prior to establishment of a vegetative cover over the landfill berm, erosion of soil from the landfill berm resulted in the transport of radiologically-impacted soil from Area 2 onto the adjacent former Ford Property (EMSI, 2000). The landfill berm and the adjacent properties were subsequently re-vegetated by natural processes such that no evidence of subsequent erosion or other failures were present at the time of the RI. Based on the results of sampling performed during the RI, occurrences of radionuclides were found in surficial (6 to 12 inches or less) soil at the toe and immediately adjacent to the landfill berm. The overall distribution and surficial nature of the occurrences of radiologically-impacted soil on the former Ford Property was determined to be consistent with historic, erosional transport of soil from the Area 2 slope onto the surface of the former Ford Property.

In November 1999, third parties scraped the vegetation and surface soil on Lot 2A2 and the Buffer Zone to a depth of approximately 2 to 6 inches. These areas were covered with gravel to allow for parking of tractor-trailers. The removed materials were piled in a berm along the southern boundary of the Buffer Zone, adjacent to the northwestern boundary of the Site. A small amount of removed materials was also placed in a small pile on the Crossroads Property near the base of the landfill berm along the east side of Lot 2A2 (Figure 2-15).

In February 2000, additional surface soil samples were collected from the disturbed area and submitted for laboratory testing. Only one sample (RC-02) obtained from the Buffer Zone, below and adjacent to the area of the former landfill berm slope failure, contained radionuclides (Th-230) above levels that would allow for unrestricted use (Table 2-8). The remainder of the samples contained either background levels of radionuclides or levels above background but within levels that would allow for unrestricted use. The results of the additional soil sampling indicated that most of the radiologically-impacted soil that had previously been present on the Buffer Zone and Lot 2A2 of the Crossroads Property had been removed and placed in the stockpiles. Evaluation of the soil sampling results obtained prior to and after the 1999 disturbance indicates that approximately one acre of the Buffer Zone still contained some radionuclides above unrestricted use levels. Inspection of the area in May 2000 indicated that native vegetation had been re-established over both the disturbed area and the stockpiled materials. The presence of native vegetation over these materials was determined to be sufficient to prevent windblown or rainwater runoff of these materials.

A 2004 inspection of this area indicated that additional soil removal/regrading had been performed on the remaining portion of the Lot 2A2 and the adjacent Buffer Zone property.

These activities appear to have resulted in removal of the soil stockpiles created during the previous regrading activity, removal of any remaining soil on Lot 2A2 and the Buffer Zone not scraped up during the 1999 event, and placement of gravel over the entirety of Lot 2A2 and much of the Buffer Zone. According to AAA Trailer, all of the soil removed during the July 1999 grading work and the May 2003 gravel layer installation was placed in the northeastern corner of the Buffer Zone (terra technologies, 2004). Respondents installed a fence between the Buffer Zone and Lot 2A2 to prevent any future disruption of the Buffer Zone by AAA Trailer or any other party.

Because no sampling has been performed since the most recent (May 2003) grading work conducted by AAA Trailer, the levels and extent of radionuclides, if any, that may remain in the soil at the Buffer Zone and Lot 2A2 are unknown. Additional soil sampling to determine current conditions with respect to radionuclide occurrences in the Buffer Zone and Lot 2A2 soil will be conducted as part of implementation of the selected remedy for this area.

The areal extent of soil containing radionuclides on the former Ford property (current Buffer Zone and Lot 2A2) was estimated in the 2000 RI to be 196,000 square feet. Based on the results of the sampling that indicated that the occurrences of radionuclides were limited to surface soil, the representative thickness of 6-inches was used to estimate the volume of soil. The volume of radiologically-impacted soil located on the former Ford Property was estimated in the OU-2 RI to be 3,600 cubic yards (EMSI, 2000 and 2006a). Because this area was subsequently scraped, graded and covered with rock, the actual volume of soil containing radionuclides on the Buffer Zone and Lot 2A2 is uncertain. However, in the absence of any more current information, the 3,600-cubic yard estimate has been used for purposes of developing and evaluating detailed cost and schedule estimates for the various remedial alternatives.

2.2.11 Occurrences of Non-Radiological Chemical Constituents in Soil/Waste

Although the primary focus of the OU-1 RI field and laboratory investigations was on radionuclide occurrences, investigation of occurrences of non-radiological, chemical constituents was also performed during the RI. The soil/waste samples collected by McLaren/Hart as part of the soil boring program (McLaren/Hart, 1996a) were analyzed for the following non-radiological constituents:

- Priority pollutant metals and cyanide;
- Total petroleum hydrocarbons (TPH);
- Volatile Organic Compounds (VOCs);
- Semi-Volatile Organic Compounds (SVOCs); and

- Pesticides and poly-chlorinated biphenyls (PCBs).

As part of the OU-1 RI field investigation and laboratory analyses, 43 soil samples from 28 borings were analyzed for VOCs, SVOCs, pesticides and PCBs, and TPH. Twelve of these borings were located in Area 1 and 16 were located in Area 2. Seventeen of the soil samples analyzed for organic compounds were collected from Area 1 borings and 23 were collected from Area 2 borings. There were also three field duplicates, for a total of 43 soil samples analyzed for organic compounds. Of the 43 samples collected and analyzed for non-radiological constituents, 15 were of surface soils, including five from Area 1 and 10 from Area 2.

In addition, 37 soil samples from 25 borings were analyzed for the 12 priority pollutant metals: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, and zinc. Cyanide analyses were also performed on these samples. Nine of these borings were located in Area 1 and 16 were located in Area 2. Eleven of the soil samples analyzed for trace metals were collected from Area 1 borings and 23 were collected from Area 2 borings. There were also three field duplicates for a total of 37 soil samples analyzed for trace metals. Additional detailed information is contained in the Soil Boring/Surface Soil Investigation Report (McLaren/Hart, 1996a).

The only other non-radiological results are for samples collected during the Phase 1D investigation of Area 1, the Additional Characterization of Areas 1 and 2, and the Cotter investigation.[9] These samples were analyzed for Target Analyte List (TAL) trace metals, inorganic parameters including pH, calcium, magnesium, sodium, potassium, alkalinity, chloride, fluoride and sulfate, and three transition metals: scandium, niobium and tantalum. A total of 138 soil samples were collected by these investigations, including 69 samples plus seven duplicate samples from Area 1 and 54 samples plus eight duplicate samples from Area 2.

A summary of the results of the non-radiological analyses (both organic and non-organic) are presented in Section 8 of the RI Addendum (EMSI, 2016b). Overall, the occurrences and concentrations of the various chemical constituents are consistent with the disposal of MSW. Disposal operations at the West Lake Landfill date back to the 1950s and predate the adoption of federal or state regulations prohibiting the disposal of hazardous wastes in solid waste landfills. An October 2, 1980 MDNR memorandum acknowledged that there was "little known about what went into Westlake Landfill prior to State regulation," but listed a number of industrial and chemical wastes known to have been disposed of in the landfill (MDNR, 1980). That memorandum listed wastes associated with insecticides, herbicides, oily sludges and waste water treatment sludges, along with various chemical and industrial waste materials. Underlying documentation associated with these materials was not included with the memo, nor does the memorandum identify the time periods, volumes, or waste disposal locations. In addition,

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[9] As described further in Sections 4.4.8 and 4.5.6 of the RI Addendum, Cotter conducted additional investigations in Areas 1 and 2 as part of the Phase 1 and Additional Characterization sampling efforts.

during the time period in which wastes were disposed at the Site, certain household products frequently contained substances that are now regulated as hazardous waste. Accordingly, there is a potential that some of the waste materials at the Site could display the characteristics of hazardous wastes.

The potential for occurrences of hazardous wastes within Areas 1 and 2 exhibiting the toxicity characteristic (TC) was evaluated by comparing the maximum levels of the 40 designated chemical constituents to the results of the RI or subsequent investigation (Phase 1D, Additional Characterization or Cotter Investigation) soil/waste samples. The maximum concentrations were compared to levels established for the Toxicity Characteristic Leaching Procedure (TCLP) established under the Resource Conservation and Recovery Act (RCRA) (40 CFR Part 261.24) and the Missouri state hazardous waste regulations (10 CSR 25-4.261). Section 1.2 of the TCLP provides that if the total analysis of a waste demonstrates that toxic characteristics are present only at concentrations below their respective regulatory levels, the TCLP need not be run. For wastes with no free liquids, this is accomplished by multiplying the TC regulatory limit by 20 (to reflect the 20x weight ratio of extraction fluid to solid in the TCLP protocol) for comparison to the respective constituent concentrations. The results of these comparisons are presented on Table 2-9.

Based on these comparisons, the possibility exists that some of the waste materials contained in Areas 1 and 2 could have TC metals, or their benzene, chloroform, or 1-4 dichlorobenzene concentrations above the regulatory levels for the toxicity characteristic. However, this possibility can only be verified by subjecting representative samples to the TCLP for those constituents, since the screening was compared to the highest single value (not necessarily the representative concentration), and the chemical form and/or attenuation by the solid matrix may preclude significant leachability under the procedure. RCRA regulatory authorities do not apply to wastes legally placed into a disposal unit prior to RCRA's effective date unless the wastes are excavated or removed from the disposal unit. Further waste classification is not necessary unless and until such excavation occurs.

2.2.12 Asbestos Containing Materials in Soil/Waste

Identification of, or testing for, regulated asbestos containing materials (RACM) was not included in the scope of the RI field investigations or the subsequent investigations. Review of the RI soil boring logs (Appendix B-1 of the RI Addendum) does not indicate that pipe insulation, transite panels or other materials that may represent RACM were encountered during drilling; however, as stated above, identification of such materials was not part of the scope of the RI field investigations. Individuals responsible for performance of the Phase 1C, Phase 1D, Additional Characterization and Cotter investigations were required to complete asbestos awareness training and were therefore conscious of the potential for asbestos. No indications of potential RACM were noted during these field investigations. However, because the RI field investigations did not include procedures to identify the presence of RACM, no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2.

2.3 Radionuclide Occurrences in Air

Radionuclides can be transported to the atmosphere either as a gas (in the case of the various radon isotopes) or as fugitive dust (in the case of the other radionuclides). This section summarizes the results of radon flux measurements from the surfaces of Areas 1 and 2 and measurements of radon levels in air along the perimeters of Areas 1 and 2. It also summarizes the results of radionuclide analyses of fugitive dust samples collected from Areas 1 and 2 during the OU-1 RI and from along the perimeters of Areas 1 and 2 during 2015-2016.

2.3.1 Radon Flux and Radon in Atmospheric Air

Radon gas is discharged into the atmosphere as a result of the decay of radium. No standard for radon emissions directly applicable to the Site have been established. In 40 CFR Part 61, EPA established a standard of an average of 20 pCi/m^2s for radon emissions from uranium mill tailings from a number of samples (generally 100) collected from the surface of the tailings in a statistically unbiased fashion. Although this standard is directly applicable only to uranium mill tailings, it does represent a health-based standard derived by EPA.

Radon flux measurements were conducted at the Site during the RI investigation using the Large Area Activated Charcoal Canisters (LAACC) method presented in Method 115, Appendix B, 40 CFR Part 61 (EMSI, 1997a). The LAACC method involves placing a canister on the surface of the Site in a designated area and then allowing radon to collect on charcoal within the canisters for a period of 24 hours. Based on the radon flux measurements obtained during the RI, the average radon flux from Area 1 is 13 pCi/m^2s, which is below the EPA standard for uranium mill tailings. The average radon flux for Area 2 is 28 pCi/m^2s. This average is above the EPA uranium mill tailings standard; however, this value is due solely to the results obtained from two locations (WL-209 and WL-223). The results obtained from these two locations represented the vast majority of the radon flux found in Area 2 during the OU-1 RI.

Radon flux emissions from the surfaces of Areas 1 and 2 were also measured in 2016 after completion of construction of the non-combustible cover over those portions of Areas 1 and 2 where RIM previously existed at the ground surface. The arithmetic mean value of the results was 0.061 pCi/m^2s, which is far below the UMTRCA standard of 20 pCi/m^2s. The maximum reported values were 0.198 $pCi/m^2/s$ for Area 1 and 1.5 $pCi/m^2/s$ for Area 2. Radon flux measured at point 2-19 (the closest point to WL-209) was 0.098 $pCi/m^2/s$ and the flux measured at point 2-65 which is located near WL-223 was non-detect (<0.023 $pCi/m^2/s$).

Radon that is emitted from the surface of Areas 1 and 2 is subject to natural dilution and dispersion processes active in the atmosphere. As noted above, radon flux measurements were taken directly at the ground surface and within the confined space of each LAACC. Measurement of radon levels in atmospheric air were conducted at the 13 air monitoring stations (Figure 2-16) installed in 2015 and operated to obtain baseline air monitoring data for the Site (Auxier and EMSI, 2014, 2016a, 2016b, 2016c, and 2017a, 2017b and 2017c). Recorded radon concentrations have ranged from less than 0.4 pCi/L up to 0.7 pCi/L at the 13 perimeter air monitoring stations. Table 2-10 presents a summary of the perimeter air monitoring radon results obtained through May 2017.

EPA has established a standard under UMTRCA (40 CFR § 192.02 (b)(2)) for radon outside an UMTRCA-regulated disposal facility. The standard specifies that control of residual radioactive materials shall be designed to provide reasonable assurances that releases of Rn-222 from residual radioactive material to the atmosphere will not increase the annual average concentration of Rn-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter (0.5 pCi/L). The radon levels measured at the Site (Table 2-10) meet this standard.

EPA also performed air monitoring at five off-site stations, four of which were located in the vicinity of the West Lake Landfill and one (EPA station 5) that was located in St. Charles, MO. EPA designated station 5 as a reference (or background) station, because it is frequently upwind of the Site and was located further away from the Site than the other stations but still within the general vicinity so as to be representative of the North St. Louis County and east St. Charles County area (TetraTech, 2016 and 2015b). For the period from April 25, 2015 through February 17, 2016, EPA reported radon levels at its reference (background) station ranging from 0.11 to 1.45 pCi/L, with a median value of 0.30 pCi/L (TetraTech, 2015e). The values measured at the 13 perimeter air monitoring stations are similar to the levels obtained from the EPA reference (background) station, and if the 0.3 pCi/L median value from the EPA reference station was considered to be background (instead of the 0.4 pCi/L value EPA has indicated is typically present in outdoor air), the results from 13 perimeter air monitoring stations at the Site are all within 0.5 pCi/L of the median result obtained by EPA at its reference station.

2.3.2 Fugitive Dust Sampling

Measurements of radionuclides in fugitive dust (particulate samples) have been obtained at the 13 air monitoring stations installed in 2015 around the perimeters of Areas 1 and 2 plus one station in the southwestern corner of the landfill property (Figure 2-16). These stations have been operated to collect baseline air monitoring data for the Site (Auxier and EMSI, 2014, 2016a, b and c and 2017a, 2017b and 2017c). Air particulate samples are collected every 28 days and submitted for analysis. Each sample is analyzed for Gross Alpha and Gross Beta levels. The results of the first eight quarters (May 2015 through April 2017) of on-site monitoring for gross alpha and gross beta are summarized on Tables 2-11 and 2-12. The results obtained during the first eight quarters of operation of the perimeter air monitoring program were compared to the results obtained from the EPA off-site monitoring program over the period from May 2014 through February 2015 (Auxier and EMSI, 2016a, b, and c and 2017a and b). Overall, the median and maximum gross alpha results obtained from the 13 on-site stations were greater than the results obtained from EPA's five off-site stations (Table 2-11). The gross beta results obtained from the 13 on-site stations are similar to the gross beta results obtained from the EPA off-site monitoring locations (Table 2-12).

For the first quarter of sampling (May through July 2015), the May and June 2015 particulate samples were analyzed for isotopic thorium, uranium, and by gamma spectroscopy. Particulate results from September and December 2015 and March, May and August 2016 (the middle of each respective three-month monitoring period) were also submitted for isotopic analysis and gamma spectroscopy. Statistics for Th-230, U-238, and combined radium results (the sum of actinium-228 [for Ra-228] and Bi-214 [for Ra-226] from gamma spectrometry) for each station in pCi/m^3 for May, June, September, and December 2015 and March, May, August, and November 2016 and February and April 2017 are presented on Tables 2-13, 2-14, and 2-15. The results of on-site monitoring for U-238, Th-230, and combined radium were also compared to the results obtained from the EPA off-site monitoring program over the period from May 2014 through February 2015 (Table 2-16). All of the median and maximum values for the isotopic uranium, isotopic thorium and combined radium results obtained from the 13 on-site stations are lower than the median and maximum results obtained from EPA's five off-site stations.

2.4 Radionuclides in Stormwater, Surface Water and Sediment

Radionuclides present in Areas 1 and 2 could potentially be transported to other portions of the Site or to offsite areas via precipitation runoff from the Site. Transport via rainwater runoff could include both dissolved phase transport and suspended phase transport within the flowing runoff water. Potential impacts to permanent surface water bodies, as well as the actual or potential receptors of any offsite migration of radionuclides, are summarized below. A more detailed discussion can be found in Section 7.2 of the RI Addendum (EMSI, 2016b).

Since completion of the original RI in 2000, improvements to the property, such as the addition of a non-combustible cover and drainage controls along the top of Area 2, have decreased the potential for runoff of surface water to contain impacts from RIM. Therefore, this release mechanism is not expected to result in unacceptable risks to current OU-1 receptors.

Current surface water runoff patterns for Areas 1 and 2 are presented on Figure 2-17. All runoff from Area 1 ultimately flows into the perimeter drainage ditch located along the northeast side of the landfill adjacent to St. Charles Rock Road (the Northeast Perimeter Drainage Ditch), which then flows into the surface water body located north of Area 2 (the North Surface Water Body).

Runoff from the northern (majority) portion of Area 2 flows into one of two closed topographic depressions created by the presence of the perimeter berm located at the top of the landfill slope. Runoff from the southeastern portion of Area 2 flows to the northeast where it enters the Northeast Perimeter Drainage Ditch and subsequently flows into the North Surface Water Body. Runoff from the southernmost portion of Area 2 eventually flows to the southeast along the internal road that provides access to Area 2 and down to the drainage ditch located on the north side of the Site access road, from where it also flows to the Northeast Perimeter Drainage Ditch. Runoff from the southwestern portion of Area 2 flows as overland flow onto the Buffer Zone where it ponds, unless sufficient water accumulates such that the water reaches the western portion of the Buffer Zone where it can flow overland into a culvert that conveys stormwater to the large Earth City stormwater basin located adjacent to Area 2 and the AAA Trailer property.

Rainwater runoff (stormwater) samples were collected in 1995/1996 by McLaren/Hart and in 1997 by EMSI during the OU-1 RI field investigations at four locations in Area 1 and six locations in Area 2 (Weirs 1 through 10, as depicted on Figure 2-18). Review of the rainwater runoff results indicates that radium levels above the drinking water standard were only present in the sample from Weir 9. Specifically, the Ra-226 level detected in the unfiltered sample obtained in April 1996 from this location was 8.85 pCi/L compared to the drinking water standard of 5 pCi/L.[10] Subsequent sampling of rainwater runoff from this location in May 1997 indicated that the combined Ra-226 (0.32 pCi/L) and Ra-228 (<0.87 pCi/L) detected in the May 1995/April 1996 and August 1997 OU-1 rainwater runoff monitoring events were below the drinking water standard of 5 pCi/L.

Stormwater monitoring has been performed at up to 11 locations (Figure 2-17) including the following:

- OU-1-001 (formerly NCC-001)
- OU-1-002 (formerly NCC-002)
- OU-1-003A (formerly NCC-003A and also NCC-003)
- OU-1-004 (formerly NCC-004)
- OU-1-005
- OU-1-006
- OU-1-007
- OU-1-008
- OU-1-009
- OU-1-010
- OU-1-011

[10] However, the filtered sample obtained from this location during the same sampling event contained only 0.80 pCi/L, indicating that the majority of the Ra-226 detected in the unfiltered sample was present as suspended sediment. Due to high MDA levels, the Ra-228 results for this sampling event did not provide any meaningful data (for purposes of comparison to the MCL).

In addition, the northern and northwestern boundaries of Area 2 are observed during or after precipitation events in accordance with the stormwater monitoring plan (EMSI, 2017b) for evidence of stormwater runoff (such as erosional channels or sediment deposition areas); however, no indication of any stormwater discharge has ever been observed in these areas.

The results of the laboratory analyses for radionuclides are summarized on Table 2-17. Results of analyses for physical and chemical parameters are summarized on Table 2-18. The reported activity concentrations of combined Ra-226 plus Ra-228 for all of the stormwater samples have all been less than the radium drinking water standard of 5 pCi/L. Total uranium results for nearly all of the stormwater samples were less than the 30 ug/L MCL for drinking water supplies (Table 2-17). The only exception was the sample of ponded water on the Buffer Zone obtained on April 30, 2017 from location OU-1-010 which contained approximately 60 ug/L of total uranium (Table 2-17), which was twice the drinking water standard. Gross alpha monitoring has also been performed. After subtraction of the total uranium activity[11], the gross alpha data were compared to the gross alpha MCL of 15 pCi/L. Comparison of the gross alpha results to the gross alpha MCL is a conservative approach and does not reflect the fact that the OU-1 stormwater monitoring program includes direct measurement of the activity levels of the specific radionuclides of concern for OU-1 (e.g., radium-226, thorium-230 and uranium). To date, five sample results have indicated an exceedance of the gross alpha MCL, including the July 6, 2016 and July 27, 2017 samples from outfall OU-1-002 (previously identified as outfall NCC-002), the May 11, 2016 and July 6, 2016 samples from internal monitoring point NCC-003, the May 12, 2016 sample from outfall NCC-004 (later renamed OU-1-004), and a April 30, 2017 grab sample of runoff from the North Quarry (expected to be identified in the future as new Bridgeton Landfill outfall 008). Gross alpha results are primarily used as an indicator for the need for more isotope specific analyses. According to EPA's (1980) description of analytical method 900.0 for gross alpha, whenever the same radioisotopes are present in standards and samples, acceptable accuracy of measurement of alpha beta activities would be expected. However, whenever different radioisotopes are present in standards and samples, especially when significantly different particle energies are involved, then any measurement of gross alpha activity in the sample will only be an estimation of the true activities. Such an estimation can only serve to indicate the need for more specific analyses (EPA, 1980).

Given that none of the stormwater sample results exceeded the radium MCL, only one standing water sample exceeded the uranium MCL, only three outfall samples exceeded the gross alpha MCL combined with the uncertainties associated with gross alpha results, and the overall low levels of thorium in the samples, the stormwater monitoring do not indicate that radionuclides at levels of concern (e.g., greater than drinking water standards) are migrating from the Site via the stormwater pathway.

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[11] The gross alpha MCL is based on total gross alpha activity less uranium and radon activity.

During the OU-1 RI field investigations, McLaren/Hart in 1995 and EMSI in 1997 collected samples of permanent surface water adjacent to the Site into which runoff from the Site may flow. The two surface water bodies adjacent to the Site are the North Surface Water Body[12] and the Earth City Flood Control Channel. The surface water sampling locations associated with these two water bodies are shown on Figure 2-18. Analytical results for these samples did not exceed the drinking water MCL of 15 pCi/L for gross alpha. Further, none of the radium sample results exceeded the radium drinking water MCL of 5 pCi/L.

Sediment sampling was conducted in 1995, 1997, and 2016 at locations depicted on Figure 2-17. Results of the 1995 and 1997 sediment sampling and analysis indicated that Th-230, Ra-226 and Pb-210 were present in sediments above EPA Preliminary Remediation Goals (PRG) at Weirs 1, 2 and 3 in Area 1 and at Weirs 5, 6, 7 and 9 in Area 2. Sediment samples were also collected in 1997 from four locations (SED-1, SED-2, SED-3 and SED-4) along the Site stormwater conveyance ditches (Figure 2-17). Sediment samples were obtained from SED-1, SED-2 and SED-4 in 2016 in conjunction with the Additional Characterization of Areas 1 and 2. Additional sediment samples were also obtained in 2016 from the Northeast Perimeter Drainage Ditch at the location of SED-4 and at approximately 100-foot increments to the north of SED-4. Analytical results for these samples are summarized on Table 2-19). None of the sediment samples contained radium levels above UMTRCA standards for vicinity properties (Section 3.1.1.1.2) which EPA has identified as the criteria to be used to define radiologically-impacted materials (Section 2.2.3). One sediment sample obtained in January 2016 from location SED-4 (Figure 2-17) contained thorium levels (14.7 pCi/g and 19.8 pCi/g in a split sample) above the criteria (7.9 pCi/g) used to identify RIM; however, samples obtained from this same location both before and after this sample did not display levels above the RIM criteria. In addition, samples collected at approximately 100-yard intervals further to the north (downstream) of this location (*e.g.,* SED-6, -7, -8, -9, and -10) did not display elevated levels of thorium. Surface gamma scans conducted in conjunction with this sampling did not identify elevated gamma levels in this drainage. The levels of thorium reported in the January 2016 samples from SED-4 were equivalent to or less than the default preliminary remediation goal of 17.8 pCi/g for outdoor workers for a potential one in a million-incremental cancer risk without contribution from any daughter products[13].

The northern portion of Area 2 is characterized by a landfill slope/berm of approximately 20 to 30 feet average height. Scouring and erosional transport of soil via rainwater runoff from the landfill berm slope down onto the adjacent former Ford Property reportedly occurred after

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[12] The North Surface Water Body is currently located partially onsite and partially on offsite property owned by STL Properties LLC (the former Emerson Electric property), and its composition has changed over time. During the initial RI investigations, the North Surface Water Body was located primarily onsite. Subsequently, the portion that is located on the Site became overgrown and silted and is now primarily swamp, except during periods of rainfall, when water ponds in this area. Because the source of the silt in this area is likely from the Site, it has a potential to be contaminated.

[13] Calculated on August 14, 2017 using EPA's Radionuclide PRG Calculator based on default parameters without daughter progeny.

disposal activities in Area 2 ceased in the mid-1970s (Whitaker, personal communication). This historic erosional scour resulted in transport of soil, some of which contained radionuclides, from Area 2 down onto the adjacent former Ford Property (which later became known as the Buffer Zone and Lot 2A2) where it meets the toe of the landfill berm. This runoff and erosion was subsequently stopped through the construction of runoff diversion berms sometime afterward and natural re-vegetation of the landfill slope that occurred during the late 1970s and 1980s. By the time of the original RI investigations (1995), extensive vegetation including large trees was present on the northern and western slopes of Area 2 (EMSI, 2017a).

Analytical results from soil samples collected from the former Ford Property during the OU-1 RI field investigation indicated that past transport of radionuclides onto the former Ford Property was limited to the upper 6 inches of soil. The current extent of radionuclide occurrences on the former Ford Property (now known as the Buffer Zone and Lot 2A2) is unknown because these areas were graded after the most recent samples were collected from these areas; however, all of these areas are currently covered with rock and or pavement. (See prior discussion in Section 2.2.10).

2.5 Groundwater Conditions

This section briefly describes the Site hydrogeology and summarizes the results of the groundwater sampling events at the Site. A more detailed evaluation of groundwater conditions and evaluation of remedial options will be handled as part of a separate RI/FS for groundwater (OU-3).

Brief descriptions of the geology and hydrogeology of the Site are provided in subsections 2.5.1 and 2.5.2. More detailed information on the geology and hydrogeology is set forth in the RI Addendum (EMSI, 2017a) and the OU-1 and OU-2 RI reports (EMSI, 2000 and Herst & Associates, 2005).

The nature and extent of radiological and chemical constituent occurrences in groundwater near Areas 1 and 2 are described in Sections 2.5.3 and 2.5.4 below. Additional information regarding the nature and extent of contamination associated with Areas 1 and 2 is presented in the OU-1 RI Addendum report (EMSI, 2017a).

2.5.1 Geology

The bedrock geology of the Site area consists of Paleozoic-age sedimentary rocks overlying Precambrian age igneous and metamorphic rocks (EMSI, 2000). The Paleozoic (Mississippian) bedrock is overlain by unconsolidated alluvial and loess deposits of recent (Holocene) age (EMSI, 2000).

The depth to bedrock and the thickness of the alluvial deposits increases to the west of the Site where the thickness of alluvium (depth to bedrock) was reported to be 120 feet (Herst & Associates, 2005). Alluvial deposits of varying thickness are present beneath Areas 1 and 2 (see Section 5.5.1 of the RI Addendum, EMSI 2017a). The underlying alluvium increases in thickness from east to west beneath Area 1. The alluvial thickness beneath the southeastern portion of Area 1 is less than 5 feet (bottom elevation of 420 feet AMSL), while the thickness along the northwestern edge of Area 1 is approximately 80 feet (bottom elevation of 370 feet AMSL). The thickness of the alluvial deposits beneath Area 2 is fairly uniform at approximately 100 feet (bottom elevation of 335 feet AMSL).

Based on review of the boring logs, the landfill debris within the Area 1 and 2 units varies in thickness from 5 to 56 feet, with an average thickness of approximately 36 feet in Area 1[14] and approximately 30 feet in Area 2. The elevation of the base of refuse in Area 1 is approximately 430 feet AMSL but refuse in localized portions of Area 1 extends down to 422 feet AMSL (1D-9), 424 feet AMSL (AC-1), and 426 feet AMSL (WL-111 and WL-113). The elevation of the base of refuse in Area 2 is approximately 430 feet AMSL or higher; however, the refuse in localized portions of Area 2 extends down to 424 feet AMSL (WL-227) or 426 feet AMSL (AC-8 and AC-13/WL-226).

2.5.2 Hydrogeology

Groundwater is present in both the bedrock units and the unconsolidated materials. Groundwater is present within alluvial deposits immediately below the solid waste materials beneath the northern two-thirds of the Site, specifically, within the pore spaces between the granular (sand and gravel) and fine-grained (silt and clay) particles that make up the alluvial deposits. Groundwater is also present in limestone and shale bedrock units beneath the alluvial deposits and in the southern one-third of the Site (where no alluvial deposits exist), within the bedrock adjacent to and beneath the North and South Quarry portions of the Bridgeton Landfill.

Water level measurements performed during the original RI indicated that the water level elevations beneath, and adjacent to, Areas 1 and 2 were consistent with only approximately one-half foot of variability in the water levels beneath these areas during any given set of measurements. Seasonally, the water levels varied by approximately 5 feet beneath and adjacent to Areas 1 and 2 from approximately 429 feet AMSL in April 1995 to 434 feet AMSL in July 1995. Water levels varied between approximately 427 feet AMSL in April 2013 up to approximately 433 feet AMSL in July 2013. These water level elevations corresponded to depth-to-groundwater in these areas of at least 35-40 feet bgs and generally nearer to 50 feet bgs beneath Areas 1 and 2. Consequently, groundwater was generally encountered beneath Areas 1

[14] This value does not include consideration of the thickness of landfill debris associated with the above grade portion of the North Quarry part of the Bridgeton Landfill that results in greater thickness of landfill debris in the southern portion of Area 1.

and 2 in the underlying alluvium near or below the base of the landfill debris. No saturated refuse was encountered during the drilling activities conducted in 2013 – 2015. Based on the close proximity of the water table to the top of the alluvial deposits/base of refuse, it is possible that the lowermost portion of some of the refuse in Areas 1 and 2, particularly those localized areas where refuse extends down below 430 ft AMSL, could, on a seasonal basis, be in contact with groundwater.

The regional direction of groundwater flow within the alluvial deposits is generally northward within the Missouri River alluvial valley, parallel or sub-parallel to the river alignment. Based upon data collected during the RI, the difference existing in the water table surface beneath the Site (less than one foot) makes interpretation of the groundwater flow direction within the alluvium based only on water level data difficult. Based on the water level data, the direction of groundwater flow in the alluvial deposits beneath Area 1 during the RI appeared to be generally to the south toward the Bridgeton Landfill. Water level elevations beneath Area 2 displayed differences of less than one foot indicating the presence of a relatively flat water table. Based on the groundwater levels, the direction of groundwater flow within the alluvial deposits beneath Area 2 is expected to be to the west/northwest toward the Missouri River.

There are no public water supply wells near the Site. Well inventories presented in the RI report (EMSI, 2000) and in the RI for OU-2 (Herst & Associates, 2005) indicate that the nearest private well reportedly used as a drinking water source is located one mile to the north of the Site (Foth & Van Dyke, 1989), and that the closest well that is registered on a database maintained by MDNR is located approximately one-mile northeast of the Site. This well was reportedly drilled to a depth of 245 feet, which indicates a bedrock completion. Regional groundwater flow in the bedrock near the Site is to the northwest, towards the Missouri River. The closest registered well that appears to be completed in alluvium is approximately 2.5 miles south (upgradient) of the Site.

An updated evaluation of the locations of water supply wells was performed by USGS during the performance of the 2012-2013 groundwater sampling events. Information regarding the locations of water supply wells is provided in the RI Addendum and the associated figures. Overall, the wells located to the north and west of the Site (*i.e.*, downgradient) are used for industrial and commercial purposes such as irrigation, construction, and dewatering (levee system operations). It is possible that one of the wells could be used for occasional domestic purposes; however, Respondents have no information that these wells are used to provide domestic or community (potable) water supplies.

Detailed discussions of the hydrogeology of the alluvial groundwater and bedrock groundwater are presented in the RI Addendum (EMSI, 2017a) and the OU-1 and OU-2 RI reports (EMSI, 2000 and Herst & Associates, 2005). Additional evaluation of groundwater occurrence and conditions is expected to be performed as part of the OU-3 RI/FS.

2.5.3 Occurrences of Radionuclides in Groundwater

Groundwater sampling and analysis was performed during 1995, 1996 and 1997 as part of the 2000 RI and during 2004 in conjunction with the FS and during 2012-2013. To date, the most comprehensive groundwater data sets for the Site were developed during the site-wide groundwater sampling events conducted in August 2012 and April, July, October, and November 2013.[15] The focus of the discussions presented in this section is largely on the results obtained from the 2012-2013 comprehensive groundwater sampling events. A comparison of the results obtained by the 2012-2013 events to results obtained during the earlier RI and FS events is presented in the RI Addendum (EMSI, 2017a).

Radionuclide water quality results are discussed in terms of radium isotopes, thorium isotopes, and uranium isotopes. Because radium isotopes are the primary radionuclides of concern (in terms of general occurrences in groundwater, mobility, and potential health risks), the majority of the discussion of the radionuclide water quality results is focused on occurrences of radium in groundwater.

It should be noted that both Ra-226 and Ra-228 are naturally occurring (EPA, 2006b and 2002 and Focazio, et al., 2000). Based on published reports (USACE, 2004 and 2011) background levels of naturally-occurring Ra-226 in groundwater are expected to range from 1 to 4 pCi/L, and background levels of naturally-occurring Ra-228 in groundwater are expected to range from 1 to 7 pCi/L. It should be noted that the West Lake Landfill Superfund Site and the other radiological sites in the general area do not share the same geologic units. Site-specific background levels for radionuclides for the West Lake Landfill Site will be determined as part of the groundwater (OU-3) RI/FS.

EPA has established (40 CFR Part 141) an MCL of 5 pCi/L for combined Ra-226 plus Ra-228 in drinking water supplies. Although this standard is not applicable to groundwater that is not used for drinking water, it was determined by EPA (2008a) to be a potentially relevant and appropriate requirement for evaluation of groundwater quality. Therefore, the combined radium results from the recent groundwater monitoring events have been compared to 5 pCi/L.

A graphical display of the results of the comparisons of the combined total (unfiltered samples) radium results to the radium MCL is shown on Figure 2-19. A graphical display of the results of the comparisons of the combined dissolved (filtered samples) radium results to the MCL is shown on Figure 2-20.

There is no MCL or other regulatory standard for thorium in groundwater. Thorium is primarily an alpha emitter and therefore the levels of thorium present in the 2012-2013 groundwater

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[15] In addition to the four events requested by EPA, two additional sampling events were conducted to obtain samples from eight new monitoring wells that were installed by Bridgeton Landfill, LLC in October 2013. These eight wells were sampled in November 2013 and February 2014.

samples were compared to the 15 pCi/L MCL established for gross alpha in drinking water systems. A graphical display of the results of the comparisons of the combined total thorium results to the gross alpha MCL is shown on Figure 2-21. All but three of the monitoring wells have never contained combined thorium levels above 15 pCi/L. Only three wells (S-53, D-85, and PZ-211-SD) contained combined total thorium above 15 pCi/L during one of the four monitoring events (represented by the yellow dots on Figure 2-21). None of the dissolved phase samples collected from any of the monitoring wells during any of the monitoring events contained combined dissolved thorium concentrations greater than 15 pCi/L (Figure 2-22).

A graphical display of the results of the comparisons of the combined total uranium results (based on conversions of the activities to mass) to the uranium MCL of 30 ug/L is shown on Figure 2-23. With the exception of two wells, none of the Site monitoring wells have ever contained combined uranium levels above 30 ug/L. Only two wells (S-53 and PZ-211-SD) contained combined total uranium above the MCL during one of the four monitoring events (indicated by the yellow dots on Figure 2-23). None of the dissolved phase samples collected from any of the monitoring wells during any of the monitoring events contained uranium concentrations greater than the MCL (Figure 2-24).

Evaluations of the potential for the radionuclides to leach will be performed as part of the groundwater (OU-3) RI/FS.

2.5.4 Occurrences of Chemical Constituents in Groundwater

The most extensive program of groundwater sampling and chemical analyses conducted were those associated with the four comprehensive groundwater sampling events conducted in August 2012 and April, July and October 2013. During these events, up to 85 monitoring wells located throughout the entire Site were sampled and submitted for chemical analyses, including VOCs, trace metals, inorganic parameters and during the first event, SVOCs.

2.5.4.1 Volatile Organic Compounds in Groundwater

The groundwater samples collected from all of the Site wells during the 2012 – 2013 comprehensive groundwater monitoring events were analyzed for 49 different VOCs. Most of these VOCs were not detected in any of the groundwater samples. The primary VOCs that were detected in some of the groundwater monitoring wells included benzene and related hydrocarbon compounds (toluene, ethyl benzene, xylenes, methyl tert-butyl ether, and cumene), chlorobenzene and other chlorinated benzenes (1,4-dichlorobenzene), and vinyl chloride and related chlorinated solvents (1,2-dichloroethene). Of these, only benzene, chlorobenzene and vinyl chloride were detected at concentrations above their respective groundwater standards (5 µg/L for benzene, 100 µg/L for chlorobenzene and 2 µg/L for vinyl chloride).

Benzene was the most commonly detected VOC and was reported to be present in 26 to 28 wells during the August 2012 and April and July 2013 monitoring events (when approximately 75 wells were sampled) and in 36 wells during the October 2013 monitoring event (when 84 wells were sampled). Benzene has been detected at concentrations greater than its MCL of 5 µg/L in three distinct areas of the Site, as shown on Figure 2-25. Most of the benzene occurrences in the groundwater are near the South Quarry portion of the Bridgeton Landfill and the southern portion of the Inactive Sanitary Landfill.

Chlorobenzene was detected in 24 to 25 monitoring wells during each of the 2012 – 2013 groundwater monitoring events (Figure 2-26). Chlorobenzene was detected in only two monitoring wells (PZ-112-AS and LR-105) at concentrations greater than its MCL of 100 µg/L (Figure 2-26).

Vinyl chloride was detected in 4 to 10 wells during each event (Figure 2-27). Vinyl chloride was detected in only four monitoring wells at concentrations greater than its MCL of 2 µg/L during some but not all of the 2012 – 2013 groundwater monitoring events (Figure 2-27).

2.5.4.2 Semi-volatile Organic Compounds in Groundwater

The August 2012 groundwater samples were analyzed for SVOCs. Very few SVOCs were detected. The most commonly detected SVOC was 1,4-dichlorobenzene, which was detected in 11 of the 73 monitoring wells that were sampled and analyzed for SVOCs. The highest detected concentration of 1,4-dichlorobenzene was 19 µg/L in LR-105, which is less than the corresponding Missouri water quality standard of 75 µg/L.

2.5.4.3 Trace Metals

Trace metals were detected in most of the groundwater samples; however, many of the trace metals were not detected at concentrations greater than their respective MCLs or were only detected in the total fraction samples at concentrations above the MCLs, possibly indicating that their presence is due to inclusion of suspended sediment in the unfiltered samples. The primary trace metals of interest that were detected in the groundwater monitoring wells include arsenic, iron, manganese, and barium.

2.5.4.3.1 Arsenic

Figure 2-28 presents a graphical summary of the locations where total (unfiltered) arsenic was detected above its MCL of 10 µg/L. The highest levels of total arsenic were reported for samples obtained from wells PZ-114-AS and S-82 near Area 1 and in wells PZ-302-AS and PZ-304-AS located on the west side of the Inactive Sanitary Landfill.

Figure 2-29 presents a graphical summary of the locations where dissolved arsenic was detected above its MCL of 10 µg/L. The highest levels of dissolved arsenic were reported for samples obtained from the same wells as those that contained high concentrations of total arsenic (*e.g.*, PZ-114-AS, PZ-302-AS, PZ-304-AS, and S-82).

2.5.4.3.2 Iron

Occurrences of total and dissolved iron at levels above its Secondary MCL (taste and aesthetic factors) of 300 µg/L were found throughout the Site area (Figures 2-30 and 2-31). The highest levels of iron were generally detected near the Inactive Sanitary Landfill and Area 1. The presence of iron in the groundwater at the Site is indicative of the presence of reducing conditions associated with MSW decomposition in landfill settings.

2.5.4.3.3 Manganese

Occurrences of total and dissolved manganese at levels above its Secondary MCL (taste and aesthetic factors) of 50 µg/L were found throughout the Site area (Figures 2-32 and 2-33). The highest levels of manganese were generally detected near the Inactive Sanitary Landfill, between the Closed Demolition Landfill and Area 2, near Area 1, beneath the hauling company yard to the east of the North Quarry portion of the Bridgeton Landfill, and near the southern corner of the South Quarry portion of the Bridgeton Landfill.

The occurrences of manganese in groundwater at the Site are, similar to iron, consistent with the presence of reducing conditions associated with decomposition of MSW.

2.5.4.3.4 Barium

Occurrences of total and dissolved barium at concentrations above its MCL (2,000 µg/L) are summarized on Figures 2-34 and 2-35.

As shown, three wells (D-3, D-85, and PZ-113-AD) exhibited total barium concentrations greater than its MCL of 2,000 µg/L during the 2012-2014 events. All three of these wells are near Area 1. Three other wells (PZ-112-AS, I-73, and PZ-304-AS) exhibited total barium concentrations above its MCL during some, but not all, of the 2012-2013 monitoring events. No other wells exhibited total barium concentrations above its MCL.

Six wells exhibited dissolved barium concentrations above its MCL during some, but not all four, of the 2012-2013 monitoring events, including: D-3, PZ-113-AD and PZ-112-AS near Area 1; I-73 and MW-1204 near the Bridgeton Landfill South Quarry; and PZ-304-AS along the west side of the Inactive Sanitary Landfill.

None of the groundwater samples obtained from wells located around Area 2 ever exhibited barium concentrations greater than its MCL.

2.5.4.4 Inorganic Constituents

Results obtained for two inorganic constituents, sulfate and chloride, are summarized in this section. Additional information regarding occurrences of inorganic constituents is presented in the RI Addendum (EMSI, 2017a).

2.5.4.4.1 Sulfate

Only four wells exhibited sulfate concentrations above its MCL (250 µg/L): wells D-12 and S-10 in Area 2; well MW-102 on the west side of Area 2; and well PZ-204A-SS on the southwest side of the Bridgeton Landfill South Quarry (Figure 2-36). Of these, sulfate was reported at concentrations above its MCL during all four 2012-2013 events at wells S-10 and D-12 and during the last two 2013 events at wells MW-102 and PZ-204A-SS.

2.5.4.4.2 Chloride

Chloride is a common constituent of landfill leachate. The highest chloride concentrations were observed in wells I-73 (1,700 mg/L in July 2013), MW-1204 (1,400 mg/L in October 2013), and LR-105 (930 mg/L in April 2013). Occurrences of chloride at concentrations greater than its Secondary Standard of 250 mg/L were observed during all four events in fifteen of the 85 wells sampled during 2012-2013 (Figure 2-37). Chloride was detected at concentrations greater than its MCL during one or more, but not all four, events in 14 additional wells (Figure 2-37). Occurrences of chloride concentrations above the MCL were generally found in wells around the Bridgeton Landfill South Quarry, on the west side of the Inactive Sanitary Landfill, near Area 1, and along the east and south sides of Area 2 (Figure 2-37).

2.5.5 Possible Radionuclide and Chemical Contributions to Groundwater from Areas 1 and 2

The USGS stated that, based on the frequency of chloride, bromide, and iodide concentrations above background in groundwater samples from the WLL Site, 47 of the 83 monitoring wells (37 alluvial wells and 10 bedrock wells) at the WLL Site are affected by landfill leachate. Wells affected by landfill leachate also have increased concentrations of dissolved calcium, magnesium, sodium, potassium, barium, iron, manganese, strontium, total alkalinity, and dissolved combined radium. Wells with the greatest leachate effects tend to have smaller concentrations of sulfate and uranium and produce anoxic groundwater. Concentrations of dissolved combined radium were significantly larger (p value less than 0.0001) in samples from alluvial or bedrock monitoring wells affected by landfill leachate compared to samples from monitoring wells that do not have landfill leachate effects.

The USGS (2014) concluded that there are four general hypotheses for the origin of dissolved combined radium above the MCL in groundwater at the Site including:

1. leaching of radium from RIM;
2. natural (background) radium in groundwater;
3. leaching of radium from non-RIM wastes disposed at the Site; and
4. mobilization of naturally occurring radium from aquifer solids by some component of landfill leachate.

The USGS further states that, except for natural radium, no single hypothesis can be invoked to explain all occurrences of radium above the MCL at the Site. Moreover, the available data are not adequate to provide definitive conclusions regarding the validity of any hypotheses (USGS, 2014).

In conclusion, the USGS 2014 groundwater study could not rule out RIM as the origin for radium identified in seven of the thirteen groundwater wells that had average combined radium levels in excess of the MCL. Additionally, of the 83 on-site groundwater wells included in the USGS 2014 study, 47 wells were identified to have landfill leachate effects.

The USGS report indicates that the origin and transport of radium at the Site is complicated by its natural presence in groundwater and aquifer materials, and the tendency of radium to be associated with mineral surfaces such as iron-oxides that are sensitive to changes in redox conditions (USGS, 2014). Changes in redox conditions in groundwater can occur with migration of landfill leachate. There is no singular mechanism, geochemical condition, or phase association that can reliably account for all occurrences of radium above the MCL in groundwater. Rather, the USGS 2014 report states that there likely is a combination of mechanisms occurring across the Site.

The results of the 2012–2013 groundwater monitoring activities suggest that Areas 1 and 2 are not contributing either uranium or thorium to the groundwater. This is not unexpected given the very low solubility of thorium and the low solubility of uranium, especially under the reducing conditions which often occur in and around MSW landfills.

Benzene occurrences are present in the southwestern portion of Area 1 (*i.e.*, wells D-14, I-4, and PZ-112-AS), chlorobenzene is present in PZ-112-AS, and vinyl chloride occurrences are present in the southwestern portion of Area 2 (*i.e.*, wells I-9 and D-93). The majority of wells in or around Areas 1 and 2 were either non-detect for VOCs or exhibited concentrations of VOCs that were less than their respective MCLs.

Detections of arsenic, iron, manganese, barium, and sulfate were observed in groundwater throughout the Site and reflect dissolution of these substances from the landfilled wastes and/or possibly enhanced dissolution of these substances from naturally-occurring minerals within the alluvial and bedrock units due to the presence of reducing conditions associated with waste decomposition within the landfills. The monitoring data do not indicate that Areas 1 and 2 are contributing substantially greater amounts of trace metals or inorganic constituents than occur in other landfill areas at the Site, or at other offsite landfills.

2.6 Baseline Risk Assessment

The BRA (Auxier, 2017) consisted of a human health and screening-level ecological risk assessment. The overall objectives of the BRA were to (i) evaluate whether radiological and chemical constituents detected in environmental media at OU-1 pose incremental cancer risks or non-cancer hazards that exceed EPA's regulatory threshold levels under current and future conditions if no remedial action was taken, and (ii) support decisions concerning risk management (i.e., in the FFS).

2.6.1 Human Health Risk Assessment Summary

Key components, results, and conclusions of the human health risk assessment are summarized in the following subsections.

2.6.1.1 Selection of COPCs

The human health risk assessment began with a screening step that focused the evaluation of constituents detected in OU-1 soil with the greatest likelihood to pose unacceptable risks (constituents of potential concern, or COPCs). Radionuclides associated with the uranium, actinium, and thorium decay series, as well as 13 inorganic constituents, were identified as COPCs.

2.6.1.2 Potential Receptors and Exposure Routes

Using information about current and reasonably anticipated 1,000-year future conditions at the Landfill and surrounding areas, receptors with potentially complete exposure pathways for soil, air, and/or external radiation were considered for quantitative evaluation. The most plausible and sensitive receptor from each receptor group was selected for quantitative evaluation. The potential receptors and exposure routes identified for the Site and the rationale for selecting a subset of receptors for quantitative evaluation are summarized in Table 2-20 and also shown on Figure 2-38. It is important to note that "future" as used in this BRA represents a point in time 1,000 years in the future, accounting for radionuclide decay and in-growth and presuming no cover or remedial measures. Hence, "current" encompasses theoretical risks within the lifetime of most individuals based on conditions at the time this report was prepared.

2.6.1.3 Summary of Potential Risks

Calculated risks to current and future receptors were evaluated in the context of the EPA's acceptable cancer risk range of 10^{-6} to 10^{-4} and the EPA's acceptable non-cancer hazard threshold (HI) of 1. The results of the risk assessment are summarized below.

2.6.1.3.1 Current Receptors

Current on-property receptors are represented by the on-property grounds keeper and commercial building user. There are no complete pathways for exposure to chemical COPCs under current conditions and, hence, no unacceptable chemical risks or hazards to on-property receptors. Additionally, radionuclide COPCs do not pose an unacceptable cancer risk to current on-property receptors. Cumulative radionuclide cancer risks are within or below (more health protective than) the EPA's acceptable risk range (Table 2-21).

Current off-property receptors are represented by the off-property resident and commercial building user. There are no complete pathways for exposure to chemical COPCs under current conditions and, hence, no unacceptable chemical risks or hazards to off-property receptors. Additionally, radionuclide COPCs do not pose an unacceptable cancer risk to current off-property receptors (Table 2-21). Cumulative radionuclide risks are below the EPA's acceptable risk range (Table 2-21).

2.6.1.3.2 Future (1,000 year) Receptors

Landfill receptors 1,000 years in the future are evaluated based upon the maximally exposed Landfill grounds keeper and storage yard worker. Evaluation of the future risk for the Baseline Risk Assessment assumes that no cover is present on the Landfill and no remediation has occurred.

Chemical COPCs do not pose an unacceptable cancer risk to future Landfill receptors. Cumulative chemical risks are within or below the EPA's acceptable risk range. Chemical COPC HIs exceed EPA's acceptable threshold of 1 for some future Landfill receptors in OU-1, indicating a potential for non-cancer health effects (Table 2-21). Zirconium (Areas 1 and 2) and, to a lesser extent, cobalt (Area 2) are the primary contributors to HIs greater than 1. As discussed in the uncertainty assessment in the updated BRA, zirconium HQs are likely overestimated due to substantial uncertainties in the reference dose and due to contributions from naturally-occurring background soil. Exposure to lead in soil does not pose an unacceptable risk to future Landfill receptors.

Radionuclide COPCs do not pose an unacceptable cancer risk to future receptors (defined as 1,000 years in the future) that work at the Landfill and periodically access OU-1 (i.e., grounds keepers). Cumulative radionuclide risks are within the EPA's acceptable risk range for these potential future receptors (Table 2-21). Radionuclide COPC cancer risks exceed the EPA's acceptable risk range for Landfill receptors that are assumed to spend a portion of each work day on OU-1 (i.e., Landfill storage yard workers). Where risks exceed 10^{-4}, direct contact with radium-226 in soil and inhalation of radon-222 in air are the primary risk drivers.

Future off-property receptors are represented by the off-property farmer and commercial building user. Potential future risks to off-property receptors 1,000 years in the future, and assuming no cover is present on the Landfill, were calculated to account for 1,000 years of in-growth. Chemical COPCs do not pose an unacceptable cancer risk to future off-property receptors. Cumulative chemical risks are within or below the EPA's acceptable risk range. Chemical COPCs do not pose an unacceptable non-cancer hazard to future off-property receptors. Calculated HIs are less than EPA's threshold HI of 1 (Table 2-21).

Radionuclide COPC cancer risks exceed EPA's acceptable risk range for future off-property farmers to the north and west, and future commercial building users to the north and at Lot 2A2 (Table 2-21). Radionuclide cancer risks to off-property farmers to the south and southeast and off-property commercial building users to the west are within the EPA's acceptable risk range. Where cumulative radionuclide risks exceed 10^{-4}, risk is driven by inhalation of radon-222 and its daughter product. As discussed in the uncertainty section of the BRA, modeled radon activity from OU-1 is comparable to naturally-occurring activity. Excluding radon and its daughter products, radiological risks to off-property receptors are with the EPA's acceptable risk range of 10^{-6} to 10^{-4}.

2.6.2 Ecological Risk Assessment Summary

The screening-level ecological risk assessment included in the BRA indicated that OU-1 COPCs, primarily radium-226 and other metals, potentially pose a risk to plants, invertebrates, and wildlife receptors within OU-1 under current conditions. Past construction associated with installation of the non-combustible cover over RIM in Areas 1 and 2 removed much of the transitional ecosystems located within those two areas. Small portions of OU-1 remain vegetated and may provide a food source or habitat for small ecological receptors, but the extent and diversity of the residual habitats around the capped areas is much reduced. These residual habitats are generally of marginal quality and are relegated to fringe areas around the property and a few small, scattered copses of vegetation. Under future conditions, vegetative growth must be controlled to maintain the integrity of the landfill cap, as required by Missouri landfill regulations. Both active (mowing) and passive (biointrusion layer) means will be used to control vegetative growth within OU-1. This suppression of vegetation likely reduces the overall ability of the area to support some types of wildlife and results in remaining larger species leaving the area.

2.6.3 BRA Summary and Conclusions

The BRA indicated there are no unacceptable risks to on-property or off-property human receptors under current conditions. For scenarios 1,000 years in the future, COPC risks to full-time Landfill workers and some off-property receptors exceed regulatory thresholds. These future risks hypothetically assume that the Landfill will not have a cover and no remediation will occur, which is consistent with the EPA baseline risk assessment process (EPA, 1989, p. 1-4). State and federal regulations, however, do require that an engineered landfill cover be installed and maintained, and accordingly, some form of cover will ultimately be installed over the Site. Future on-property cancer risk is primarily attributable to radium-226 in OU-1 soil (and assumed direct contact) and radon and its daughter products in air. Future off-property risks are primarily attributable to radon and its daughter products in air. Notably, the modeled radon activity in air from OU-1 is comparable to background radon activity.

Site-related COPCs were also identified as potentially posing a risk to ecological receptors under current and near-term future conditions. Site management goals to protect human health (e.g., capping) will also address site-related ecological risk by reducing COPC exposure. As such, further consideration of ecological receptors is not warranted.

Overall, the findings of this BRA are sufficient to support decisions concerning risk management at OU-1 (i.e., in the FFS).

3 POTENTIAL ARARS AND REMEDIAL ACTION OBJECTIVES

This section of the FFS describes potentially applicable or relevant and appropriate requirements (ARARs) for the proposed remedial action alternatives for OU-1. This section also describes additional requirements associated with offsite disposal and on-site landfilling by creating a new landfill cell. Remedial action objectives (RAOs) to be addressed by the remedial alternatives are also presented in this section. Cleanup levels that would allow for unrestricted use of the Site relative to radionuclide occurrences are developed in this section based on EPA's directives regarding chemical-specific ARARs and Site-specific risk-related factors. Cleanup levels associated with partial excavation alternatives identified by EPA (EPA, 2015a) are also discussed.

3.1 Potentially Applicable or Relevant and Appropriate Requirements

CERCLA remedial actions must be analyzed for compliance with ARARs. Individual ARARs are identified by first determining whether a requirement is applicable, and if it is not applicable, then whether it may be relevant and appropriate. ARARs are divided into three categories (EPA, 1988):

- Chemical-specific ARARs;
- Location-specific ARARs; and
- Action-specific ARARs.

Compliance with ARARs is one of the criteria used to evaluate potential remedial alternatives in an FS. Descriptions of ARARs, the criteria used to identify whether a regulation contains potential ARARs for OU-1, and identification of potential ARARs for OU-1 are provided in the FS and SFS reports (EMSI, 2006 and EMSI et al., 2011). The following sections provide additional evaluation of ARARs as they relate to the ROD-selected remedy and the full and partial excavation alternatives. In addition, this section addresses additional ARARs specified by EPA in the SOW and supplements thereto.

3.1.1 Potential Chemical-Specific ARARs

Chemical-specific ARARs include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics, or containing specified chemical compounds. Evaluations of potential chemical-specific ARARs for West Lake Landfill OU-1 are presented in the FS and SFS reports (EMSI, 2006 and EMSI et al., 2011). The results of these evaluations, as well as additional evaluations for this FFS, are summarized on Table 3-1 and are discussed below.

3.1.1.1 Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

The health and environmental protection standards promulgated by EPA under the Uranium Mill Tailings Radiation Control Act (UMTRCA) (40 C.F.R. Part 192) contain potential chemical- and action-specific requirements. Because the UMTRCA standards only apply to certain designated uranium mill tailings sites (see discussion in Section 3.1.1.1.2, below), they are not applicable to the Site. Certain of the UMTRCA standards may nonetheless represent potentially relevant and appropriate requirements for remedial actions at the Site, as discussed further below.

The UMTRCA regulations establish specific standards for the control of residual radioactive materials at disposal sites and the cleanup of land and buildings that have become contaminated with residual radioactive materials from a uranium processing site. These standards have been evaluated for relevance with respect to Areas 1 and 2 of OU-1, as well as the Buffer Zone/ Lot 2A2. Specifically, the requirements relative to the standards for radon emissions from closed tailing impoundments (40 C.F.R. Part 192 Subpart A), standards for cleanup of contaminated land and buildings (40 C.F.R. Part 192 Subpart B), and groundwater protection standards (40 C.F.R. Part 192 Subparts A and B) were evaluated for potential chemical-specific ARARs. Additional discussion of these standards as they relate to the ROD-selected remedy, the UMTRCA cover alternative, and the full and partial excavation alternatives is presented below.

3.1.1.1.1 Radon Emissions Standards – 40 C.F.R. § 192.02(b) and 40 C.F.R. § 192.12(b)(1)

The UMTRCA regulations establish standards for release of radon to the atmosphere from residual radioactive material (40 C.F.R. § 192.02(b)). Specifically, these standards state that control of residual radioactive materials and their listed constituents shall be designed to:

> (b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
>
> (1) Exceed an average release rate of 20 picocuries per square meter per second, or
>
> (2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

Section 192.02(b)(1) further states that the average release rate specified therein “shall apply over the entire surface of the disposal site and over at least a one-year period.”

These standards may potentially be relevant and appropriate chemical-specific criteria for radon emissions from Areas 1 and 2. The standards also represent potential performance criteria for the design of the cover system for Areas 1 and 2 that is included in the ROD-selected remedy, UMTRCA cover alternative, the partial excavation alternatives, and the new on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative.

Radon monitoring was performed as part of the RI for OU-1 (see prior discussion in Section 2.3.1). These results indicate that the overall radon emission from Areas 1 and 2 (21.8 pCi/m^2/s based on the average of 50 test locations) slightly exceeded the 20 pCi/m^2/s radon emission flux standard. This exceedance is attributable to the presence of three samples that exhibited high flux. Additional radon flux monitoring was performed by Respondents following the substantial completion of the construction activities for a non-combustible cover over Areas 1 and 2. This additional monitoring demonstrated that the average radon flux from these areas both individually and collectively meets the UMTRCA radon emission standard. In addition, monitoring performed along the margins of Areas 1 and 2 has demonstrated that under current conditions the radon emission rate from these areas meets the UMTRCA standard of less than a 0.5 pCi/L increase in radon levels in air outside of Areas 1 and 2 (see prior discussion in Section 2.3.1). Furthermore, an evaluation of the design and thickness of a landfill cover for the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives—which is necessary to meet the 20 pCi/m^2/s and 0.5 pCi/L standards in the future based on the anticipated level of radium in-growth over time—has been performed as part of the evaluation of potential remedial alternatives as discussed in Section 6 of this FFS.

Remedial actions involving placement of an engineered cover pursuant to the ROD-selected remedy, UMTRCA cover alternative, the partial excavation alternatives, or the new on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative should be designed to meet the radon emission standard promulgated under UMTRCA. Because this standard applies to design, monitoring after disposal is not required to demonstrate compliance with this standard. However, due to the anticipated increase in radium expected to occur over time from the decay of thorium, the design of an engineered cover should be based on projected future radium activity levels and associated radon generation instead of the currently observed radon flux levels.

While habitable buildings are not expected to be constructed on Area 1 or Area 2, the UMTRCA radon standards regarding any occupied or habitable building (40 C.F.R. § 192.12(b)(1)) represent potentially relevant and appropriate requirements for radon monitoring relative to occupied buildings. Specifically, the objective of the remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed a 0.02 Working Level (WL) (40 C.F.R. § 192.12(b)(1)).[16] In any case, the radon decay product concentration (including background)

[16] A Working Level is a unit of measure for documenting exposure to radon decay products, which are termed "daughter products" or simply "daughters." One Working Level is defined as any combination of short-lived

shall not exceed a 0.03 WL (40 C.F.R. § 192.12(b)(1)). The EPA's Radiation Risk Assessment at CERCLA Sites: Q&A (OSWER 9285.6-20) further provides that users may assume that 5 pCi/L of Rn-222 corresponds to a 0.02 WL. Therefore, 5 pCi/L of Rn-222 may be considered the concentration for compliance with the UMTRCA indoor radon standard as an ARAR. That guidance further explains that "[t]hese values are based on an indoor residential equilibrium fraction of 0.4 (40%) for Rn-222 and 0.02 (2%) for Rn-220" (OSWER 9285.6-20, page 18).

3.1.1.1.2 Standards for Cleanup of Contaminated Land – 40 C.F.R. § 192.12(a)

Requirements relative to standards for cleanup of land contaminated with residual radioactive materials from an inactive uranium processing site (40 C.F.R. § 192.12(a)) are evaluated as potentially relevant and appropriate chemical-specific ARARs in the FS (EMSI, 2006). These standards state that:

> Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:
>
> (a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than—
>
> (1) 5 pCi/g, average over the first 15 cm of soil below the surface, and
>
> (2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

The Office of Solid Waste and Emergency Response, or OSWER (currently named the Office of Land and Emergency Management), in its Directive 9200.4-25, titled "Use of Soil Cleanup Criteria in 40 C.F.R. Part 192 as Remediation Goals for CERCLA Sites" (EPA, 1998a) (the CERCLA UMTRCA guidance), discusses the potential applicability, relevance and appropriateness, and use of the soil cleanup standards established pursuant to UMTRCA at CERCLA sites. Pursuant to the CERCLA UMTRCA guidance, EPA has determined that the surface soil standard for cleanup of soil at UMTRCA sites (5 pCi/g plus background for combined Ra-226 plus Ra-228 or combined Th-230 plus Th-232) would only be applicable to cleanup of uranium mill tailings at the 24 uranium mill tailing sites designated under Section 102(a)(1) of UMTRCA (Title I sites). The West Lake Landfill Superfund Site is not a Title I site and therefore these standards are not applicable to any remedial actions at the Site.

The UMTRCA standards apply to "land," which is defined in the regulations as any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building (40 C.F.R. § 192.11(b)). The definition of a disposal site as described in 40 C.F.R. § 192.00(d) is as

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daughters in one liter of air which will ultimately release 1.3 x10^5 MeV (million electron volts) of alpha by decay through polonium-214.

follows: "Disposal site means the region within the smallest perimeter of residual radioactive materials (excluding cover materials) following completion of control." Control is further defined in 40 C.F.R. § 192.00(c) as "any remedial action intended to stabilize, inhibit future misuse of, or reduce emissions or effluents from residual radioactive materials." Neither the presence of MSW in OU-1 nor the use of OU-1 Areas 1 and 2 as solid waste disposal units qualifies these areas as disposal sites. Therefore, 40 C.F.R. § 192.12 standards should be evaluated for potential relevance to Areas 1 and 2, as well as the Buffer Zone/Lot 2A2 property portion of OU-1. Because RIM (defined in this FFS by specific levels of radium, thorium, and uranium) has been determined to be or to have been present in portions of Area 1, Area 2, the Buffer Zone, and Lot 2A2, and because the concentrations of Th-230 are out of equilibrium, which will cause the Ra-226 concentrations to increase in the future, the EPA has determined that the residual radioactive materials considered in 40 C.F.R. § 192.12 are similar to the RIM present in OU-1 of the Site.

The EPA notes that OSWER Directive 9200.4-25 states, "The purpose of these standards was to limit the risk from inhalation of radon decay products in houses built on land contaminated with tailings, and to limit gamma radiation exposure of people using contaminated land (see 48 FR 600)." The EPA agrees that the probability of residential land use on Areas 1 and 2 is unlikely, and therefore, is not an anticipated future land use. However, because RIM is similar to residual radioactive materials considered in 40 C.F.R. § 192.12, the EPA has concluded that the cleanup standards in 40 C.F.R. § 192.12 are relevant and appropriate for all of OU-1, except for the areas covered by an engineered cap compliant with standards in UMTRCA Subpart A. In accordance with OSWER Directive 9200.4-25, areas not covered by such an engineered cap require a site-specific determination of risk demonstrating protectiveness under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The EPA also notes that these standards include concentrations for both surface and sub-surface soils as discussed further in OSWER Directive 9200.4-25. OSWER Directive 9200.4-25 provides guidance on the use of soil cleanup criteria in 40 C.F.R. Part 192 as remediation goals for CERCLA sites and therefore is evaluated below as a potential "to-be-considered" (TBC) criterion.

OSWER Directive 9200.4-25 provides that for CERCLA sites where subsurface contamination exists at a level between 5 pCi/g and 15 pCi/g averaged over areas of 100 square meters, conditions are not considered to be sufficiently comparable to an UMTRCA site to warrant use of the UMTRCA subsurface soil standard of 15 pCi/g over background as a relevant and appropriate requirement. Instead, EPA recommends 5 pCi/g as a suitable subsurface cleanup level so long as a site-specific risk assessment demonstrates that 5 pCi/g is protective. EPA further notes that when the UMTRCA subsurface cleanup standards are found to be relevant and appropriate requirements for a CERCLA site, the 5 pCi/g standard should be applied to both the combined levels of radium-226 and radium-228, and to the combined level of thorium-230 and thorium-232. This is to provide reasonable assurance that the preceding radionuclides in the series would not be left behind at levels that would permit the combined radium activity to build up to levels exceeding 5 pCi/g after completion of the response action.

Finally, and as stated in OSWER Directive 9200.4-25, the standards established pursuant to 40 C.F.R. § 192.12(a) address cleanup of so-called "vicinity" sites at which cleanup to unrestricted use is authorized for specified off-site properties. Because these "vicinity" sites are related solely to the 24 UMTRCA Title I sites, the standards established for vicinity sites are not applicable to any remedial actions at the West Lake Landfill. Overland gamma surveys and surface soil sampling of land adjacent to Area 2 have indicated that soil containing radioactive material was previously present on the surface of the Buffer Zone and a portion of the Crossroads Industrial Park due to erosion from the surface of Area 2. Subsequent site development of the Crossroads Industrial Park resulted in regrading of the surface soil located on Lot 2A2, which is owned by Crossroad Properties, LLC. These regrading activities included placement of a portion of the surface soil from Lot 2A2 onto the Buffer Zone. Any RIM determined, during subsequent investigations or confirmation sampling events, to be present on land outside of Area 1 and Area 2, including the Buffer Zone and Lot 2A2, could potentially represent conditions that are similar to "vicinity" sites as defined by the UMTRCA regulations. Therefore, the standards established pursuant to 40 C.F.R. 192.12(a) represent potentially relevant and appropriate requirements for remedial actions taken to address radionuclides in soil at these locations, except for the areas covered by an engineered cap compliant with standards in UMTRCA Subpart A. In accordance with OSWER Directive 9200.4-25, areas not covered by such an engineered cap require a site-specific determination of risk demonstrating protectiveness under CERCLA.

Previously, the Buffer Zone was not owned by or part of the landfill property, but it was subsequently purchased by Rock Road Industries, Inc. This area is fenced and access is restricted to remedial action workers trained in health and safety procedures at hazardous waste and radioactive sites. This parcel is zoned M3 – Planned Manufacturing District, consistent with the zoning for the rest of the Crossroads Industrial Park. For these reasons, current and anticipated land use for this parcel does not include residential. A portion of the Buffer Zone was recently used for construction of a rock buttress as part of the placement of a non-combustible cover over RIM occurrences at the ground surface in Area 2. Implementation of some of the remedial alternatives evaluated in this feasibility study could require utilizing a portion of the Buffer Zone for extension of the toe of the Area 2 landfill to achieve the maximum slope angles. In those instances, other standards may be relevant and appropriate for these portions of the Buffer Zone, including those in 40 C.F.R. 192.02. As stated above, the UMTRCA cleanup standards in 40 C.F.R. 192.12 are potentially relevant and appropriate for all of OU-1 except for the areas which may be covered by an engineered cap compliant with standards in UMTRCA subpart A. In accordance with OSWER Directive 9200.4-25, such areas not covered by such an engineered cap require a site-specific determination of risk demonstrating these cleanup levels are protective under CERCLA.

EPA has established an approach for development of Supplemental Standards for implementation of the UMTRCA soil standards 40 C.F.R. 192.21(c). The Supplemental Standards may be used when the estimated cost of remedial action to satisfy Section 192.12(a) at a "vicinity" site is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under 40 C.F.R. 192.12(a). The Supplemental Standards at 40 C.F.R. 192.22 (a) require that remedial action alternatives must come as close to meeting the otherwise applicable standard under 40 C.F.R. 192.02(c)(3) as is reasonably achievable. Should the site-specific factors which were the basis for the development of a supplemental standard change at any point in the future, remediation may be required to the otherwise applicable standard.

3.1.1.1.3 Groundwater Protection Standards – 40 C.F.R. Part 192 Subpart A

Based on the presence of radioactive and other hazardous substances at OU-1, and the potential for leaching to groundwater, the groundwater protection standards (40 C.F.R. 192.02(c)(3) and (4)) of the UMTRCA regulations are potentially relevant and appropriate to any remedy that will result in RIM remaining on site. These standards establish limits for radionuclides and other substances in groundwater, including a standard of 5 pCi/L for combined radium-226 plus radium-228 and a standard of 30 pCi/L for uranium. Other groundwater standards are listed in Section 3.1.3.1 below.

OSWER Directive 9283.1-14, which addresses the use of uranium drinking water standards under 40 C.F.R. 131 and 40 C.F.R. 192 as Remediation Goals for Groundwater at CERCLA sites, is discussed in Section 3.1.1.5.1, below.

3.1.1.2 10 C.F.R. Part 40, Appendix A, I, Criterion 6(6)

On October 16, 1985, the Nuclear Regulatory Commission (NRC) promulgated standards under 10 C.F.R. Part 40 (NRC's UMTRCA rule) to address uranium mill tailings at sites licensed in conjunction with uranium and thorium milling, or where milling operations generated byproduct material (50 FR 41852). Part of these 1985 regulations established soil cleanup standards for radium-226 and radium-228. The radium soil standards under the NRC's UMTRCA rule were intended as conforming standards to EPA's UMTRCA soil standards under 40 C.F.R. Part 192, and were essentially identical to the EPA’s similar standards. On April 12, 1999, NRC amended its UMTRCA rule by adding Criterion 6(6) to Appendix A (69 FR 17506 to 17510) Radiological Criteria for License Termination of Uranium Recovery Facilities (Criterion 6(6) rule). The amendment uses the existing soil radium standard to derive a dose criterion (benchmark approach) for cleaning up milling wastes, including radium in soil, and for cleanup of surface activity on structures to be released for unrestricted use. In areas where there is more than one residual radionuclide, the benchmark dose applies to the sum of all radionuclides present in that area (i.e., radium, uranium, thorium, etc.).

The Criterion 6(6) rule addresses the lack of remediation standards for residual radionuclides, other than radium in soil, for decommissioning of lands and structures (excluding radon) at uranium recovery facilities. Criterion 6(6) uses the existing soil radium standard (5 pCi/g surface and 15 pCi/g subsurface) to derive a dose criterion (benchmark approach) for cleaning up byproduct material, and for cleanup of surface activity on structures to be released for unrestricted use.

The radium dose benchmark approach of the Criterion 6(6) rule requires licensees subject to the rule to calculate the potential peak effective dose equivalent (excluding radon) to an individual at the site within 1,000 years from exposure to the residual levels allowed under the radium soil standard. Licensees are then to remediate the site such that the residual site-related radionuclides (including radium) remaining on the site, both in soil and the surface radioactivity in structures, would not result in a dose greater than the radium soil standard. The radionuclides of concern addressed by the Criterion 6(6) rule are thorium, natural uranium, and radium.

Because the Site is not a uranium recovery facility or NRC licensed site, Criterion 6(6) is not applicable. OSWER Directive 9200.4-35P explains that "The Criterion 6(6) rule is a supplement to the radium standards of 40 C.F.R. Part 192, to address other site-related radionuclides. Therefore, when the 5 pCi/g and 15 pCi/g standards under EPA's UMTRCA rule are not [relevant and appropriate] RARs for either radium-226 and/or radium-228, the Criterion 6(6) rule is generally not appropriate … Even if EPA's UMTRCA soil standards were used as TBCs, we recommend that the Criterion 6(6) rule's benchmark dose should not be used as a TBC." To the extent that the cleanup standards in 40 C.F.R. 192.12(a) are potentially relevant and appropriate for OU-1, as discussed in Section 3.1.1.1.2, the Criterion 6(6) rule, including Table 3, may be potentially relevant and appropriate as well, to derive surface soil cleanup goals for non-radium radionuclides (based on doses derived from the 40 C.F.R. 192 radium criteria). When evaluating the non-carcinogenic risks posed by uranium, the December 21, 2016, EPA memorandum titled, "Considering a Noncancer Oral Reference Dose for Uranium for Superfund Human Health Risk Assessments" provides updated guidance on toxicity values. In particular, Page 4 of the memo states, "OSRTI, therefore, recommends the use of the ATSDR intermediate MRL for soluble uranium without further adjustment, in lieu of the RfD currently published in IRIS, for assessment of chronic exposures also."

3.1.1.3 Drinking Water Standards

EPA has established maximum contaminant levels (MCL) for public drinking water systems in 40 C.F.R. 141. Because the Site does not operate a public drinking water system and neither groundwater nor surface water on the Site are used for drinking water, these regulations are not applicable to the remedial actions under consideration for OU-1. Because groundwater beneath the Site is part of a larger alluvial aquifer which could potentially be used for drinking water by private and/or public wells outside of the Site, these regulations, while not directly applicable, are potentially relevant to the remedial actions evaluated under this FFS. The MCLs provide numerical standards against which the groundwater monitoring results obtained as part of the remedial action can be evaluated to assess the overall protectiveness of the remedy and the effectiveness of the various remedy components. Therefore, MCLs are potentially appropriate criteria for evaluation of OU-1 remedial actions.

Relative to radionuclides, EPA has established MCLs of 15 pCi/L for gross alpha, (40 C.F.R. 141 (c)), a total dose equivalent of 4 mrem/yr for gross beta (40 C.F.R. 141 (d)), 5 pCi/L for combined radium-226 plus radium-228 (40 C.F.R. 141.66 (b)) and 30 ug/L for uranium as a metal (40 C.F.R. 141.66 (e)). No MCL or other criteria has been established for thorium.

OSWER Directive 9283.1-14 “Use of Uranium Drinking Water Standards under 40 C.F.R. 141 and 40 C.F.R. 192 as Remediation Goals for Groundwater as CERCLA sites” addresses the use of uranium drinking water standards for groundwater remediation at CERCLA sites. This directive specifies that both the uranium MCL (40 C.F.R. 141) of 30 ug/L and the UMTRCA standards (40 C.F.R. 192) of 30 pCi/L are potentially relevant and appropriate (see additional discussion in Section 3.1.1.5.1 below). Uranium has only been detected above its public drinking water system MCL in two out of the nearly 650 groundwater samples collected during these four events.

There is no MCL for thorium. Because thorium is an alpha emitter, the results were compared to the Gross Alpha MCL of 15 pCi/L. Thorium has never been detected at levels greater than the Gross Alpha public drinking water system MCL.

Public drinking water MCLs also exist for metals, VOCs, and other constituents. Benzene, chloroethane and vinyl chloride have been detected at levels above their respective public drinking water system MCLs. Arsenic, iron, manganese, barium, sulfate, and chloride have also been detected above their public drinking water system MCLs or secondary MCLs.

Additional discussion of the nature and extent of radionuclide and chemical occurrences in groundwater can be found in the RIA (EMSI, 2017a). EPA has indicated that groundwater will be addressed as a separate operable unit (OU-3) which will be subject to a separate RI/FS.

3.1.1.4 Other Potential Chemical-Specific ARARs

Other potential chemical-specific ARARs are identified and evaluated in the FFS and are summarized on Table 3-1. Some of these ARARs were determined to be potentially applicable or relevant and appropriate to OU-1, and in particular, to the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives. These include the following:

- The National Emissions Standards for Hazardous Air Pollutants (NESHAPs) standards for radon-222 emissions (40 C.F.R. Part 61 Subpart T);
- The Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation (10 C.F.R. Part 20);
- 40 C.F.R. 61 Subpart I - National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H; and
- Missouri Water Quality Standards (10 C.S.R. 20-7.031) and Maximum Contaminant Levels (10 C.S.R. Division 60 Chapter 4).

3.1.1.4.1 National Emissions Standards for Hazardous Air Pollutants

Subpart T of the NESHAPs include standards for radon-222 emissions to ambient air from designated uranium mill tailings piles that are no longer operational. Specifically, these standards provide that radon-222 emissions from inactive uranium mill tailings piles should not exceed 20 pCi/m^2/s (40 C.F.R. Part 61.222). Per the compliance procedures specified in 40 C.F.R. 61.223, flux testing must be done after the uranium mill tailings pile is covered, but prior to long-term stabilization, or in any case to demonstrate conditions have been met for disposal. In addition, 40 C.F.R. 61.223(a) specifies that flux measurements should be conducted in accordance with 40 C.F.R. 61, Appendix B, method 115, or other procedures with prior EPA approval.

Because West Lake Landfill OU-1 is not a designated uranium mill tailings site, this NESHAP requirement is not applicable. Insofar as a portion of the waste materials in West Lake Landfill OU-1 do emit radon, however, the NESHAP standards are potentially relevant and appropriate to any remedial alternatives that result in radioactive materials remaining at the Site.

The full excavation with off-site disposal alternative includes removal of all RIM above the cleanup standards from Areas 1 and 2 and from the Buffer Zone/Lot 2A2, if necessary, such that additional engineering and institutional controls would not be required due to the radiological content of Areas 1 and 2. As the RIM would be disposed of offsite, there would be no RIM left at the Site above the cleanup standards. Therefore, the radon NESHAP is not considered to be a relevant and appropriate requirement for this alternative.

3.1.1.4.2 Nuclear Regulatory Commission Standards for Protection Against Radiation

The Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation (10 C.F.R. Part 20) apply only to persons licensed by the NRC to use or handle nuclear materials under certain, defined circumstances (*see* 10 C.F.R. § 20.1002). Since no licenses have been issued by NRC for the West Lake Landfill, Part 20 is not applicable. However, Part 20 contains standards for protection against radiation, certain subparts of which may, under certain circumstances, represent potentially relevant and appropriate requirements for OU-1.

Subpart D to Part 20 contains radiation dose limits for members of the public, who are located beyond the licensee's restricted area. Because there is no license for the West Lake Landfill, there is no restricted area. Therefore, the limits in Subpart D are not generally relevant or appropriate. However, if one were to consider the Site boundary for OU-1 as a surrogate for the restricted area, then the limits in Subpart D might be viewed as relevant and appropriate during a remedial action for purposes of identifying non-occupational radiation dose limits.

Subpart C to Part 20 contains occupational radiation dose limits. Occupational doses are defined as the dose received by an individual during employment in which the individual's assigned duties involve exposure to radiation. Occupational doses do not include doses received as a member of the public (i.e., people in locations beyond the restricted area, or people within the restricted area whose jobs do not involve exposure to radiation). Because there is no license for the West Lake Landfill, there is no restricted area. Therefore, the limits in Subpart C are not generally relevant or appropriate. However, if one were to view the Site boundary for OU-1 as a surrogate for the restricted area, then the limits in Subpart C might be viewed as relevant and appropriate during a remedial action for purposes of identifying occupational radiation dose limits. In such a case, various protective measures required by Part 20 and NRC guidance may also be potentially relevant and appropriate, such as establishment of radiation monitoring and protection programs to control occupational doses within limits. *See, e.g.,* 10 C.F.R. 20 Subpart F (survey and monitoring requirements for individual exposures), Subpart H (respiratory protection and controls), and Subpart J (caution signs and other warning labels). These measures are typically addressed as part of development of a Health and Safety Plan and associated Radiation Safety Plan as part of RD/RA. As a precaution, these protective measures previously have been implemented at the Site, and will continue to be performed as part of the ROD remedy phase.

Finally, depending on the nature of the remedy, the waste disposal requirements set forth in 10 C.F.R. Subpart K may be relevant and appropriate (if, for example, certain treatment methods are used to address the radionuclides within OU-1, or if radionuclide-impacted soils are shipped off site for treatment or disposal).

Pursuant to OSWER Directive 9200.4-18, the dose limits established in NRC's Radiological Criteria for License Termination (62 FR 39058 July 21, 1997), codified in 10 CFR Part 20, among other places) will generally not provide a protective basis for establishing PRGs under CERCLA, and accordingly should not be used to establish cleanup levels. See OSWER Directive 9200.4-18 at 3 and attachment B. See generally Section 3.1.1.5.1, below, for a discussion of OSWER Directives 9200.4-18 and 9285.6-20.

3.1.1.4.3 National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H

The NRC has promulgated certain standards for emissions of radionuclides into the ambient air pursuant to 40 C.F.R. 61 Subpart I. This regulation applies to any facilities owned or operated by any Federal agency other than the Department of Energy and not licensed by the Nuclear Regulatory Commission, except that this subpart does not apply to disposal at facilities regulated under 40 C.F.R. Part 191, subpart B, or to any uranium mill tailings pile after it has been disposed of under 40 C.F.R. Part 192, or to low energy accelerators. As the Site is not owned or operated by any federal agency, nor subject to any of the other conditions, these standards are not applicable. However, insofar as these regulations address standards for emissions of radionuclides into the ambient air, they are potentially relevant and appropriate in identifying emissions levels that are protective of the public outside Areas 1 and 2 during any remedial actions that may be taken. Pursuant to this standard, emissions of radionuclides, including iodine, to the ambient air from a facility regulated under this subpart shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr (40 C.F.R. 61.102(a)).

3.1.1.4.4 National Emissions Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities

40 C.F.R. Part 61 Subpart H establishes standards for emissions of radionuclides to ambient air from Department of Energy facilities. Specifically, such emissions shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent to 10 mrem/yr (40 C.F.R. 61.92). These standards apply to any DOE facility that emits any radionuclide other than radon-222 and radon-220 into the air except a disposal facility subject to 40 C.F.R. Part 191, Subpart B or 40 C.F.R. Part 192. Therefore, these standards are not applicable to OU-1. Facility is defined as “all buildings, structures and operations on one contiguous site” 40 C.F.R. 61.91(b). Although not applicable to OU-1, these standards may be potentially relevant and appropriate to any buildings, structures or operations on OU-1 if 40 C.F.R. Part 192 does not otherwise apply.

3.1.1.4.5 Missouri Clean Water Law, Water Quality Standards (10 C.S.R. 20-7.031) and Maximum Contaminant Levels (10 C.S.R. Division 60 Chapter 4)

EPA has established MCLs and Maximum Contaminant Level Goals (MCLGs) pursuant to the Safe Drinking Water Act (40 C.F.R. Part 141, Subparts F and G). Implementation of the requirements of the Safe Drinking Water Act in Missouri has been delegated to the State of Missouri and is the subject of regulations promulgated by the MDNR.

MDNR identified part of Missouri’s Clean Water Law (644.051.1 RSMo) as a potential state, action-specific ARAR. The law states that it is unlawful for any person:

(1) to cause pollution of any waters of the state or to cause or permit to be placed any water contaminant in an allocation where it is reasonably certain to cause pollution of any waters of the state;
(2) to discharge any water contaminants into any waters of the state which reduce the water quality below water quality standards;
(3) to violate any pretreatment and toxic material control regulations, or to discharge any water contaminants into any waters of the state which exceed effluent regulations or permit provisions as established by the commission or required by any federal water pollution control act; and
(4) to discharge any radiological, chemical or biological or high-level radioactive wastes into waters of the state.

Missouri regulations (10 C.S.R. Division 60 Chapter 4 and 10 C.S.R. 20-7.031) establish MCLs for public drinking water systems. The State of Missouri also published a Total Maximum Discharge Limit (TMDL) regulation in which the waste load allocation of PCBs and chlordane in the Missouri River is zero. These regulations are not applicable to the remedial actions under consideration for OU-1 because the Site does not operate a public drinking water system, neither groundwater nor surface water on the Site are used for drinking water, and neither PCBs nor chlordane are COCs. Additionally, selection and implementation of groundwater standards is not part of the OU-1 decision process but would be performed as part of the OU-3 RI/FS and resultant decision document.

However, given that an on-site cell option is being evaluated in this FFS, and that groundwater beneath the Site is part of a larger alluvial aquifer which could potentially be used for drinking water by private and/or public wells outside of the Site, these regulations, while not directly applicable, are potentially relevant to the remedial actions evaluated under this FFS. The MCLs and TMDL provide numerical standards against which the groundwater monitoring results obtained as part of the remedial action can be evaluated to assess the overall protectiveness of the remedy and the effectiveness of the various remedy components.

Additional MDNR regulations (10 C.S.R. 20-7.031) state that "[w]ater contaminants shall not cause [certain criteria] to be exceeded. Concentrations of these substances in bottom sediments or waters shall not harm benthic organisms and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded. More stringent criteria may be imposed if there is evidence of additive or synergistic effects."

These regulations should also be evaluated for applicability to stormwater discharges. The use of drinking water standards may apply if the receiving stream is designated for a Drinking Water Supply (DWS) (https://s1.sos.mo.gov/cmsimages/adrules/csr/current/10csr/10c20-7a.pdf). DWS is defined as "[m]aintenance of a raw water supply which will yield potable water after treatment by public water treatment facilities." Generally, the use of a DWS criterion to derive an effluent limit would occur only in the absence of a more stringent criterion applicable to the waterbody. Also, MDNR has applied a DWS criterion when the outfall is in close proximity to a waterbody designated for a DWS. However, DWS criteria are developed to protect against a "chronic" condition whereas stormwater is considered an "acute" exposure event. Since chronic criteria should not be applied to acute exposure events such as a stormwater discharge, these criteria are not considered ARARs for stormwater.

3.1.1.5 Chemical-Specific TBCs

This section presents an evaluation of non-promulgated criteria, guidance and policies that could represent chemical-specific to-be-considered (TBC) criteria for OU-1, as identified by EPA.

3.1.1.5.1 EPA OSWER Directives

EPA has developed several guidance documents related to cleanup of radionuclides at CERCLA sites. Specifically, EPA has developed guidance on use of the UMTRCA standards for vicinity properties (40 C.F.R. 192 Subpart B) as cleanup standards at CERCLA sites. OSWER Directives 9200.4-25 and 9200.4-18 (EPA, 1998a and 1997a) provide guidance on use of these standards relative to risk-based radiological cleanup levels. These Directives, as well as OSWER Directive 9285.6-20, provide guidance for establishing protective cleanup levels for radioactive contamination at CERCLA (Superfund) sites. Specifically, these Directives provide clarification on the use of the UMTRCA soil cleanup criteria as remediation goals at CERCLA sites. EPA has also developed guidance on the use of NRC benchmark dose method to establish cleanup levels, the use of the uranium reference dose (RfD) value, and the use of the uranium MCL as a cleanup standard for groundwater.

<u>OSWER Directive 9200.4-18</u>

OSWER Directive 9200.4-18, titled "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (EPA, 1997a), provides clarifying guidance regarding protection of human health at CERCLA sites containing radionuclides. This guidance identifies potential applicable or relevant and appropriate requirements (ARARs) of other regulations relative to radionuclide occurrences at CERCLA sites. In particular, this guidance indicates that where ARARs are not available or are not sufficiently protective, EPA generally sets site-specific remediation levels for: (1) carcinogens at a level that represents an exceedance of upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}; and, (2) non-carcinogens such that the cumulative risks from exposure will not result in adverse effects to human populations (including sensitive sub-populations) that may be exposed during a lifetime or part of a lifetime, incorporating an adequate margin of safety. Since all radionuclides are carcinogens, this guidance addresses carcinogenic risk. OSWER Directive 9200.4-18 states that overall the EPA finds that a 15 mrem/yr effective dose equivalent level (with a risk of 3 x 10-4) is at the upper end of the remediation levels that have generally been selected at radioactively contaminated CERCLA sites. This level has been subsequently lowered as specified in OSWER Directive 9285.6-20 presented later in this section. In addition, this guidance (in Attachment B) provides that the NRC rule (at 62 FR 39058, July 21, 1997, codified at, e.g., 10 CFR Parts 20 and 40) dose levels provide no basis for a significant departure from the CERCLA risk ranges. This guidance is considered to be a TBC for OU-1.

OSWER Directive 9200.4-25

OSWER Directive 9200.4-25 “Use of Soil Cleanup Criteria in 40 C.F.R. Part 192 as Remediation Goals for CERCLA Sites” (EPA, 1998) provides direction on the use of the UMTRCA standards for cleanup of vicinity properties as a cleanup standard for CERCLA sites. Because RIM may be similar in some respects to the materials considered in 40 C.F.R. 192.12, the EPA has concluded that the cleanup standards in 40 C.F.R. 192.12 are potentially relevant and appropriate for all of OU-1, except for the areas covered by an engineered cap compliant with standards in UMTRCA Subpart A. In addition, the UMTRCA standards for vicinity properties are considered potentially relevant and appropriate for cleanup of any radionuclides that may still be present in soil on Lot 2A2 or other portions of the Crossroads Industrial Park and potentially the Buffer Zone, depending upon the future use of that parcel. Under CERCLA, the risk posed based on the reasonably anticipated future use should be considered in determining if additional controls such as institutional controls may be warranted.

OSWER Directive 9200.4-25 provides that for CERCLA sites where subsurface contamination exists at a level between 5 pCi/g and 15 pCi/g averaged over areas of 100 square meters, conditions are not considered to be sufficiently similar to an UMTRCA site to warrant use of the UMTRCA subsurface soil standard of 15 pCi/g over background as a relevant and appropriate requirement. Instead, EPA recommends 5 pCi/g as a suitable subsurface cleanup level so long as a site-specific risk assessment demonstrates that 5 pCi/g is protective. EPA further notes that when the UMTRCA subsurface cleanup standards are found to be relevant and appropriate requirements for a CERCLA site, the 5 pCi/g standard should be applied to both the combined levels of radium-226 and radium-228 and the combined levels of thorium-230 and thorium-232. This is to provide reasonable assurance that the preceding radionuclides in the series would not be left behind at levels that would permit the combined radium activity to build up to levels exceeding 5 pCi/g after completion of the response action. This guidance is considered to be a TBC for OU-1.

OSWER Directive 9285.6-20

OSWER Directive 9285.6-20 “Radiation Risk Assessment at CERCLA Sites: Q&A” states (at page 18) that, "For purposes of demonstrating compliance with the 0.02 WL Uranium Mill Tailings Radiation Control Act (UMTRCA) regulations as an ARAR, users may assume that either 5 pCi/L of Rn-222, or 7.5 pCi/L of Rn-220 corresponds to 0.02 WL. Therefore 5 pCi/L of Rn-222 or 7.5 pCi/L of Rn-220 may be considered to be the concentration for complying with the UMTRCA indoor radon standard as an ARAR. These values are based on an indoor residential equilibrium fraction of 0.4 (40%) for Rn-222 and 0.02 (2%) for Rn-220.” OSWER Directive 9285.6-20 also specifies an ARAR protectiveness criteria evaluation recommendation of 12 mrem/yr in place of the 15 mrem/yr value previously specified in Directive 9200.4-18. OSWER Directive 9285.6-20 also provides that, generally, dose recommendations from other federal agencies should not be used to assess risk or establish cleanup levels. (See Q36). This guidance is considered to be a TBC for OU-1.

OSWER Directive 9200.4-23

OSWER Directive 9200.4-23, "Clarification of the Role of Applicable or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA," clarifies the relationship between 1) the requirement to protect human health and the environment, and 2) the requirement to attain, or waive if justified based on site-specific circumstances, ARARs. Specifically, this directive clarifies that EPA may establish preliminary remediation goals at levels that are more protective than required by ARARs. This guidance is considered to be a TBC for OU-1.

OSWER Directive 9200.4-35P

OSWER Directive 9200.4-35P "Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 C.F.R. Part 40 Appendix A, I, Criterion 6(6)" clarifies the relationship between the UMTRCA soil standards under 40 C.F.R. 192 and the NRC radium benchmark approach under the 10 C.F.R. 40 Appendix A, I, Criterion 6(6) in setting remediation goals in soil and structures. The Criterion 6(6) rule addresses the lack of remediation standards for residual radionuclides, other than radium in soil, for decommissioning of lands and structures (excluding radon) at uranium recovery facilities.

OSWER Directive 9200.4-35P explains that "The Criterion 6(6) rule is a supplement to the radium standards of 40 C.F.R. Part 192, to address other site-related radionuclides. This rule uses the existing soil radium standard to derive a dose criterion (benchmark approach) for cleaning up byproduct material, including radium in soil, and for cleanup of surface activity on structures to be released for unrestricted use." The radionuclides addressed by the Criterion 6(6) rule are thorium, natural uranium, and radium. The rule requires calculation of the potential peak effective does equivalent (excluding radon) to an individual at the site within 1,000 years from exposure to the residual levels allowed under the radium soil standard. The guidance states that the Criterion 6(6) standard is potentially applicable only for the Title II sites designated under Section 206 of UMTRCA, but that the benchmark dose limit is potentially relevant and appropriate to sites where the radiological risks posed by contaminants of concern that are the same (i.e., radium-226, radium-228, thorium-230, thorium-232, uranium-234 and/or uranium-238) as those existing at NRC thorium mills and uranium recovery facilities. In this case, the benchmark dose limit is a potentially relevant and appropriate requirement for those contaminants.

Site-specific application of the Criterion 6(6) rule as a relevant and appropriate requirement (RAR) will involve both a dose assessment to establish potential cleanup levels for the residual radionuclides as well as a determination of whether the dose assessment developed under the rule is protective enough to establish cleanup levels under CERCLA. Dose assessments (excluding radon) are conducted to convert the radium soil standards into a benchmark dose for all radionuclides at the site. When the Criterion 6(6) rule is considered a relevant and appropriate requirement, the dose assessments that are conducted to develop the benchmark dose for a site, and to show compliance of remediation goals for soil and structures with the benchmark dose (the "compliance dose"), should be conducted site-specifically, using Superfund's reasonably maximum exposure (RME) scenario parameters that are consistent with the reasonably anticipated land use of the site. Both the benchmark dose and the dose analysis to confirm compliance with the benchmark dose (the "compliance dose") should be estimated as the sum of doses from all appropriate exposure pathways. For soil, these pathways would typically include: direct ingestion of soil; inhalation of fugitive dusts; ingestion of contaminated ground water caused by migration of radionuclides through soil to an underlying potable aquifer; external radiation exposure from radionuclides in soil; and ingestion of homegrown produce that has been contaminated via plant uptake. This guidance is considered to be a TBC for OU-1.

OSWER Directive 9283.1-14

OSWER Directive 9283.1-14, "Use of Uranium Drinking Water Standards under 40 C.F.R. 141 and 40 C.F.R. 192 as Remediation Goals for Groundwater as CERCLA sites," addresses the use of uranium drinking water standards for groundwater remediation at CERCLA sites. This directive specifies that both the uranium MCL (40 C.F.R. 141) and the UMTRCA standards (40 C.F.R. 192) are potentially relevant and appropriate. This directive also provides guidance on the groundwater point of compliance standard in 40 C.F.R. 192.02 (c)(4) relative to the CERCLA approach for conducting groundwater responses. Specifically, page 6 of this OSWER directive states "For example, the CERCLA approach for complying with the MCL throughout the plume is more stringent than the UMTRCA approach of complying with the groundwater standard only in the uppermost aquifer." This guidance is considered to be a TBC for OU-1.

EPA December 21, 2016 Memorandum

On December 21, 2016, EPA issued a memorandum titled "Considering a Noncancer Oral Reference Dose for Uranium for Superfund Human Health Risk Assessments." This memorandum provides information and recommendations about an oral reference dose (RfD) for non-radiological toxicity of soluble uranium. This memorandum recommends the use of the ATSDR intermediate MRL for soluble uranium without further adjustment, in lieu of the RfD currently published in IRIS, for assessment of chronic exposures also. Specifically, evaluation of the non-carcinogenic risks posed by uranium should use a toxicity value of 0.0002 mg/kg-day. This guidance is considered to be a TBC for OU-1.

3.1.2 Potential Location-Specific ARARs

Location-specific ARARs are those requirements that relate to the geographical or physical location of the site or remedial action rather than the nature of the contaminants or the actions being taken. The FS (EMSI, 2006) includes evaluations of potential location-specific ARARs. The results of these evaluations are summarized on Table 3-2. The significant location-specific

ARARs identified in the FS are those related to floodplain management and the site selection standards of the Missouri Solid Waste Management regulations regarding the construction of a new cell and proximity to airport runways and floodplains. The requirements of these regulations are discussed below.

3.1.2.1 Floodplain Management

All of OU-1 is located within the geomorphic floodplain. In addition, the Buffer Zone and Crossroads Property are located within the historic 500-year (0.2% recurrence interval) floodplain of the Missouri River. These areas are currently protected by the engineered Earth City levee and flood control system. As discussed in Section 2.1.6 and shown on Figure 2-9, the waste disposal areas of the West Lake Landfill site, including the waste masses in Areas 1 and 2, are located outside the 0.2-percent annual chance (500-year) floodplain. Although the Area 1 and Area 2 waste materials are located outside the floodplain, portions of the Site are located within the area that is protected by levees from a 0.2% recurrence interval flood event. Furthermore, in the event of failure of the levee system during a 0.2% recurrence event, flood water could reach the edges of portions of the landfill, including the landfill toe, along the northern and western boundaries of Area 2 and the eastern boundary of Area 1. Some of the remedial alternatives being evaluated in this FFS include leaving RIM on site. Because the RIM will remain radioactive for thousands of years, and conditions associated with the river course and floodplain could change, there is uncertainty as to future conditions relative to the floodplain. The potential impacts of such uncertainties are evaluated as part of the long-term effectiveness of each alternative in Section 6 of this FFS.

Executive Order 11988, 40 C.F.R. 6.302(b), and the Missouri Governor's Order 82-19 relative to floodplain management, are considered as potential location-specific ARARs relative to floodplain management. These orders require actions to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Executive Order 11988 requires the following:

1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).
2. Conduct early public review, including public notice.
3. Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain.
4. Identify impacts of the proposed action.
5. If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.
6. Reevaluate alternatives.
7. Present the findings and a public explanation.
8. Implement the action.

The goal of floodplain mitigation is to lessen the potential impact floods have on people, property, and the environment. Impacts can occur due to forces of water causing damage to location-specific or project-specific structures and/or to the overall functions of the floodplain, which may include the flood-holding capacity of the floodplain, fish and wildlife habitat values of the floodplain, water quality functions of the floodplain, or other hydrological processes (*e.g.*, groundwater recharge). The nature of potential mitigative measures depends on the nature of the potential impacts that could occur. For example, with respect to location- or project-specific structures, flood-protection techniques such as elevation of critical structures, application of rip-rap armoring, or other measures to reduce impacts of flooding on project structures may be appropriate mitigation measures. Mitigation of potential impacts to the overall functions of a floodplain could also include construction and operation of stormwater detention basins to offset reductions in the flood-holding capacity or water quality functions of a floodplain, or designation of open/natural areas to offset habitat loss from construction in a floodplain.

Because the disposal areas of the Site are located outside of the 0.2-percent annual chance (500-year) floodplain, no mitigative actions would be required unless the remedial action (1) impacts the base floodplain, (2) indirectly supports floodplain development, or (3) is a critical action. Critical actions are those for which even a slight chance of flooding would be too great. Remedial actions for OU-1 are not expected to impact the base floodplain or indirectly support floodplain development. In the event of a failure of the Earth City Levee system (which provides protection from flood events with a recurrence interval greater than 500 years), floodwaters could inundate the Buffer Zone and Lot 2A2[17]. Due to the current distance from the river, such floodwaters would not be expected to be high energy, but instead would be nearly stagnant and without the velocity and energy capable of resulting in significant erosion of these areas.

3.1.2.2 Missouri Solid Waste Management Regulations – Site Selection

The Missouri Solid Waste Regulations contain site selection standards that apply to new or operating landfills (10 C.S.R. 80.3.010(4) and 10 C.S.R. 80-3.010(4)(A)). Some of the site-selection standards also apply to horizontal expansions of existing landfills. The solid waste site-selection standards address landfills located in proximity to airports, within 100-year floodplains, within wetlands, within seismic impact zones, and within unstable areas. The site selection criteria also specify site condition information required for design and operation plan submittals and requirements relative to the base elevation of a landfill liner to the depth of groundwater.

Because Areas 1 and 2 are neither new nor operating landfills, these requirements are not considered applicable to remediation of Areas 1 and 2. Although these standards are not applicable to Areas 1 and 2, some of these requirements are considered to be potentially relevant and appropriate to Areas 1 and 2. In particular, the regulatory requirements relating to airport

[17] It is expected that any radiologically-impacted soil that may remain on these properties would be removed as part of the implementation of any remedial action taken for OU-1.

safety and floodplains are potential ARARs for the ROD-selected remedy, the partial excavation alternatives, and the full excavation alternative because regrading or excavation of wastes within Areas 1 and 2 is a component of each of these alternatives. These regulations would be applicable if the on-site landfill cell alternative is the selected remedial alternative. These potential ARARs are described below.

3.1.2.3 Missouri Solid Waste Management Regulations – Floodplains

The Missouri Solid Waste Regulations contain requirements for landfills located within floodplains (10 C.S.R. 80-3.010(4)(B)2). Specifically, owners/operators of sanitary landfills located in 100-year floodplains must demonstrate to MDNR that the sanitary landfill would not restrict the flow of the 100-year flood, reduce temporary water storage capacity of the floodplain, or result in washout of solid waste so as to pose a hazard to public health or the environment. Areas 1 and 2 are not within the 100-year floodplain, and therefore this standard is not applicable and neither relevant nor appropriate to actions taken in Areas 1 and 2. These regulations may be applicable if the on-site landfill cell alternative is the selected remedial alternative and is located in a floodplain.

3.1.2.4 Missouri Solid Waste Management Regulations – Seismic Impact Zones

The solid waste regulations require that sanitary landfills located in seismic impact zones shall generally not be located within 200 feet of a fault that has had displacement in Holocene time (10 C.S.R. 80-3.010(4)B.4). Landfills located within seismic impact zones must demonstrate that all containment structures (e.g., liners, final covers, leachate collection systems and surface water control systems) are designed to resist permanent cumulative earthquake displacements greater than 6 inches resulting from the maximum credible Holocene time earthquake event's acceleration versus time history (10 C.S.R. 80-3.010(4)B.5).

The St. Louis area is part of the New Madrid Seismic Impact Zone and therefore these requirements are potentially applicable to the design of the final cover system for Areas 1 and 2 under all of the alternatives. There is no indication that any Holocene-age faults are present at the Site. Extensive geologic mapping of the quarry walls in the area of the inactive Bridgeton Sanitary Landfill did not identify the presence of any faults in that area (Golder Associates, 1996). These regulations would be applicable if the on-site landfill cell alternative is the selected remedial alternative.

3.1.2.5 Missouri Solid Waste Management Regulations – Unstable Areas

The Missouri solid waste regulations require that sanitary landfills located in unstable areas demonstrate that the landfill design ensures that the integrity of the structural components of the sanitary landfill will not be disrupted (10 C.S.R. 80-3.010(4)B.6). Minimum factors to be considered in determining whether an area is unstable include the following:

- areas where on-site or local rock or soil conditions may result in failure or significant differential settlement;
- on-site or local geologic or geomorphologic features; and
- on-site or local human-made features or events (both surface and subsurface).

None of these features are known or currently expected to be present in the area. Therefore, this requirement is not applicable, relevant or appropriate. These regulations may be applicable if the on-site landfill cell alternative is the selected remedial alternative and is located in an unstable area.

3.1.2.6 Missouri Solid Waste Management Regulations – Plans

The Missouri solid waste regulations require that design and operations plans for new sanitary landfills include maps showing initial and proposed topographies at specified scales and contour intervals, and maps showing land use and zoning within one quarter mile including specific features listed in the regulations (10 C.S.R. 80-3.010(4)B.7). The regulations also require a description of project post-closure land use and evaluations of the characteristics and quantity of available on-site soil with respect to its suitability for sanitary landfill operations. Because these regulations address new sanitary landfills, they are not applicable to the existing Areas 1 and 2, nor are they relevant or appropriate for the remedial alternatives. Furthermore, much of these represent administrative rather than substantive requirements and therefore would not be ARARs.

3.1.2.7 Missouri Solid Waste Regulations – Airport Safety

The Missouri Solid Waste Regulation requirements for airport safety apply to new or existing municipal solid waste landfills or lateral expansions that are located within 10,000 feet of the end of any airport runway used by turbojet aircraft or within 5,000 feet of any airport runway end used by only piston-type aircraft (10 C.S.R. 80-3.010(4)(B)1). Landfills or landfill expansions located within these areas must demonstrate that the units are designed and operated so as to pose no bird hazards to aircraft.

Portions of the Site, including a portion of Area 1, are located within approximately 9,166 feet of the end of Lambert-St. Louis International Airport's Runway 11-29 (Figure 2-8). Because Area 1 is located in an inactive/closed portion of the Site, these requirements are currently not applicable. Insofar as the intent of the regulations is to control bird hazards, however, these requirements potentially may be relevant to remedial activities that could result in the exposure of previously placed refuse which could attract birds and therefore present a potential hazard to aircraft. Consequently, these regulations may be relevant and appropriate to excavation and regrading activities that may be performed in Area 1 under the ROD-selected remedy, and for the excavation and regrading activities required for the full excavation and partial excavation alternatives. These regulations may be applicable if the on-site landfill cell alternative is the selected remedial alternative and is located within an area that falls within the criteria described above.

3.1.2.8 Missouri Solid Waste Regulations – Design and Operation

The Missouri Solid Waste Regulation requirements for the design and operation of solid waste facilities apply to new or existing municipal solid waste landfills or lateral expansions (10 C.S.R. 80-3.010(4)(B) and 10 C.S.R. 80-3.010(5) and (6)). Landfills or landfill expansions must demonstrate that the units are designed and operated so as to pose no threat to human health and the environment.

If the on-site cell is the selected remedial alternative, these regulations will be applicable to excavation and construction of a new landfill cell. Because these regulations were developed for the waste materials (MSW) that are present at West Lake Landfill and that would be placed in an on-site disposal cell, they are considered to be relevant and appropriate for the design, operation, or closure of an on-site disposal cell.

3.1.2.9 FAA Guidance

The Federal Aviation Administration (FAA) has developed guidance to address safety issues associated with aircraft bird strikes (Appendix A-3). The FAA also issued a Record of Decision (the Lambert Airport ROD) (FAA, 1998) (Appendix A-3) for federal actions related to improvements at Lambert-St. Louis International Airport (Lambert), including construction and operation of a new air carrier length runway (then designated 12W/30W, now known as Runway 11/29). The FAA ROD included requirements relative to proximity of the proposed new runway to the existing Bridgeton Sanitary Landfill. In 2003, the FAA, EPA and other agencies also entered into a Memorandum of Understanding (the FAA MOU) (Appendix A-3) addressing aircraft-wildlife strikes. These advisories, decision document, and memoranda are not cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law and therefore are not ARARs. Likewise, because the FAA guidance, Lambert Airport ROD, and FAA MOU are not legally binding, they are not ARARs. They do, however, represent to-be-considered (TBC) criteria relative to the potential remedial actions at the Site.

In its Lambert Airport ROD (Appendix A-3), the FAA noted that the end of the proposed runway would be located within 10,000 feet of a then-active landfill (the Bridgeton Landfill) and therefore would not be consistent with FAA's current runway siting guidelines without mitigation. The decision document noted that at its closest point, the Bridgeton Landfill is located approximately 9,166 feet west of the northwest end of proposed Runway 12W/30W. This is not consistent with FAA's runway siting guideline of 10,000 feet, which was developed to protect aircraft from potential bird strikes.

Pursuant to an agreement between Bridgeton Landfill, LLC and the City of St. Louis (among other parties) on behalf of the STLAA, the Bridgeton Landfill ceased accepting waste materials prior to the opening of Runway 11/29.

FAA Advisory Circular AC 150/5200-34A, dated January 26, 2006, "Construction or Establishment of Landfills Near Public Airports," contains guidance on complying with federal statutory requirements regarding the construction or establishment of a new municipal solid waste landfill (MSWLF) near public airports (Appendix A-3). This advisory only applies to a new MSWLF constructed or established after April 5, 2000, near an airport that received Federal grants (under the Airport and Airway Improvement Act of 1982 as amended, 49 U.S.C. § 47101, et seq.) and primarily serves general aviation aircraft and scheduled air carrier operations using aircraft with fewer than 60 passenger seats. This advisory requires a minimum separation distances of six statute miles between a new MSWLF and a public airport as measured from the closest point of the airport property boundary to the closest point of the MSWLF property boundary. Because no new landfill cells are included within the scope of most of the remedial alternatives considered in this FFS, this guidance does not provide any criteria that are expected to affect most of the alternatives; however, this requirement would be a TBC with regard to the location of a new on-site disposal cell.

FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, "Hazardous Wildlife Attractants On or Near Airports," provides guidance on certain land uses that have the potential to attract hazardous wildlife on or near public-use airports (Appendix A-3). This circular recommends against locating a MSWLF within the separation distances identified below:

1. Airports serving piston-powered aircraft – 5,000 feet
2. Airports serving turbine-powered (jet) aircraft – 10,000 feet
3. Protection of approach, departure and circling airspace – 5 statute miles

These separation distances are to be maintained between the Air Operations Area (AOA) and the nearest point to the hazardous wildlife attractant. The AOA is defined as any area of an airport used or intended to be used for landing, takeoff, or surface maneuvering of aircraft which includes such paved or unpaved areas that are used or intended to be used for the unobstructed movement of aircraft in addition to its associated runway, taxiways, or apron. With respect to landfills, the separation distances should be measured from the closest point of the AOA to the closest planned MSWLF cell (AC 150/5200-33B, p. 4). The FAA strongly recommends against allowing a waste disposal operation to be located within 10,000 feet of a jet aircraft runway if the material contains putrescible waste or has the potential to attract wildlife that could threaten air traffic. This requirement would be a TBC relative to the location of a new on-site disposal cell.

The FAA, EPA, and other agencies developed and signed the FAA MOU to address risks that aircraft-wildlife strikes pose to safe aviation (Appendix A-3). Because this MOU is not a standard, requirement, criteria or limitation under Federal or State environmental laws, it does not represent a potential applicable or a potentially relevant and appropriate requirement; however, it may be a TBC. Specific aspects of this MOU that could be considered as part of potential remedial actions at the Site include the following:

Paragraph M – Agree to cooperate with the airport operator to develop a specific wildlife hazard management plan for a given location when a potential wildlife hazard is identified.

Paragraph O - Agree that information and analyses relating to mitigation that could cause or contribute to aircraft-wildlife strikes should, whenever possible, be included in documents prepared to satisfy the National Environmental Policy Act (NEPA).

These requirements would be a TBC for any actions that may be taken that could increase the potential for birds to congregate at or in the vicinity of the West Lake Landfill.

During the preparation of the SFS, EPA and representatives of Bridgeton Landfill, LLC met with the STLAA to discuss the remedial actions at the Site and to obtain STLAA input on the remedial alternatives included in the SFS. (See Appendix A-4.) The STLAA sent a letter to EPA regarding the potential remedial actions under consideration for the Site (included in Appendix A-5). Additional correspondence has been sent by the STLAA, including on August 11, 2014 (Appendix A-6), and, most recently, a letter sent to EPA on August 11, 2017 (Appendix A-7), reiterating the airport's previously stated concerns about the risks of bird strikes that would be posed by digging up or disturbing waste at the landfill. It is anticipated that additional meetings with the STLAA will occur as the project progresses. It is also anticipated that any remedial work plan would require development of a plan to mitigate hazards to aircraft operations that may be posed by bird populations at the Site during implementation of remedial actions, and that such a plan will be provided to the STLAA for review and input. These actions should meet the objectives of Paragraph M of the FAA MOU. Evaluation of potential risks associated with bird hazards to aircraft and evaluation of potential mitigation measures for aircraft-bird hazards as part of the detailed analysis of alternatives in the FFS addresses the objectives of Paragraph O of the FAA MOU.

3.1.2.10 Airport Negative Easement and Restrictive Covenants

Although not part of a promulgated Federal or State standard and therefore by definition not an ARAR or a TBC standard or criteria, use of the Site is subject to additional constraints relative to airport and airline passenger safety. As previously discussed, in August 2005, the Bridgeton Sanitary Landfill stopped receiving waste pursuant to an agreement with the airport owner, the City of St. Louis, to reduce or mitigate the potential harm to airport-related activities that could be caused by certain wildlife or birds on or from the landfill property. As part of this closure plan, a Negative Easement and Declaration of Restrictive Covenants Agreement (Restrictive Covenant) (Appendix A-2) was recorded against the majority of the West Lake Landfill Site, including all of Area 1, most of Area 2, and all of the soil borrow/stockpile area (see Appendix A-2). Paragraph 1 of the Restrictive Covenant imposes the following restrictions upon the Site:

> There shall be no new or additional depositing or dumping of municipal waste, organic waste, and/or putrescible waste (municipal waste, organic waste and putrescible waste hereinafter collectively referred to as "Putrescible Waste") above, upon, on, or under the Property beginning as of August 1, 2005 and continuing in perpetuity, unless and until such time as this Agreement is terminated or canceled by St. Louis in accordance with the terms set out in paragraph 3 below. For purposes of this Agreement, "Putrescible Waste" shall mean solid waste that contains organic matter capable of being decomposed by micro-organisms and of such a character and proportion as to be capable of attracting or providing food for birds. For purposes of this Agreement, "Putrescible Waste" shall not include construction waste or demolition waste.

Section 4 of the Restrictive Covenant states that the agreement shall end only if and when the City of St. Louis chooses in its sole and absolute discretion to abandon its negative easement. Consequently, although the Restrictive Covenant is not an ARAR, construction and operation of any new engineered disposal cell would violate the terms of this recorded land use covenant.

On September 7, 2010, representatives of Bridgeton Landfill, LLC and the EPA met with representatives of the St. Louis Airport Authority (STLAA) and the U.S. Department of Agriculture (USDA) to follow up on concerns raised that the Restrictive Covenant entered into between landfill owners and STLAA would prohibit construction of the "on-site cell" evaluated as part of the SFS. The STLAA and USDA also reiterated their concerns that an excavation remedy would create risks they could not even calculate and would take years to perform (further increases any risks). The EPA provided a summary of the alternatives considered in the SFS. The notes of this 2010 meeting were provided to the EPA and are included in Appendix A-4.

By letter dated September 20, 2010 (Appendix A-5), the City of St. Louis provided written comments on the SFS Work Plan. The letter identified the Site as a hazardous wildlife attractant for the airport. The City stated that the excavation (full excavation) alternatives would adversely affect wildlife mitigation measures taken by the airport to protect aircraft from bird strikes, thereby placing the City in violation of the FAA ROD and its requirement that such mitigation efforts be undertaken and maintained. The City also stated that implementation of the excavation alternatives would violate the Restrictive Covenant.

By letter dated August 11, 2014 (Appendix A-6) the Airport submitted comments to EPA emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives. On August 11, 2017, STLAA issued a further letter to EPA, reiterating the Airport's previously stated concerns about the risks of bird strikes that would be posed by digging up or disturbing waste at the landfill. (Appendix A-7) The Airport noted that approximately 15 million passengers were expected to arrive and depart from the airport that year, and a "large number of those flights will fly directly over the landfill." The Airport also expressed concern that the longer it takes to complete the chosen option or remedy and/or the more putrescible waste is disturbed, the more likely and more significant the threat for potential bird hazards.

Bird Mitigation and Control Plans (LGL Ltd, 2015) were prepared as part of the Isolation Barrier Alternatives Assessment (EMSI, et al., 2014 and 2015). Key elements of these plans relative to potential bird attraction associated with waste excavation included training of bird control personnel, frightening off birds using properly-applied procedures based on standard pyrotechnics, and reporting and notification. A similar type of plan would be developed during remedial design for any remedial action selected for implementation for OU-1.

3.1.3 Potential Action-Specific ARARs

Action-specific ARARs are technology-based requirements that define handling, treatment, disposal, and other procedures triggered by the type of remedial action under consideration. These requirements generally set performance or design standards for specific activities related to the management of wastes. Evaluations of potential action-specific ARARs are presented in the FS report (EMSI, 2006) and are summarized on Table 3-3. Table 3-3 also lists additional potential action-specific ARARs related to the full excavation and partial excavation alternatives. The potential action-specific ARARs associated with the ROD-selected remedy, UMTRCA cover alternative, the full excavation (including the construction of an on-site landfill cell), and the partial excavation alternatives are discussed below.

3.1.3.1 Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

Part 192 of Title 40 of the Code of Federal Regulations provides for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings pursuant to UMTRCA. As previously discussed, the UMTRCA regulations only apply to designated Title I sites and therefore are not applicable to West Lake Landfill. However, those portions of these regulations that provide closure performance standards may potentially be relevant and appropriate to remedial actions for OU-1.

3.1.3.1.1 40 C.F.R. 192 Subpart A

Subpart A of these UMTRCA regulations contains standards for the control of residual radioactive materials from inactive uranium processing sites. 40 C.F.R. § 192.02 states that "[c]ontrol of residual radioactive materials and their listed constituents shall be designed to: (a) be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years[.]" In addition, 40 C.F.R. § 192.02(d) requires that "[e]ach site on which disposal occurs shall be designed and stabilized in a manner that minimizes the need for future maintenance." For UMTRCA tailings piles, the longevity consideration is typically addressed through use of natural materials for construction and often includes placement of a rock armoring layer over the upper surface of the tailings pile capping system to reduce the potential for erosion.

In developing this requirement, EPA was concerned with long-term hazards relating to misuse by humans or disruption by natural phenomena. While large volumes of uniform sand-like tailings from uranium mining activities piled on the ground or in impoundments may be of concern due to misuse by humans (for example, use of tailings as construction or fill material), Areas 1 and 2 contain radiological contamination mixed with solid waste, construction and demolition debris and other wastes contained within an even larger volume of solid waste. It is highly unlikely that old garbage and debris of these types would be misused by humans. Furthermore, the solid waste regulations require the upper portion of a landfill cover system to consist of a vegetative layer that supports grass that through evapotranspiration can intercept and reduce potential for infiltration of precipitation. A grass cover also can be periodically mowed to prevent establishment of woody vegetation that could damage or otherwise reduce the functionality of the landfill cover system.

Since RIM accounts for the majority of the risk posed by the Site, including potential exposure to gamma radiation and radon, as well as the potential for RIM to leach, the cap design should focus on the performance standards of UMTRCA. Additional measures as specified by any RCRA closure criteria would supplement the design of the capping system, as needed, to ensure it is protective for all materials present at the Site.

This FFS also evaluates an UMTRCA cover alternative that would be specifically designed to meet the UMTRCA performance standards for control of residual radioactive materials. The UMTRCA standards are presented in 40 C.F.R. 192.02 and require:

> Control of residual radioactive materials and their listed constituents shall be designed[18] to:
>
> (a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,
>
> (b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
>
> (1) Exceed an average[19] release rate of 20 picocuries per square meter per second, or

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[18] Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) and (b).

(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

(c) Provide reasonable assurance of conformance with the following groundwater protection provisions:

(1) The Secretary shall, on a site-specific basis, determine which of the constituents listed in Appendix I to Part 192 are present in or reasonably derived from residual radioactive materials and shall establish a monitoring program adequate to determine background levels of each such constituent in groundwater at each disposal site.

(2) The Secretary shall comply with conditions specified in a plan for remedial action which includes engineering specifications for a system of disposal designed to ensure that constituents identified under paragraph (c)(1) of this section entering the groundwater from a depository site (or a processing site, if residual radioactive materials are retained on the site) will not exceed the concentration limits established under paragraph (c)(3) of this section (or the supplemental standards established under § 192.22) in the uppermost aquifer underlying the site beyond the point of compliance established under paragraph (c)(4) of this section.

(3) Concentration limits:

(i) Concentration limits shall be determined in the groundwater for listed constituents identified under paragraph (c)(1) of this section. The concentration of a listed constituent in groundwater must not exceed:

(A) The background level of that constituent in the groundwater; or

(B) For any of the constituents listed in Table 1 to subpart A, the respective value given in that Table if the background level of the constituent is below the value given in the Table, or

(C) An alternate concentration limit established pursuant to paragraph (c) (3) (ii) of this section.

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[19] This average shall apply over the entire surface of the disposal site and over a least a one-year period. Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

TABLE 1 TO SUBPART A OF PART 192—MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION

Constituent concentration [1]	Maximum
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Nitrate (as N)	10
Molybdenum	0.1
Combined radium-226 and radium-228	5 pCi/liter
Combined uranium-234 and uranium-238 [2]	30 pCi/liter
Gross alpha-particle activity (excluding radon and uranium).	15 pCi/liter
Endrin (1,2,3,4,10,10-hexachloro-6,7-exposy-,4,4a,5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma insomer).	0.004
Methoxychlor (1,1,1-trichloro-2,2′-bis(p-ethoxyphenylethane)).	0.1
Toxaphene (C10 H10 Cl6, technical chlorinated camphene, 67–69 percent chlorine).	0.005
2,4-D (2,4-dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-trichlorophenoxypropionic acid).	0.01

[1] Milligrams per liter, unless stated otherwise.
[2] Where secular equilibrium obtains, this criterion will be satisfied by a concentration of 0.044 milligrams per liter (0.044 mg/l). For conditions of other than secular equilibrium, a corresponding value may be derived and applied, based on the measured site-specific ratio of the two isotopes of uranium.

Selection and implementation of groundwater standards, including any potential alternate concentration limits, is not part of the OU-1 decision process but would be performed as part of the OU-3 RI/FS and resultant decision document.

3.1.3.1.2 Standards for Management of Uranium Byproduct Material, 40 C.F.R. 192 Subpart D

The standards set forth in 40 C.F.R. 192 Subpart D apply to the management of uranium byproduct materials under section 84 of the Atomic Energy Act of 1954 (“the Act”), as amended, during and following processing of uranium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act. These regulations apply to sites licensed pursuant to section 84 of the Act and therefore are not applicable to West Lake Landfill.

The standards established under these regulations relating to uranium tailing piles may, however, be relevant and appropriate with regard to a new on-site disposal cell.

Selected standards from 40 C.F.R. 192.32(a) standards that may be relevant or appropriate in connection with a potential on-site disposal cell include the following:

40 C.F.R. 192.32(a)(2) requires uranium byproduct materials to be managed so as to conform to the groundwater protection standard in 40 C.F.R. § 264.92), with certain modifications (set forth in 40 C.F.R. 192.32(a)(2)(i)-(iv).

40 C.F.R. 192.32(a)(3)(i) requires uranium mill tailings piles or impoundments that are nonoperational and subject to a license by the Nuclear Regulatory Commission or an Agreement State to limit releases of radon-222 by emplacing a permanent radon barrier, in accordance with the various procedural requirements set forth therein. This permanent radon barrier shall be constructed as expeditiously as practicable considering technological feasibility (including factors beyond the control of the licensee) after the pile or impoundment ceases to be operational.

40 C.F.R. 192.32(a)(4) requires

(i) Upon emplacement of the permanent radon barrier pursuant to 40 C.F.R. 192.32(a)(3), the licensee shall conduct appropriate monitoring and analysis of the radon-222 releases to demonstrate that the design of the permanent radon barrier is effective in limiting releases of radon-222 to a level not exceeding 20 pCi/m 2−s as required by 40 C.F.R. 192.32(b)(1)(ii). This monitoring shall be conducted using the procedures described in 40 C.F.R. part 61, Appendix B, Method 115, or any other measurement method proposed by a licensee that the Nuclear Regulatory Commission or Agreement State approves as being at least as effective as EPA Method 115 in demonstrating the effectiveness of the permanent radon barrier in achieving compliance with the 20 pCi/m 2−s flux standard.

(ii) When phased emplacement of the permanent radon barrier is included in the applicable tailings closure plan (radon), then radon flux monitoring required under § 192.32(a)(4)(i) shall be conducted, however the licensee shall be allowed to conduct such monitoring for each portion of the pile or impoundment on which the radon barrier has been emplaced by conducting flux monitoring on the closed portion.

40 C.F.R. 192.32 (b) Standards for application after the closure period.

At the end of the closure period:

(1) Disposal areas shall each comply with the closure performance standard in 40 C.F.R. § 264.111 with respect to nonradiological hazards and shall be designed[1] to provide reasonable assurance of control of radiological hazards to

(i) Be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(ii) Limit releases of radon-222 from uranium byproduct materials to the atmosphere so as to not exceed an average[2] release rate of 20 picocuries per square meter per second (pCi/m2s).

[1] The standard applies to design with a monitoring requirement as specified in § 192.32(a)(4).

[2] This average shall apply to the entire surface of each disposal area over periods of at least one year, but short compared to 100 years. Radon will come from both uranium byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard applies only to emissions from uranium byproduct materials to the atmosphere.

(2) The requirements of § 192.32(b)(1) shall not apply to any portion of a licensed and/or disposal site which contains a concentration of radium-226 in land, averaged over areas of 100 square meters, which, as a result of uranium byproduct material, does not exceed the background level by more than:

(i) 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) below the surface, and
(ii) 15 pCi/g, averaged over 15 cm thick layers more than 15 cm below the surface.

40 C.F.R. 192.33 Corrective action programs.

40 C.F.R. 192.33 provides that "If the ground water standards established under provisions of § 192.32(a)(2) are exceeded at any licensed site, a corrective action program as specified in § 264.100 of this chapter shall be put into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance."

The requirements described above for Subpart D are substantively similar to the requirements previously discussed for UMTRCA Subpart A, above.

3.1.3.2 NRC Low-Level Waste Regulations 10 C.F.R. 61

These regulations establish the procedures, criteria, and terms and conditions upon which the Commission issues licenses for land disposal of radioactive waste containing byproduct, source and special nuclear material. Per 10 C.F.R. 61.1(b)(2), the regulations in this part do not apply to disposal of uranium or thorium tailings or wastes in quantities greater than 10,000 kilograms and containing more than 5 millicuries of radium-226. Therefore, these regulations are not applicable to the West Lake Landfill. Certain of the performance objectives and technical requirements of these regulations may, however, potentially be relevant and appropriate for an on-site cell.

3.1.3.2.1 Subpart C Performance Objectives

A general requirement of these regulations is that land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44.

- Section 61.41: Protection of the general population from releases of radioactivity.

  Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

- Section 61.42: Protection of individuals from inadvertent intrusion.

  Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.

- Section 61.43: Protection of individuals during operations.

  Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by § 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.

- Section 61.44: Stability of the disposal site after closure.

  The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

3.1.3.2.2 Subpart D—Technical Requirements for Land Disposal Facilities

This Subpart describes the requirements for disposal site suitability, disposal site design, disposal site operation and closure, and environmental monitoring and waste classification. The waste classification requirements address waste materials different than those found at West Lake Landfill and therefore are not applicable or relevant for the Site. Similarly, many of the requirements are not appropriate as they are not well-suited to the Site.

Section 61.50: Disposal site suitability requirements for land disposal.

This section describes the factors to be evaluated in determining the suitability of site for land disposal including the following

(1) The minimum characteristics a disposal site must have to be acceptable for use as a near-surface disposal facility[20]. The primary emphasis in disposal site suitability is given to isolation of wastes, a matter having long-term impacts, and to disposal site features that ensure that the long-term performance objectives of subpart C of this part are met, as opposed to short-term convenience or benefits.

(2) The disposal site shall be capable of being characterized, modeled, analyzed and monitored.

(3) Within the region or state where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of subpart C of this part.

(5) The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988, "Floodplain Management Guidelines."

(6) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.

(7) The disposal site must provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste will not occur. The Commission will consider an exception to this requirement to allow disposal below the water table if it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives of subpart C of this part being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table.

[20] A near-surface disposal facility is one where disposal of radioactive waste is within the first 30 meters of the surface, 10 CFR 61.2.

(8) The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site.

(9) Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of subpart C of this part, or may preclude defensible modeling and prediction of long-term impacts.

(10) Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of subpart C of this part, or may preclude defensible modeling and prediction of long-term impacts.

(11) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of subpart C of this part or significantly mask the environmental monitoring program.

Section 61.51: Disposal site design for land disposal.

This portion of these regulations describe the design requirements for land disposal including:

(1) Site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.

(2) The disposal site design and operation must be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives of subpart C of this part will be met.

(3) The disposal site must be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives of subpart C of this part will be met.

(4) Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.

(5) Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.

(6) The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.

Section 61.52: Land disposal facility operation and disposal site closure.

This portion of these regulations address near-surface disposal facility operation and disposal site closure. Many of these requirements are related to facility operations for specific classes or types of packaging of wastes that are not similar to the material at West Lake Landfill and therefore are not relevant or appropriate to the on-site disposal alternative. Portions of these regulations related to closure of a disposal facility may be potentially relevant and appropriate including:

(8) A buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in § 61.53(d) of this part and take mitigative measures if needed.

(9) Closure and stabilization measures as set forth in the approved site closure plan must be carried out as each disposal unit (e.g., each trench) is filled and covered.

(10) Active waste disposal operations must not have an adverse effect on completed closure and stabilization measures.

(11) Only wastes containing or contaminated with radioactive materials shall be disposed of at the disposal site.

Section 61.53: Environmental monitoring.

This portion of the regulations describes the requirements for environmental monitoring of a disposal facility, including:

(a) preoperational monitoring shall be performed to provide basic environmental data on the disposal site characteristics including information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, data must cover at least a twelve month period.

(b) Plans must be established for taking corrective measures if migration of radionuclides would indicate that the performance objectives of subpart C may not be met.

(c) A monitoring program must be maintained during the land disposal facility site construction and operation. Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need for mitigative measures….

An environmental monitoring program will be developed as part of the CERCLA process.

The portions of the 10 C.F.R. Part 61 regulations described above are potentially relevant to the design and operation of a new on-site disposal cell. However, because these regulations were developed for waste materials that are substantially different from those present at West Lake Landfill (including wastes that would potentially be placed in an on-site disposal cell at the Site), they are not considered to be appropriate for the design, operation, or closure of an on-site disposal cell. The UMTRCA regulations discussed above and certain NRC regulations related to disposition of uranium mill tailings described above and below would be more appropriate to the design and operation of an on-site disposal cell.

3.1.3.3 NRC Criteria for Operation of Uranium Mills and Disposition of Tailings or Wastes

Appendix A to 10 C.F.R. Part 40 presents the NRC "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings of Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content."[21] This appendix establishes technical, financial, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located. These regulations are applicable to uranium or thorium milling and disposition of tailings or wastes resulting from such milling activities at sites licensed by the NRC. Because the West Lake Landfill and a new on-site disposal cell are not and would not be licensed by the NRC, these regulations are not applicable to the Site or the on-site disposal alternative. Those portions of these regulations related to siting, operation, decontamination, decommissioning, and reclamation of uranium and thorium mills are not relevant to OU-1 or a new on-site disposal cell. Certain portions of these regulations that provide technical criteria related to siting, operation, decontamination, decommissioning, and reclamation of tailing or waste disposal units are potentially relevant to a new on-site disposal cell. These technical criteria, which largely echo the UMTRCA requirements are set forth below.

As its name ("NRC UMTRCA") suggests, the standards established by these regulations are essentially the same as those set forth in the UMTRCA standards (40 C.F.R. 192) and, therefore, compliance with the UMTRCA standards should result in compliance with these standards. Where additional specificity is provided by the NRC standards, such as the requirement for a maximum final grade of 5 horizontal to 1 vertical (5:1), the preliminary conceptual design of the on-site cell has been developed to address such standards. Many elements of this regulation, such as the financial assurance criteria, are not relevant as such requirements would be addressed by a Consent Decree or other enforcement mechanism issued by EPA for implementation of any selected remedy that entails on-site disposal. The long-term site surveillance requirements in Criterion 12 of these regulations are primarily administrative requirements related to annual

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[21] 10 C.F.R. 40 is often referred to as the "NRC UMTRCA".

inspections and reporting to the NRC and therefore are not ARARs for OU-1. The hazardous constituent requirements in Criterion 13 of these regulations do not contain any specific standards or performance criteria but instead are a listing of non-radiological constituents for which groundwater protection standards may be required. Although this section of the regulations may be relevant, based on the nature of the waste materials at West Lake Landfill, it is not considered to represent appropriate requirements for an on-site cell (or otherwise). The groundwater monitoring requirements established under the Missouri Solid Waste Regulations represent the more appropriate requirements for development and implementation of a groundwater monitoring program for non-radiological constituents associated with the OU-1 waste material.

I. Technical Criteria

Criterion 1—similar to 40 C.F.R. 61.50 and 61.51, Criterion 1 discusses the general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. The following site features which will contribute to such a goal or objective must be considered in selecting among alternative tailings disposal sites or judging the adequacy of existing tailings sites:

- Remoteness from populated areas;
- Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from groundwater sources; and
- Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term.

In the selection of disposal sites, primary emphasis must be given to isolation of tailings or wastes, a matter having long-term impacts, as opposed to consideration only of short-term convenience or benefits, such as minimization of transportation or land acquisition costs. While isolation of tailings will be a function of both site and engineering design, overriding consideration must be given to siting features given the long-term nature of the tailings hazards. Tailings should be disposed of in a manner that no active maintenance is required to preserve conditions of the site.

Criterion 3—Also overlapping with 40 C.F.R. 60.50 and 51, Criterion 3 discusses the "prime option" for disposal of tailings as placement below grade, either in mines or specially excavated pits (that is, where the need for any specially constructed retention structure is eliminated). In some instances, below grade disposal may not be the most environmentally sound approach, such as might be the case if a groundwater formation is relatively close to the surface or not very well isolated by overlying soils and rock. Also, geologic and topographic conditions might make full below grade burial impracticable: For example, bedrock may be sufficiently near the surface that blasting would be required to excavate a disposal pit at excessive cost, and more suitable alternative sites are not available. Where full below grade burial is not practicable, the size of retention structures, and size and steepness of slopes associated exposed embankments must be minimized by excavation to the maximum extent reasonably achievable or appropriate given the geologic and hydrologic conditions at a site. In these cases, it must be demonstrated that an above grade disposal program will provide reasonably equivalent isolation of the tailings from natural erosional forces.

Criterion 4— Echoing the requirements of 40 C.F.R. 60.50 and 51, Criterion 4 provides that the following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade.

(a) Upstream rainfall catchment areas must be minimized to decrease erosion potential and the size of the floods which could erode or wash out sections of the tailings disposal area.

(b) Topographic features should provide good wind protection.

(c) Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade; this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided, and compensating factors and conditions which make such slopes acceptable should be identified.

(d) A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system.

The following factors must be considered in establishing the final rock cover design to avoid displacement of rock particles by human and animal traffic or by natural process, and to preclude undercutting and piping:

- Shape, size, composition, and gradation of rock particles (excepting bedding material average particles size must be at least cobble size or greater);
- Rock cover thickness and zoning of particles by size; and
- Steepness of underlying slopes.

Individual rock fragments must be dense, sound, and resistant to abrasion, and must be free from cracks, seams, and other defects that would tend to unduly increase their destruction by water and frost actions. Weak, friable, or laminated aggregate may not be used.

Rock covering of slopes may be unnecessary where top covers are very thick (on the order of 10 m or greater); impoundment slopes are very gentle (on the order of 10 h:1v or less); bulk cover materials have inherently favorable erosion resistance characteristics; and, there is negligible drainage catchment area upstream of the pile and good wind protection as described in points (a) and (b) of this Criterion.

Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability.

(e) The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A of 10 C.F.R. Part 100. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material.

(f) The impoundment, where feasible, should be designed to incorporate features which will promote deposition. For example, design features which promote deposition of sediment suspended in any runoff which flows into the impoundment area might be utilized; the object of such a design feature would be to enhance the thickness of cover over time.

Criterion 5—Criteria 5A-5D and new Criterion 13 incorporate the basic groundwater protection standards imposed by the Environmental Protection Agency in 40 C.F.R. Part 192, Subparts D and E (48 FR 45926; October 7, 1983) which apply during operations and prior to the end of closure. Groundwater monitoring to comply with these standards is required by Criterion 7A. Because these requirements are based on the requirements of 40 C.F.R. Part 192 Subpart A, which have previously been discussed, they are not repeated here. Furthermore, selection and implementation of groundwater standards, including any potential alternate concentration limits, is not part of the OU-1 decision process but would be performed as part of the OU-3 RI/FS and resultant decision document.

Criterion 6 – these requirements echo the UMTRCA (40 C.F.R. 192) standards, and provide as follows:

(1) In disposing of waste byproduct material, an earthen cover (or approved alternative) shall be placed over tailings or wastes at the end of milling operations and the waste disposal area shall be closed in accordance with a design[1] which provides reasonable assurance of

control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average[2] release rate of 20 picocuries per square meter per second (pCi/m^2s) to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this Criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals.

[1] In the case of thorium byproduct materials, the standard applies only to design. Monitoring for radon emissions from thorium byproduct materials after installation of an appropriately designed cover is not required.
[2] This average applies to the entire surface of each disposal area over a period of a least one year, but a period short compared to 100 years. Radon will come from both byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from byproduct materials to the atmosphere.

(2) As soon as reasonably achievable after emplacement of the final cover to limit releases of radon-222 from uranium byproduct material and prior to placement of erosion protection barriers or other features necessary for long-term control of the tailings, the licensee shall verify through appropriate testing and analysis that the design and construction of the final radon barrier is effective in limiting releases of radon-222 to a level not exceeding 20 pCi/m2s averaged over the entire pile or impoundment using the procedures described in 40 C.F.R. part 61, appendix B, Method 115, or another method of verification approved by the Commission as being at least as effective in demonstrating the effectiveness of the final radon barrier.

(3) When phased emplacement of the final radon barrier is included in the applicable reclamation plan, the verification of radon-222 release rates required in paragraph (2) of this criterion must be conducted for each portion of the pile or impoundment as the final radon barrier for that portion is emplaced.

…

(5) Near surface cover materials (i.e., within the top three meters) may not include waste or rock that contains elevated levels of radium; soils used for near surface cover must be essentially the same, as far as radioactivity is concerned, as that of surrounding surface soils. This is to ensure that surface radon exhalation is not significantly above background because of the cover material itself.

(6) The design requirements in this criterion for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material, does not exceed the background level by more than: (i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 centimeters (cm) below the surface, and (ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm thick layers more than 15 cm below the surface. (These requirements are substantively similar to those set forth under 40 CFR 192 Subparts A and B; see Section 3.1.1.1.)

Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more than one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed "1" (unity). A calculation of the potential peak annual TEDE within 1000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site must be submitted for approval. (These requirements were previously discussed in Section 3.1.1.2.)

(7) The licensee shall also address the nonradiological hazards associated with the wastes in planning and implementing closure. The licensee shall ensure that disposal areas are closed in a manner that minimizes the need for further maintenance. To the extent necessary to prevent threats to human health and the environment, the licensee shall control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the ground or surface waters or to the atmosphere.

The portions of the 10 C.F.R. Part 40, Appendix A referenced here are not applicable, but may be potentially relevant to the design and operation/performance of a new on-site disposal cell. Certain of the above criteria are not well suited to the Site, which is a closed landfill, and accordingly those criteria would not be appropriate. The standards established by these regulations are essentially the same as those set forth in the UMTRCA standards (40 C.F.R. 192), and therefore, compliance with the UMTRCA standards should result in compliance with these standards, and they may be more appropriate to the design and operation/performance of an on-site disposal cell. See also the separate discussion in Section 3.1.1.2 with regard to Criterion 6(6).

3.1.3.4 Missouri Solid Waste Management Regulations

The ROD-selected remedy was developed and selected to provide engineered containment of the solid wastes and RIM contained in Areas 1 and 2. Because these areas contain solid wastes, the RCRA Subtitle D regulations and the MDNR Solid Waste Management regulations must be considered in addition to UMTRCA performance standards for design and implementation of a containment remedy (10 C.S.R. 80-2.015, 10 C.S.R. 80-2.020, 10 C.S.R. 80-2.030 and 10 C.S.R. 80-3.010). Specifically, the landfill cover design, gas control measures, maintenance, groundwater monitoring, and corrective action criteria of these regulations are potentially relevant and appropriate.

An evaluation of these solid waste management criteria as potential ARARs relative to the evaluation of remedial alternatives for OU-1, including the remedial alternative that ultimately became the ROD-selected remedy, is presented in the FS report (EMSI, 2006). In particular, the FS report presents an extensive discussion of the final grading and cover requirements for solid waste landfills as potentially relevant and appropriate requirements for construction of new landfill covers over Areas 1 and 2. In the ROD (EPA, 2008a), EPA provided an evaluation of solid waste regulations as potential ARARs, including how they would apply to the ROD-selected remedy.

The Missouri Solid Waste regulations prohibit the disturbance of sanitary waste without approval from MDNR. The regulations apply to closed, existing landfills (10 C.S.R. 80-2.030(3) and 260.210.1(2) RSMo) and state that an applicant cannot remove, disrupt, or excavate from a discontinued landfill without prior approval from MDNR. 10 C.S.R. 80-20.030(3). This requirement may be relevant to the partial and full excavation alternatives since Areas 1 and 2 are discontinued landfills. Specifically, requirements would include:

- MDNR would have to be notified if waste was removed from Areas 1 or 2 10 C.S.R. 80-2.030(3);
- Screening and removal of unapproved wastes (10 C.S.R. 80-2.010(3)(B)2);
- Removal of any whole waste tires encountered (10 C.S.R. 80-2.010(3)(A)11).

Additionally, Missouri Solid Waste Regulations governing the design and operation of sanitary landfills may be relevant to the development of the on-site cell, including:

- A one-hundred foot buffer zone to provide room for assessment of remedial actions (10 C.S.R. 80-3.010(5)(B)1);
- Water quality would have to be protected during the detailed site investigation, the projected use of water resources and groundwater elevation would have to be determined, and state and local waterways would have to be protected from impact (10 C.S.R. 80-3.010(8)(B)1.A -10 C.S.R. 80-3.010(8)(B)1.C);
- A leachate collection system (10 C.S.R. 80-3.010(9)(A)) and maintaining less than one foot of leachate on the liner (10 C.S.R. 80-3.010(9)(B)1.E);

- A groundwater monitoring program (10 C.S.R. 80-3.010(11)(A));
- An air quality control program (10 C.S.R. 80-3.010(13));
- Control of any landfill gas (10 C.S.R. 80-3.010(14)A) and decamped gas (10 C.S.R. 80-3.010(14) (C)1).
- Conditions would have to be unfavorable for vectors and prevent the harboring, feeding or breeding of such vectors (10 C.S.R. 80-3.010(15)A);
- A suitable cover to minimize fire hazards, vectors, infiltration of water, and to control gas (10 C.S.R. 80-3.010(17));
- Closure and post closure plans (10 C.S.R. 80-3.010(20)(C) 1.I), including financial assurance (10 C.S.R. 80-3.010(20)(C) 1.J);

The final grading and final cover requirements of the Missouri Solid Waste regulations are not applicable to remedial alternatives for OU-1, because they apply only to existing sanitary landfills that are closed after October 9, 1991. However, the Solid Waste regulations would be relevant and appropriate to regrading and design and construction of final cover over Areas 1 and 2 as part of the ROD-selected remedy or the partial and full excavation alternatives. EPA determined that the 5% minimum sloping requirement under the Solid Waste regulations was not appropriate for the ROD-selected remedy (see ROD at p. 50). The ROD required the selected remedy to include final grades of at least 2% and less than 25% (unless a stability analysis is performed to support inclusion of steeper slopes, but in no event shall the final slopes exceed 33$1/3$%). The ROD also required that the selected remedy include final cover of at least two feet (2') of compacted clay with a coefficient of permeability of 1×10^{-5} cm/sec or less, overlaid by at least one foot (1') of soil capable of sustaining vegetative growth (10 C.S.R. 80-3.010(17)(C)(4)). Analysis of these requirements and the basis for use of a minimum slope of 2% for the ROD-selected remedy is provided in the ROD (EPA, 2008a) and the FS (EMSI, 2006). For the partial excavation and full excavation alternatives, the final grading and cover requirements will likely need to include final grades of at least 5% and less than 25% (unless a stability analysis is performed to support inclusion of steeper slopes, but in no event shall the final slopes exceed 33⅓%) and final cover of at least two feet (2') of compacted clay with a coefficient of permeability of 1×10^{-5} cm/sec or less overlaid by at least one foot (1') of soil capable of sustaining vegetative growth (10 C.S.R. 80-3.010(17)(C)(4)).

3.1.3.5 RCRA Subtitle C and the Missouri Hazardous Waste Management Law

The RCRA Subtitle C requirements relative to identification of hazardous wastes (40 C.F.R. Part 261), packaging, temporary storage, offsite transportation of hazardous wastes (40 C.F.R. Parts 262 and 263), and treatment and disposal of hazardous wastes (40 C.F.R. Part 268), are potentially applicable requirements in the event that hazardous wastes are encountered during implementation of any remedy at the Site. Similarly, the requirements of the Missouri Hazardous Waste Management Law (260.350 – 260.430 RSMo RSMo 260) and associated regulations (10 CSR 25-7) would apply in the event that hazardous wastes are encountered. The RCRA Subtitle C and Missouri hazardous waste management regulations would also apply to the design, construction, operation and closure of a new on-site engineered disposal cell in the event that hazardous wastes would be disposed in this cell. However, the evaluations of the remedial alternatives presented in this FFS are predicated on the presumption that any hazardous or mixed waste that may be encountered during implementation of any of the remedial alternatives would be transported offsite for treatment and/or disposal. Therefore, the hazardous waste regulations related to design, operation, closure or post-closure of a hazardous waste landfill are not expected to be applicable to any of the remedial alternatives being evaluated in this FFS. Although not applicable, the design criteria for a hazardous waste landfill, in particular those related to liner and cover system design and construction requirements, could be relevant and appropriate to the design of a new engineered on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative.

The RCRA Subtitle C landfill closure design criteria were also evaluated as potential action-specific ARARs for closure of Areas 1 and 2. RCRA landfill closure regulations (40 C.F.R. § 264.310) specify that at final closure of a landfill or cell, the landfill or cell must be covered with a final cover designed and constructed to:

1. Provide long-term minimization of migration of liquids through the closed landfill;
2. Function with minimum maintenance;
3. Promote drainage and minimize erosion or abrasion of the cover;
4. Accommodate settling and subsidence so that the cover's integrity is maintained; and
5. Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

Per EPA guidance (EPA, 1988 and 1989), RCRA Subtitle C requirements, including closure requirements, are applicable to a Superfund remedial action if the following conditions are met:

- The waste is a RCRA hazardous waste, and either:

- The waste was initially treated, stored, or disposed of after November 19, 1980 (the date upon which the RCRA Subtitle C requirements became effective), or

- The activity at the CERCLA site constitutes treatment, storage, or disposal, as defined by RCRA.

As discussed in Section 2.2.11, the waste materials in Area 1 and 2 are typical MSW and do not contain confirmed amounts of hazardous waste. Regardless, the wastes in Area 1 and 2 were disposed of prior to November 19, 1980 and therefore do not meet the second criterion listed above. To the extent that the remedial actions being considered for Areas 1 and 2 entail consolidation, regrading and capping of the waste within Areas 1 and 2, these actions should not constitute treatment, storage or disposal. Therefore, the RCRA regulations, including the closure requirements, would not be applicable to remedial actions for Areas 1 and 2.

RCRA requirements that are not applicable may nonetheless be relevant and appropriate, based on site-specific circumstances (EPA, 1988 and 1989). The determination of relevance and appropriateness of RCRA requirements is based on the circumstances of the release, including the hazardous properties of the waste, its composition and matrix, the characteristics of the site, the nature of the release or threatened release from the site, and the nature and purpose of the requirement itself.

Each of the two capping designs presented in this FFS (the ROD-selected remedy, and the UMTRCA cover alternative) address the possibility of leaching, and will be designed to prevent infiltration of surface water that might cause leaching of contaminants to the groundwater. (Whether RIM has leached to groundwater, and if so, to what extent, will be addressed separately as part of OU-3.) The RCRA Subtitle C regulations are also intended to address closure of smaller areas containing high concentration (hazardous) wastes, and are not considered appropriate for closure of larger, dispersed areas of lower level contamination associated with a MSW landfill (EPA, 1988b). EPA (1988b) has indicated that RCRA covers are generally not appropriate for large municipal landfills where the waste is generally of a lower toxicity, and the Site encompasses an area that bears little resemblance to the discrete units regulated under RCRA Subtitle C. RCRA Subtitle C landfill covers are, however, less permeable than Subtitle D covers (10^{-7} cm/sec and 10^{-5} cm/sec, respectively). Accordingly, in light of the West Lake Landfill contaminant's toxicity, longevity, potential to leach, and location (in certain instances) at depth near the water table, a cap meeting the standards describe in the Subtitle C cap guidance may be more likely to achieve the groundwater protectiveness standard of the UMTRCA regulations (40 C.F.R. 192.02(c)(3)).

Although RCRA Subtitle C regulations are neither applicable nor relevant and appropriate to West Lake Landfill OU-1, EPA guidance on the design of landfill covers for RCRA and CERCLA sites may provide information useful for the design of a final cover system under any of the alternatives. These include the July 1989 Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments (EPA, 1989c) and the April 2004 (Draft) Technical Guidance for RCRA/CERCLA Final Covers (EPA, 2004b). The 1989 Technical Guidance Document provides design guidance on final cover systems for hazardous waste landfills and surface impoundments. This guidance addresses multilayer cover design to provide long-term protection from infiltration of precipitation. The 2004 Draft Technical Guidance provides design information regarding cover systems for municipal solid waste (MSW) and hazardous waste (HW) landfills being remediated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA) Corrective Action, and sites regulated under RCRA. This guidance includes updated information related to development of design criteria, use and types of geosynthetics such as geosynthetic clay liners, alternative materials and designs, performance monitoring, maintenance of cover systems, and other issues. Because proper design and construction of a final cover is key to long-term protection from infiltration of precipitation, these guidance documents would be TBCs for design of the engineered landfill cover system. Similarly, the objectives of 40 C.F.R. 264.111(a) and (b) and 264.310(a)(1)–(5), while not applicable or relevant and appropriate (as discussed above), are instructive for the design of a new engineered landfill cap for all alternatives that result in RIM remaining in Areas 1 and 2 and for the new on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative.

MDNR identified the Missouri Hazardous Waste Management Law (260.350 – 260.430 RSMo) and its associated regulations (10 C.S.R. 25-7) as a potential state location-specific ARAR for an on-site disposal cell of hazardous waste. Along with RCRA Subtitle C, these might apply to the design, construction, operation and closure of a new on-site engineered disposal cell if hazardous wastes were to be disposed of in the cell. The Missouri law's disposal prohibitions do not apply to the storage or treatment of hazardous waste by a generator on-site (260.394.1 RSMo) and are specifically not applicable at National Priorities List sites, like the West Lake Landfill. However, though not applicable, the design criteria for a hazardous waste landfill could be relevant and appropriate to the design of a new engineered on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative if identified hazardous wastes were disposed within the newly constructed cell. Relevant requirements would include:

- Before using a hazardous waste disposal facility permitted under sections 260.350 to 260.432, generators of hazardous waste must prove that they have investigated and reviewed alternatives to landfilling to an extent acceptable to the hazardous waste management commission. The generator shall use, to the maximum extent feasible, the best demonstrated available technology for source reduction, recycling, treatment, stabilization, solidification or destruction, including, but not limited to, biodegradation, detoxification, incineration and neutralization, as determined by the commission. In determining the best demonstrated available technology, the commission shall give consideration to the relative economic feasibility of the technology, including potential future costs of cleanup and environmental damage. Such technology shall render the hazardous waste sufficiently low in toxicity, reactivity and corrosivity as to present the least possible risk to human health and safety and to the environment in the event of a release from a hazardous waste disposal facility. 260.394.2. RSMo.

- The commission shall determine that the best demonstrated available technology is used at hazardous waste disposal facilities in the state of Missouri in accordance with the provisions of sections 260.350 to 260.432, and the federal Resource Conservation and Recovery Act (P.L. 94-580), as amended. 260.394.3. RSMo.

- Any hazardous waste diluted below the listed concentration threshold shall remain a listed hazardous waste unless the dilution occurs as a normal part of the manufacturing process. 260.394.4. RSMo.

- The provisions of this section shall not apply to abandoned or uncontrolled sites as listed under section 260.440, or sites listed in the National Priority List pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of

1980 (P.L. 96-510), as amended, unless otherwise determined by the department or required by the commission by rule. 260.394.5. RSMo.

3.1.4 Additional Requirements Associated with Off-site Disposal

This section discusses additional requirements that would apply to the full excavation with off-site disposal or partial excavation alternatives. The requirements under CERCLA for compliance with other laws differ for on-site and off-site actions. Importantly, the ARARs provision applies only to on-site actions; off-site actions need only comply with any laws that apply to such an action. In other words, off-site actions need only comply with “applicable” requirements, not with “relevant and appropriate” requirements. Consequently, CERCLA actions involving the transfer of hazardous substances, pollutants or contaminants off-site must comply with applicable Federal and State requirements and are not exempt from formal administrative permitting requirements.

The primary requirements affecting off-site disposal are the CERCLA Off-Site Rule (OSR), requirements associated with transportation of the RIM to an off-site disposal facility, and the waste acceptance criteria (WAC) associated with each potential off-site disposal facility. These requirements are described below. The ability of the various off-site disposal facilities to accept the materials identified as present at OU-1 (based on a preliminary determination) is discussed further in Section 6.

3.1.4.1 CERCLA Off-site Rule

Section 121(d)(3) of CERCLA (42 U.S.C.§ 9621(d)(3)) applies to any CERCLA response action involving the off-site transfer of any hazardous substance, pollutant or contaminant (*i.e.*, CERCLA wastes). These principles are interpreted in the off-site rule (OSR) set forth in the NCP at 40 C.F.R. § 300.440. The OSR requires that CERCLA wastes be placed only in a facility operating in compliance with RCRA or other applicable Federal or State requirements. The OSR prohibits the transfer of CERCLA wastes to a land disposal facility that is releasing contaminants into the environment, and requires that any releases from other waste management units at the disposal facility be controlled. The purpose of the OSR is to avoid having CERCLA wastes from site response actions authorized or funded under CERCLA contribute to present or future environmental problems by directing these wastes to management units determined to be environmentally sound (preamble to final OSR, 58 Fed. Reg. 49,200, 49,201, Sept. 22, 1993).

The OSR establishes the criteria and procedures for determining whether facilities are acceptable for the receipt of CERCLA wastes from response actions authorized or funded under CERCLA. The OSR establishes both compliance and release criteria, and establishes a process for determining whether facilities are acceptable based on those criteria. The OSR also establishes procedures for notification of unacceptability, reconsideration of unacceptability determinations, and re-evaluation of unacceptability determinations.

EPA verifies the acceptability of off-site treatment, storage, and disposal facilities (TSDFs) on a frequent basis. Consequently, before any off-site shipment occurs, a verification of current acceptability (VCA) must be obtained from EPA certifying that the proposed receiving facility is operating in compliance with the requirements of CERCLA Section 121(d)(3) and 40 C.F.R. § 300.440. EPA (usually the applicable EPA Regional Office) will determine the acceptability under this section of any facility selected for the treatment, storage, or disposal of CERCLA waste. EPA will determine if there are relevant releases or relevant violations at a facility prior to the facility's initial receipt of CERCLA waste. A facility which has previously been evaluated and found acceptable under this rule is acceptable until the EPA Regional Office notifies the facility otherwise pursuant to § 300.440(d).

3.1.4.2 Off-site Transportation Requirements

Under the full or partial excavation alternatives, RIM would be excavated and shipped for off-site disposal. It is currently anticipated that the excavated RIM would be loaded directly into intermodal containers which would be hauled by trucks to a local off-site rail loading facility where they would be loaded on rail cars. Once loaded on rail cars, the intermodal containers containing RIM would be shipped via rail directly to the off-site disposal facility or to a rail unloading facility located near the off-site disposal facility, where the containers would be loaded onto trucks and taken to the off-site disposal facility.

Because transportation to an off-site disposal location would constitute an off-site action, the transportation activities would need to comply with both the substantive and administrative requirements of any regulations applicable to transportation of radiologically-contaminated materials. The U.S. Department of Transportation (DOT) has developed regulations for transport of hazardous materials (49 C.F.R. Parts 100 – 178), including specific regulations related to transport of radioactive materials (49 C.F.R. Parts 171 – 180). These include regulations on hazardous materials communications, emergency response information, training requirements and security plans (49 C.F.R. Part 172) which address special provisions, preparation and retention of shipping papers, packaging and container marking, emergency response, security, and planning. The regulations contain specific requirements associated with shipment of radioactive materials (e.g., 49 C.F.R. §§ 172.310, 172.436-440, and 172.556). Other regulations (49 C.F.R. Part 173) describe requirements for shipment and packaging that are applicable to shippers, including specific requirements for shipment of radioactive materials. Regulations set forth in 49 C.F.R. Part 174 address shipment by rail and include special handling requirements for radioactive materials (49 C.F.R. § 174.700). Required emergency response information is described in 49 C.F.R. Subpart G (49 C.F.R. § 173.602). The NRC, through a Memorandum of Understanding with DOT, also has promulgated regulations related to transport of radioactive materials (10 C.F.R. Part 71).

Requirements established by rail carriers relative to transport of waste materials or radioactive wastes would also be applicable to the full excavation and partial excavation with off-site disposal alternatives. Because the specific carriers that might be used to transport the wastes under these alternatives cannot be identified at this time, identification and evaluation of the carrier-specific requirements has not been performed. This evaluation would be completed if necessary as part of design of the full or partial excavation alternatives that include off-site disposal.

State requirements and fees, including Missouri fees for transport of the RIM (Section 260.392 RSMo), would also potentially be applicable to the full or partial excavation with off-site disposal alternatives. Review, description and detailed evaluation of these requirements is beyond the scope of this FFS, but would be addressed in detail in planning documents in the event the full excavation or partial excavation with off-site disposal alternatives were to be implemented.

As of the writing of this draft FFS, four disposal facilities have been identified that could potentially accept RIM from the Site for off-site disposal:

- U.S. Ecology's facility in Grandview, Idaho,
- U.S. Ecology's facility in Wayne, Michigan,
- Energy*Solutions* facility in Clive, Utah, and
- Clean Harbors' Deer Trail facility in Last Chance, Colorado.

Discussions with representatives of potential off-site disposal facilities in conjunction with preparation of the SFS (EMSI et al., 2011) indicated that most of the facilities would provide a turnkey service that includes transport of the RIM from the Site and disposal. In conjunction with preparation of the SFS, these companies provided unit costs for complete turnkey services for waste profiling and acceptance testing, waste transportation (including all related fees and taxes), and waste disposal services (including all related fees and taxes). Under a turnkey service, the disposal company would be responsible for arranging for transport, preparation of waste/shipping manifests, testing the RIM after they are loaded into transportation vehicles/containers, securing vehicles/containers, unloading vehicles/containers, safety and emergency response plans, and all other aspects associated with transport of RIM from the Site to an off-site disposal facility. Additional discussion with U.S. Ecology in conjunction with preparation of this FFS indicated that they would provide turnkey services for transportation and disposal including all of the related services described above. U.S. Ecology provided updated unit costs for these services for use in preparing this FFS.

3.1.4.3 Waste Acceptance Criteria for Off-site Disposal

Waste Acceptance Criteria (WAC) are established pursuant to the specific permit or license issued to each waste disposal facility and consequently are different for each facility. As part of the evaluation of potential remedial technologies for the full excavation and the partial excavation alternatives that include off-site disposal, potential off-site disposal facilities were identified. The WAC for the off-site disposal facilities were reviewed as part of the prior SFS evaluation and re-examined as part of the FFS to assess the ability of each facility to accept the RIM. Summaries of the WAC for each off-site disposal facility are presented below. Copies of the WAC provided by each of the facilities are contained in Appendix C.

A summary of the WAC for each facility is presented below. As discussed in Section 6, for purposes of this FFS, it has been assumed that any alternative that includes off-site disposal of RIM would entail shipping the material to the US Ecology facility in Grandview Idaho. Comparison of the radionuclide levels in any materials that may be shipped to this facility to this facility's WAC is presented in Section 6.

3.1.4.3.1 U.S. Ecology, Grandview, Idaho

U.S. Ecology - Idaho (USEI) has a RCRA Part B Permit that contains waste acceptance criteria relative to radionuclide levels (Appendix C-1). USEI's WAC (dated March 12, 2015) are listed in the tables below:

USEI Table C.1: Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media

Status of Equilibrium	Maximum Concentration of Source Material	Sum of Concentrations Parent(s) and All Progeny Present
Natural uranium in equilibrium with progeny	<500 ppm / 167 pCi/g (^{238}U activity)	≤ 3000 pCi/g
Refined natural uranium	<500 ppm / 167 pCi/g	≤ 2000 pCi/g
Depleted Uranium	<500 ppm / 169 pCi/g	≤ 2000 pCi/g
Natural Thorium	<500 ppm / 555 pCi/g	≤ 2000 pCi/g
^{230}Th (with no progeny)	<0.1 ppm / ≤ 2000 pCi/g	
Any mixture of Thorium and Uranium	Sum of ratios <1	≤ 2000 pCi/g

USEI Table C.2: Naturally Occurring Radioactive Material (NORM) Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media

Status of Equilibrium	Maximum Concentration of Parent Nuclide	Sum of Concentrations of Parent and All Progeny Present
^{226}Ra or ^{228}Ra with progeny in bulk form	500 pCi/g	≤ 4500 pCi/g
^{226}Ra or ^{228}Ra with progeny in reinforced 1P-1 containers	1500 pCi/g	13,500 pCi/g
^{210}Pb with progeny (Bi & ^{210}Po)	1500 pCi/g	4500 pCi/g
^{40}K	818 pCi/g	N/A
Any other NORM		≤ 3000 pCi/g

USEI is also permitted to accept 11e.(2) mixed waste (Appendix C-1).

3.1.4.3.2 U.S. Ecology, Wayne, Michigan

The US Ecology Michigan facility in Belleville, Michigan (also known as Wayne Disposal), is permitted to accept solid waste, hazardous waste and Naturally Occurring Radioactive Material (NORM) and Technologically Enhanced Radioactive Material (TENORM) waste. US Ecology Michigan has a RCRA Part B Permit that contains waste acceptance criteria relative to hazardous wastes and a NORM/TENORM Waste Addendum that identifies waste acceptance criteria relative to radionuclides (Appendix C-2).

Based on the January 26, 2015 NORM/TENORM Waste Addendum criteria, US Ecology Michigan can accept generally exempt unimportant quantities (as that term is defined in NRC regulations) of source material uniformly distributed in soil or other media provided the total percentage of uranium and/or thorium (Th-232) is less than 0.05% by weight. US Ecology Michigan can accept source material containing natural uranium and thorium (Th-232) provided the sum of the fractions of U-238 activity (pCi/g) / 167 pCi/g plus Th-232 activity (pCi/g) / 55 pCi/g is less than 1. US Ecology Michigan can accept NORM/TENORM waste that contains less than 50 pCi/g Ra-226 and less than 260 pCi/g Pb-210 or that after treatment or blending meets these criteria.

3.1.4.3.3 Clean Harbors, Deer Trail, Colorado

Clean Harbors Deer Trail facility is a fully permitted Subtitle C landfill authorized to treat, store and dispose of a wide variety of hazardous and industrial wastes including RCRA, TSCA ("Mega Rule") and debris for encapsulation. Since December 21, 2005, Deer Trail has been licensed to dispose of Naturally Occurring Radioactive Material (NORM) and Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) wastes. This license was issued by the State of Colorado, Department of Public Health and Environment. Deer Trail can accept NORM and TENORM wastes containing radionuclides (in the decay series of U-238, U-235 and Th-232) up to 2,000 pCi/gram.

The Clean Harbors Deer Trail, Colorado facility WAC dated May 31, 2010 is contained in Appendix C-3. The Deer Trail facility can only accept materials classified by Colorado Regulations as NORM and TENORM (Appendix C-3). Acceptable radionuclides are limited to naturally-occurring radionuclides only, including the radionuclides in the decay series for uranium-238 (U-238), uranium-235 (U-235), and thorium-232 (Th-232), and potassium-40 (K-40). This facility can only accept materials radioactive materials with total activity levels (including all decay progeny) that are less than 2,000 pCi/g and Ra-226 must be less than 222 pCi/g Lead-210 must be less than 666 pCi/g. The Deer Trail facility can accept mixed RCRA/NORM wastes, but additional testing of such wastes may be required.

3.1.4.3.4 Energy*Solutions*, Clive, Utah

The Energy*Solutions* facility can receive two types of wastes. The first type contains both low-level radioactivity and a hazardous waste component, known as mixed waste, and the second type of waste contains only a low-level radioactive component. The mixed wastes operations are regulated by the Utah Division of Waste Management and Radiation Control (DWMRC). Wastes that are only radioactive are also regulated by the Nuclear Regulatory Commission. Energy*Solutions* has an Agreement State Radioactive Materials License issued by the State of Utah that authorizes Energy*Solutions* to receive Class A Low Level Radioactive Waste (LLRW), NORM and Accelerator-Produced Radioactive Material (NARM) waste, Class A Mixed Low-Level Radioactive Waste, 11e.(2) Byproduct Material, Special Nuclear Material, uranium, radium-226 waste, and other forms of radioactive waste. Energy*Solutions* also has a separate license to receive and dispose of uranium and thorium mill tailings byproduct material as defined by Section 11e(2) of the Atomic Energy Act, as amended. EnergySolutions WAC dated October 2015 is contained in Appendix C-4.

Energy*Solutions*' Radioactive Material License allows receipt and disposal of NORM or NARM. that does not include byproduct, source, or special nuclear material and generally contains radionuclides in the uranium and thorium decay series. Because NORM/NARM waste is not considered LLRW, the waste classification regulations do not apply.

Energy*Solutions* is authorized to dispose of waste containing radium-226 (Ra-226) in concentrations not to exceed 10 nCi/gram. Any shipment containing Ra-226 concentrations greater than or equal to 1,000 pCi/g requires written approval by Energy*Solutions* Technical staff. Any shipment containing Ra-226 in soil, soil-like material, or easily dispersal material such as fine rubble or floor sweepings in concentrations $\geq$ 1,000 pCi/g must be packaged in non-bulk containers (*i.e.,* drums or boxes) unless written approval is obtained from Energy*Solutions* Technical staff.

3.1.4.3.5 Other Off-site Disposal Facilities

Several other off-site disposal facilities were identified, including the US Ecology facility in Robstown, Texas; the Waste Control Specialists facility in Andrews, Texas; and the Energy*Solutions* facility in Barnwell, South Carolina. Based on the results of the prior EPA evaluation (TetraTech, 2009), subsequent discussions with representatives of these facilities, and review of the permit limitations or WAC for these facilities, it was determined that disposal of RIM from the Site at these facilities was not likely to be acceptable. Factors anticipated to limit acceptance of RIM from the Site include prohibitions on landfilling of radioactive wastes mixed with other materials, limits on the total or specific radionuclide activity levels, and prohibitions on acceptance of wastes generated outside of particular low-level radioactive waste regional compact areas.

Although disposal of soil containing radionuclides may be acceptable at the US Ecology facility in Richland, Washington (Hanford Nuclear Reservation area), disposal of mixed refuse and soil was not likely to be acceptable at this facility. In addition, as this facility was designed to accept higher activity wastes, disposal fees at the Richland facility are substantially higher than those charged by US Ecology at its Grandview, Idaho or Michigan facilities or at the Energy*Solutions* Clive, Utah facility. Both the prior EPA evaluation (TetraTech, 2009) and evaluations made for the SFS determined that disposal of RIM from the Site at the Richland, Washington facility would be substantially more expensive than disposal at US Ecology's Grandview, Idaho facility.

3.1.4.4 "Stennett Analysis"

In addition to meeting the requirements of EPA's Off-Site Rule (see prior discussion in Section 3.1.4.1), off-site disposal of radioactive material from the West Lake Landfill would also be subject to a "Stennett Analysis." In a June 26, 2000 letter in response to a February 28, 2000 letter from Idaho State Senator Clint Stennett, EPA described the basic requirements of an analysis regarding disposal of pre-1978 byproduct material. The NRC had determined that disposal of such material was outside of its jurisdiction because that material was not licensed (EPA, 2000). EPA's June 26, 2000 letter addressed factors associated with disposal of such unregulated wastes at non-NRC permitted facilities. Such an evaluation is now commonly referred to as a "Stennett Analysis".

A Stennett analysis would require evaluation of the design of the disposal facility, safeguards and controls, and community involvement. The analysis would need to demonstrate that disposal of the waste at a non-NRC-licensed facility would meet the protectiveness criteria established by CERCLA (i.e., constraining excess cancer risk to 10^{-4} to 10^{-6} and a hazard index of less than 1). This analysis would also look at the measures used to protect the health and safety of workers at the off-site disposal facility and the surrounding community. It would also examine the facilities ability to protect groundwater.

Only one (Energy*Solutions* Clive Utah facility) of the four facilities identified in this FFS is currently licensed by the NRC. The other three facilities are licensed by their host state agencies pursuant to RCRA Subtitle C and state radioactive waste management regulations. At least three Stennett Analyses have been performed for the US Ecology Idaho facility, including those related to (1) disposal of soil from Welsbach Superfund Site in Camden New Jersey (USACE, 2016), (2) disposal of radioactive soil from the Denver Radium sites (Walker, 2013), and (3) disposal of radioactive debris from Safety Light Corporation in Bloomsburg, Pennsylvania (USACE, 2012). These analyses determined that disposal of low-level radioactive material at the US Ecology Idaho facility would be protective of worker and community health and safety.

Because of the site-specific nature of the waste materials, if material from West Lake Landfill were to be disposed at one of the three off-site disposal facilities that are not licensed by NRC, a Stennett Analysis would need to be performed during remedial design. Based on the results of the prior Stennett Analyses previously performed for the US Ecology Idaho facility and the fact that the Energy*Solutions* facility is regulated by NRC, this requirement is not expected to affect the feasibility of off-site disposal of material from West Lake Landfill.

3.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are developed based on contaminants, media of interest, and exposure pathways that permit a range of containment and treatment alternatives to be developed. RAOs are developed based on chemical-specific ARARs and site-specific risk-related factors.

The NCP sets forth a requirement to "establish remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals" [40 C.F.R. § 300.430 (e)(2)(i)]. The RAOs are developed based on chemical-specific ARARs and site-specific risk-based cleanup levels, serve as a basis for developing and assessing remedial action alternatives, and describe what the remedial alternatives need to accomplish in order to be protective of human health and the environment. In particular, the development of the RAOs is based on contaminants, media of interest, and exposure pathways that permit a range of containment and treatment alternatives to be developed. Specific remediation goals (RGs) are developed consistent with protective ARARs. If ARARs are not available or are not sufficiently protective due to multiple contaminants or multiple pathways, then RGs are based on site-specific risk-based cleanup levels.

The following RAOs are identified for West Lake Landfill OU-1:

a. Prevent direct contact to contaminated media (including waste material, fill, stormwater, sediments, leachate and groundwater) located on or emanating from OU-1.

b. Prevent exposure by inhalation and external radiation from contaminated media (including waste material, fill, leachate, and gas emissions) located on or emanating from OU-1 that exceed the more stringent of a 10^{-4} to 10^{-6} risk (or a Hazard Index of 1 for non-carcinogenic risk) or other health-based standards identified in the ARARs.

c. Minimize infiltration to prevent contaminants from leaching to groundwater in excess of MCLs, or if there is no MCL, other standards identified by the ARARs.

d. Control and manage leachate to ensure that groundwater and surface water are protective of reasonably anticipated use.

e. Control and treat landfill gas from OU-1, including radon to ensure that there is no residential exposure off-site or to site workers and trespasser.

f. Additional RAO for Lot 2A2 – Remediate soils to the extent necessary to meet unrestricted use criteria in this area.

Groundwater will be further evaluated separately as part of the anticipated "OU-3" investigations directed by EPA.

3.3 Cleanup Levels

This section describes the preliminary remediation goals (PRGs) or "cleanup levels" that are used to define the various remedial alternatives evaluated in the FFS.

3.3.1 ROD-Selected Remedy and UMTRCA Cover Alternative Cleanup Levels

Because the ROD-selected remedy and the UMTRCA cover alternative are containment remedies, no specific cleanup levels would apply to the portions that are covered. Any engineered landfill cover that would be installed under either of these alternatives will extend as necessary to comply with all ARARs.

Any portions of OU-1 that are not expected to receive an engineered cover and that are determined to be impacted by radioactive materials from the Site, such as Lot 2A2, will require cleanup levels consistent with the ARARs and TBCs determined for the Site so long as a Site-specific evaluation of risk demonstrates the cleanup level is protective under CERCLA.

3.3.2 Full Excavation Alternatives

Although the UMTRCA standards are not applicable, they are potentially relevant and appropriate for OU-1 and represent standards that have been established by the EPA for remediating radionuclide occurrences to allow for unrestricted use so long as a site-specific evaluation of risk demonstrates these levels are protective. The cleanup levels for the full excavation alternative are based on the UMTRCA standards (40 C.F.R. Part 192 Subpart B) for cleanup of so-called "vicinity properties". Although the UMTRCA standards are not applicable or appropriate for the landfill portion of OU-1 that will be capped with an engineered cover (see prior discussion in Section 2.2.3), they do represent standards that have been established by EPA for remediating radionuclide occurrences to allow for unrestricted use. EPA has indicated that "[o]ne intent of the 'complete rad removal' alternatives, if implemented, would be to leave disposal areas 1 and 2 in a condition that would not require additional engineering and institutional controls due to their radiological content, if feasible." (EPA, 2010a). The standards established pursuant to 40 C.F.R. Part 192 Subpart B are intended to allow for unrestricted use of land relative to radionuclide occurrences at so-called "Title I" sites and therefore are not applicable to OU-1. The Site would still contain MSW and other wastes even if RIM were removed at levels above the UMTRCA standard. Therefore, the remaining wastes would still be subject to the solid waste regulation requirements including installation of an engineered landfill cover and institutional controls that prohibit residential land use (although the engineered cover would not have the same requirements as those specified in UMTRCA Subpart A).

Based on the evaluations presented in Section 2.2.3, the radiological cleanup levels specified in OSWER directive 9200.4-25 are total Ra-226 + Ra-228 greater than 5 pCi/g (above background) and total Th-230 + Th-232 greater than 5 pCi/g (above background). For purposes of performing the evaluations in this FFS for the full excavation alternative, an initial cleanup level of 50 pCi/g plus background (54.5 pCi/g) was evaluated for uranium. This value was selected based on values established by EPA for the uranium remediation goals for the St. Louis Downtown Site (SLDS) [EPA, 1998b] and the St. Louis Airport Site (SLAPS) (EPA, 2005a).

The proposed uranium cleanup level of 54.5 pCi/g for the full excavation alternatives was subjected to additional analyses to assess the protectiveness of this level. Although the Site-specific BRA is not being used to justify the cleanup values presented above, comparisons between the BRA results and the cleanup levels derived from the UMTRCA regulations as described above do provide an additional qualitative line of evidence that the cleanup levels will be protective of human health. The highest cancer risk levels calculated in the BRA for uranium were for a future storage yard worker at Area 2 and corresponded to 6.6×10^{-6} for total uranium (1.5×10^{-6} for uranium-238, 2.0×10^{-6} for uranium-234, and 3.1×10^{-6} for uranium-235). These risk estimates were based on 95% upper confidence limit (UCL) values for uranium-238, uranium-234, and uranium-235 activity levels of 42.2, 51.5, and 2.64 pCi/g, respectively, which together are approximately twice the value of the proposed cleanup criteria of 50 pCi/g plus background. Therefore, the risk level associated with the proposed cleanup level would be within EPA's acceptable risk range. Note that because site samples contain natural uranium, the activity concentration of uranium-235 in the samples must be approximately 5% of the activity concentration of either uranium-238 or uranium-234. The BRA determined that uranium did not pose a non-carcinogenic risk to the maximally exposed individual (MEI), which consists of potential future outdoor storage yard workers in Areas 1 and 2.

The protectiveness of the proposed uranium cleanup level was also evaluated using the procedure set forth in NRC regulations 10 C.F.R. 40 Appendix A Criterion 6(6). Criterion 6(6) states:

> *Byproduct material containing concentrations of radionuclides other than radium in soil… must not result in a total effective dose equivalent (TEDE) exceeding the dose from the cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as reasonably achievable. If more than one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed "1"(unity). A calculation of the potential peak annual TEDE within 1000 years to the average member of the critical group that would result from the standard (not including radon) on the site must be submitted for approval.*

The proposed remediation goal for combined U-238, U-235 and U-234 was evaluated by EPA using the benchmark dose approach defined in 10 C.F.R. 40, Appendix A, Criterion 6(6). EPA calculated the total dose from exposure to 5 pCi/g radium-226 in the upper 6-inches (15 cm) of soil (without radon contribution) by an outdoor storage yard worker via all exposure routes (e.g., outdoor ingestion and inhalation and indoor ingestion and inhalation) using EPA's Dose

Compliance Calculator (DCC) to be 5.19 mrem/yr (Appendix O). Because this dose is less than 12 mrem/yr, per OSWER Directive, this benchmark dose would be protective. The 50 pCi/g cleanup level (before the addition of background) is expected to contain equal parts of U-238 and U-234 and U-235 equal to 5% of the U-238 activity, resulting in expected activity levels of 24.4 pCi/g for U-238 and U-234 and 1.22 pCi/g for U-235. The expected dose to an outdoor storage yard worker from these levels of uranium was calculated using the DCC. The results of these calculations are presented in Appendix O. The projected total dose from the uranium isotopes and their progeny was estimated by EPA to be 1.04 mrem/yr which is less than the projected dose from the 5 pCi/g radium cleanup level. Therefore, the proposed uranium cleanup level of 50 pCi/g plus background is protective. Additional evaluation of the uranium cleanup level may be performed during remedial design.

A uranium remediation goal of 50 pCi/g is equivalent to a mass-based, elemental uranium concentration of 71 mg/kg. This goal was derived for the West Lake Landfill OU-1 using the same approach as that used for SLAPS, which is part of the North St. Louis sites, for potential carcinogenic risks. EPA's current non-carcinogenic screening level for elemental uranium is 230 mg/kg for commercial/industrial land uses[22]. As the mass-concentration of the uranium remediation goal is less than EPA's current non-carcinogenic screening levels (71 mg/kg < 230 mg/kg), the uranium remediation goal of 71 mg/kg (50 pCi/g) represents a more conservative cleanup target than EPA's current non-carcinogenic screening level for elemental uranium and residual uranium concentrations equal to or less than 50 pCi/g plus background (54.5 pCi/g) will not pose any non-carcinogenic risks.

EPA's radionuclide preliminary remediation goal (PRG) calculator was used[23] to evaluate risks to a composite worker exposed to 50 pCi/g of elemental uranium using calculator default parameters. The individual PRGs for a 10^{-6} risk target calculated for the individual isotopes that make up natural uranium were: 31.2 pCi/g for uranium-234, 0.433 pCi/g for uranium-235, and 27.8 pCi/g for uranium-238. The risk from 50 pCi/g of natural uranium[24] in the same scenario is approximately 4.3×10^{-6}, which is in the lower region of the CERCLA acceptable risk range of 10^{-6} to 10^{-4}, supporting the observation that the proposed cleanup level of 54.5 pCi/g will be protective for both carcinogenic and non-carcinogenic risks.

Use of the proposed cleanup levels for combined radium, combined thorium and combined uranium for the so-called full excavation alternative would not result in complete removal of all radionuclides from the Site. Rather, this alternative is intended to result in removal of radionuclides to a level such that engineering measures and institutional controls intended to

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[22] https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017

[23] EPA Radionuclide PRG calculator run performed on August 18, 2017.

[24] 50 pCi/g of natural uranium contains 24.3 pCi/g of uranium-238, 1.12 pCi/g of uranium-235 and 24.6 pCi/g of uranium-234.

address radionuclide occurrences would no longer be required. EPA's policies pursuant to CERCLA and the NCP do not require removal of all radionuclides.

EPA has defined the full excavation alternative to mean attainment of the risk-based radiological cleanup levels specified in OSWER directives 9200.4-25 and 9200.4-18. These directives provide guidance for establishing protective cleanup levels for radioactive contamination at CERCLA (Superfund) sites. In particular, these directives provide clarification as to the use of the UMTRCA soil cleanup criteria as remediation goals at CERCLA sites. The UMTRCA soil cleanup criteria are based on concentrations above background levels. Similarly, EPA has stated elsewhere that CERCLA cleanup levels are not set at concentrations below natural background levels (EPA, 2002). As a result, the cleanup standards to be used for the development and evaluation of the full excavation alternative are background-based standards. Determination of background levels is an important part of the development of the soil cleanup levels for the full excavation alternative.

As with any set of data, background values are subject to variability. By definition, the mean background value represents the central tendency of the background data set, but does not incorporate any measure of the variability of the background data set. Values greater than the mean value may nonetheless be representative of background conditions. Therefore, some measure of the variability of the background data is necessary to define the uncertainty associated with the mean of the background values. A common type of value for the interval around an estimate is a "confidence interval." A confidence interval may be regarded as combining an interval around an estimate with a probabilistic statement about the unknown parameter. Confidence intervals are based on the standard deviation of the data set and published statistical values defining population distributions.

Background concentrations of the various isotopes of radium, thorium and uranium are presented in Section 6.2 of the RI report (EMSI, 2000). These background concentrations were determined using analytical results from samples collected at four background locations. In order to account for the variability in the background results, the representative background values used in the RI are the mean values of the four results plus two standard deviations. Use of two standard deviations reflects the critical value of 1.96 used to calculate the 95% confidence limit for a normally distributed population with a large number (greater than 30) of sample results. Specifically, through repeated sampling, the true mean value is expected to fall within a range defined by two times the standard deviation 95% of the time. For smaller sample sizes, the critical values are larger. In the case of a sample set consisting of four data values, the critical value would be 2.35. Therefore, use of a value of two is a reasonable, yet slightly conservative (more protective), method of estimating the variability of the background values.

The mean background concentrations and the mean background concentrations plus two standard deviations were presented in the RI report (EMSI, 2000) and are listed below.

Collection of additional background samples to provide a larger data set for use in estimating background values, or incorporation or use of background values obtained from other studies conducted in the general area of the Site (such as SLAPS) may provide a better estimate of the background values, but these efforts are outside the scope of–and are not necessary for–completion of this FFS.

Parameter	Mean of the background sample results	Standard deviation of the background sample results	Mean value plus two standard deviations
Radium-226	1.06	0.12	1.30
Radium-228	1.65	0.36	2.37
Thorium-230	1.51	0.47	2.45
Thorium-232	0.90	0.33	1.55
Uranium-238	1.33	0.46	2.24
Uranium-235	0.39	0.38	1.15
Uranium-234	1.47	0.63	2.73

All values reported as pCi/g

Each of these radionuclides is a member of either the U-238 or the Th-232 decay chain. The short-lived members of these chains are normally in equilibrium with longer-lived progenitors in the same chain. For example, Th-232 and Ra-228 are members of the Th-232 decay series and should be in equilibrium with each other. As can be observed in the results listed above, the Th-232 and Ra-228 results are noticeably different. These differences likely result from variations in the analytical results obtained from the four samples, combined with the effects of averaging the results and incorporation of two standard deviations about the results to address the overall variability of the sample results.

In order to address the difference in activity levels of the parent and daughter radionuclides for purposes of the FFS, the representative background concentration for all short-lived members of a decay chain were set to the lowest value calculated for any member in the chain. This is a small adjustment that results in a slightly lower derived concentration guideline (DCGL). In the case of the Th-232 series, the background concentration of all members of the Th-232 series was set to 1.55 pCi/g for this FFS. Applying this same logic to the remaining radionuclides, the background values to be used for series nuclides in this evaluation are as follows:

- Radium-226 = 1.3 pCi/g
- Radium-228 = 1.55 pCi/g
- Thorium 232 = 1.55 pCi/g (parent of Ra-228)
- Thorium-230 = 1.3 pCi/g (parent of Ra-226)

- Uranium-238 = 2.24 pCi/g (parent of U-234)
- Uranium 234 = 2.24 pCi/g (parent of Th-230)

These values are comparable to the following background values identified for SLAPS (EPA, 1998b):

- Radium-226 = 2.8 pCi/g
- Radium-228 = not identified
- Thorium 232 = not identified
- Thorium-230 = 1.9 pCi/g
- Uranium-238 = 1.4 pCi/g
- Uranium 234 = not identified

The resultant cleanup levels are the sum of the representative background concentrations and the appropriate risk-based remediation concentrations listed in the OSWER directives (*i.e.*, 5 pCi/g plus background). Based on the Site background values presented in the RI and RI Addendum (EMSI, 2000 and 2016a), the Site cleanup values would be as follows:

- Radium-226+228 = 7.9 pCi/g[25]
- Thorium-230+232 = 7.9 pCi/g
- Total uranium = 54.5 pCi/g

For purposes of this FFS, these cleanup values were used to identify the Site soils that would be included with the scope of the full excavation alternative and that would otherwise be used to define the extent of any engineered landfill cover that may be included within the scope of the ROD-selected remedy, UMTRCA cover alternative, or the partial excavation alternatives. Any engineered landfill cover that would be installed under either of these alternatives will extend as necessary to comply with all ARARs. For Lot 2A2, which would not be capped, these cleanup values would be used to identify soil containing radionuclides that would be removed from these areas and either consolidated with the other material in OU-1 or shipped to an off-site disposal facility. In the event that the Buffer Zone is used for something other than regrading of the Area

[25] Total radium DCGL = 1.3 pCi/g radium-226 + 1.6 pCi/g radium-228 + 5 pCi/g radium cleanup level = 7.9 pCi/g total radium

2 slope, such as for a future stormwater detention basin, these standards may also be used to identify soil to be removed from this parcel.

3.3.3 Partial Excavation Alternatives Cleanup Levels

EPA specified three potential partial excavation alternatives for evaluation in the FFS (EPA, 2015a):

1. Partial Excavation 1,000 pCi/g – Excavation of all soil/waste containing combined radium (radium-226 plus radium-228) or combined thorium (thorium-230 plus thorium-232) with activity levels greater than 1,000 pCi/g;

2. Partial Excavation 52.9 pCi/g – Excavation of all soil/waste containing combined radium or combined thorium with activity levels greater than 52.9 pCi/g down to a total depth of 16 feet beneath the 2005 topographic surface; and

3. Partial Excavation Based on Risk-Based Levels – Partial excavation of all soil/waste containing combined radium or combined thorium with activity levels greater than a risk-based level based on the reasonably anticipated future land use of the Site (industrial use).

The 1,000 pCi/g value is based in part on the criterion used in the original 2006 FS to define potential "hot spots." EPA has also indicated that a value of 1,000 pCi/g is consistent with what it has defined elsewhere as high-activity tailings. OSWER Directive 9200.4-25 states, "The criterion for subsurface soil was derived as a tool for use in locating and remediating discrete deposits of high activity tailings (typically 300-1000 pCi/g) in subsurface locations at mill sites or at vicinity properties." Also noteworthy is the Final Environmental Impact Statement (FEIS, 1983) for Standards for the Control of Byproduct Materials from Uranium Ore Processing (40 C.F.R. 192) Volume I. The FEIS states on pages 3-4, "The ore grade at the different mills typically varies from 0.15 percent to 0.3 percent uranium, and the radium concentration (and presumably other radionuclides in the Uranium-238 decay series) varies from 200 pCi/g to 900 pCi/g." Also provided in the FEIS are Tables 3-1 and 3-3, which indicate radium concentrations at licensed mills up to 850 pCi/g, and average concentrations of radium in inactive uranium mill tailings up to 1000 parts per trillion. It should be noted that installation of an engineered landfill cover, which is included as part of all of the alternatives, would achieve a calculated risk of approximately 10^{-6}, within EPA's acceptable risk range.

The partial excavation alternatives were discussed with EPA during a meeting on September 24, 2013. EPA recently stated that the 16-foot depth alternative was previously identified based on a qualitative determination, conducted prior to the additional characterization investigation, that a large portion of the RIM was present above this depth and materials could be excavated to this depth utilizing common excavation practices. EPA also recently stated that excavation of RIM that exceeds 52.9 pCi/g of combined radium or combined thorium to a depth of 16 feet also eliminates any future exposures that would result in a risk greater than 10^{-3}, assuming that sufficient fill or other non-RIM materials are placed back on the surface of the landfill. The EPA's guide to Principal Threat and Low Level Threat Wastes states that while there is no "threshold level" of toxicity/risk that has been established to equate to "principal threat," treatment alternatives should be evaluated where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater. It should be noted that installation of an engineered landfill cover, which is included as part of all of the alternatives, would achieve a calculated risk of approximately 10^{-6}, within EPA's acceptable risk range.

The third partial excavation alternative includes removal of RIM to the extent that the remaining material would be protective of future industrial uses (*i.e.*, outdoor storage yard worker) in Areas 1 and 2. Per EPA direction, this alternative was evaluated without consideration of the presence of any new engineered cover over these areas. This assumption is required despite the fact that a new landfill cover is required to comply with ARARs, and is therefore included in the scope of all of the remedial alternatives, including this industrial land use partial excavation alternative. Any remedial action that would be taken at the Site, including the industrial land use partial excavation alternative, will require regrading of the surface of Areas 1 and 2 to achieve the minimum and maximum slope angles allowed under the Missouri Solid Waste Regulations. Regrading of the surfaces of Areas 1 and 2 will require cutting (excavating) waste materials from some portions of these areas and relocation of this waste material to other portions of these areas. It may also require importation of clean fill (soil or inert fill) in order to achieve the required minimum slope angles. For purposes of evaluation of any alternative that includes large amounts of excavation, such as the full excavation alternative and the other partial excavation alternatives, it is assumed the final surface would achieve a minimum slope angle of 5% per the Solid Waste Regulations, in contrast to the minimum slope angle of 2% associated with the capping alternatives. Projected radon emissions, direct contact with radium in soil/waste materials, and gamma exposures were evaluated to identify RIM that would need to be removed to be protective of an industrial worker and to comply with ARARs in the absence of an engineered cover.

4 TECHNOLOGY SCREENING

The technology screening process in a CERCLA FS involves identifying General Response Actions (GRAs) that may be applicable for development of remedial alternatives based on the site characterization results and the RAOs established for the site or the operable unit. Potential remedial action technologies associated with each GRA that may be applicable to addressing the site characterization results and satisfying the RAOs are first identified and screened based on technical implementability. The resultant technologies are then evaluated based on anticipated effectiveness, implementability, and relative cost to identify the most applicable technologies. These technologies are then combined to develop remedial action alternatives for the FS.

In identifying potential GRAs and technologies, EPA's expectations with respect to developing appropriate remedial alternatives should be considered. These expectations are included in the National Contingency Plan (NCP) at 40 CFR §300.430(a)(iii), specifically:

- EPA expects to use treatment to address the principal threats posed by a site, wherever practicable. Principal threats for which treatment is most likely to be appropriate include liquids, areas contaminated with high concentrations of toxic compounds, and highly mobile materials;

- EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable;

- EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of the principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls, as appropriate, for treatment residuals and untreated waste;

- EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants;

- EPA expects to consider using innovative technologies when such technologies offer the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies; and

- EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site.

Because of the presence of radionuclides in the waste material in Areas 1 and 2 of OU-1 at the West Lake Landfill Superfund Site, EPA's Technology Reference Guide for Radioactively

Contaminated Media (EPA, 2007) is used as a reference for technologies that can effectively treat environmental media at radioactively contaminated sites. This guidance document states that the special characteristics of radioactive material in a waste constrain the technologies available to address site characterization results and satisfy RAOs. These special characteristics should be considered in light of the NCP's preference for treatment. The Technology Reference Guide for Radioactively Contaminated Media states:

> [U]nlike non-radioactive hazardous waste, which contains chemicals alterable by physical, chemical, or biological processes to reduce or destroy the hazard, radioactive waste cannot be similarly altered or destroyed. Since destruction of radioactivity is not an option, response actions at radioactively contaminated sites must rely on measures that prevent or reduce exposure to radiation.
>
> The concepts of "Time, Distance and Shielding" are used in radiation protection. Increasing the distance from radioactive material, increasing the shielding between the radioactive material and the point of exposure, and/or decreasing the time of exposure to radioactive material will rapidly reduce the risk from all forms of radiation. The concept of time as used in waste stream management and remediation has an additional meaning. Time allows the natural radioactive decay of the radionuclide to take place, resulting in reduction in risk to human health and the environment. Therefore all remediation solutions involve either removing and disposing of radioactive waste, or immobilizing and isolating radioactive material to protect human health and the environment.

EPA's reference guide includes 13 treatment technologies that can potentially be applied to radioactively-contaminated solid media. Descriptions of these technologies are included in Section 4.3.

Previously, GRAs were identified and technologies were screened and evaluated and used to develop the remedial alternatives in the FS (EMSI, 2006). Additional GRAs and technologies were identified and evaluated in the Supplemental Feasibility Study (SFS) (EMSI et al., 2011) as part of the evaluation of the two "complete rad removal" alternatives. In the SFS, some technologies that were screened out or not retained in the FS were revisited, and additional technologies from the Technology Reference Guide for Radioactively Contaminated Media (EPA, 2007) were evaluated relative to the development of the two "complete rad removal" alternatives. Because EPA added partial excavation alternatives for the FFS evaluations, the technologies that were previously evaluated in the FS (EMSI, 2006) and the SFS (EMSI et al., 2011) were re-examined. EPA also identified additional technologies for consideration in the FFS (EMSI, 2016a) such as volume separation/volume reduction techniques and apatite/phosphate-based treatment, which are also evaluated in this section.

4.1 Technologies Evaluated in the FS Report

The results of the technical implementability screening and evaluation of technologies previously conducted for the Site are presented in Figures 4-1 and 4-2 of the FS (EMSI, 2006). GRAs and retained technologies and process options within the technologies included:

General Response Action	Remedial Technology	Process Options
No Action		
Institutional Controls	Access Restrictions	• Fences and guards
	Proprietary Controls	• Deed restrictions • Deed notices • Easements • Covenants • Groundwater use restrictions
Monitoring	Long-term Performance Monitoring	• Groundwater, surface water, and sediment monitoring
Containment	Surface Controls/Diversions	• Diversion/collection, grading, swales and berms, and vegetation to isolate storm water from Areas 1 and 2
	Surface Water/ Sediment Control Barriers	• Sediment traps, sedimentation basins
	Dust Controls	• Revegetation, capping
	Capping and Covers	• Soil, clay, and vegetation; asphalt or concrete; synthetic membrane material; and multilayer, multimedia material
Physical Treatment/Pre-Treatment following Removal	Solids Separation	• Soil sorting and screening
Removal	Excavation	• Backhoe, bulldozer, scraper, and front-end loader
	Disposal	• Off-site disposal in licensed facility • On-site disposal on Area 2 (for surface soil from Buffer Zone/Crossroad property)

4.2 Additional Technology Evaluations/Revisit Previously Eliminated Technologies

In its January 11, 2010 letter and accompanying Statement of Work (SOW) for the SFS (EPA, 2010a), EPA identified two "complete rad removal" alternatives to be developed and evaluated in the SFS:

- Excavation of radioactive materials with off-site commercial disposal of the excavated materials ("complete rad removal" with off-site disposal alternative); and

- Excavation of radioactive materials with on-site disposal of the excavated materials in an on-site engineered disposal cell with a liner and cap if a suitable location outside the geomorphic flood plain can be identified ("complete rad removal" with on-site disposal alternative).

Development and evaluation of the "complete rad removal" alternatives required amendment of several remedial technologies and process options included in the FS, and inclusion in the SFS of a few technologies that were screened out in the FS. These same technologies were retained for the FFS. As required by the SOW, additional technologies were also evaluated in the FFS including apatite/phosphate-based treatment, physical separation, and radiological segregation. All of the technologies and process options evaluated in the FFS are listed below and presented on Figure 4-1.

Figure 4-1 is a graphical presentation of the technical implementability screening of remediation technologies and process options and provides a brief description for each of the potential technologies. In addition to the volume separation/volume reduction techniques and apatite/phosphate-based treatment volume/size reduction technology, the technologies and process options listed below were added to the technical implementability screening in this FFS to potentially be considered as components of the full excavation and partial excavation alternatives. Long-term performance monitoring and short-term monitoring during construction – two specific process options under the "monitoring" GRA that were discussed in general in the FS – are described in more detail in this section. Technical implementability screening comments are also included for each technology on Figure 4-1.

General Response Action	Remedial Technology	Process Options
Monitoring	Long-term performance monitoring Short-term monitoring during construction	• Landfill and radon gas monitoring • Perimeter environmental media air monitoring • Work zone monitoring • Excavation guidance/ clearance monitoring

General Response Action	Remedial Technology	Process Options
		• Waste acceptance monitoring • Post cover construction radon flux monitoring
Containment	Land encapsulation	• On-site: new cell • Off-site licensed facility
	Cryogenic Barriers	• Subsurface cryogenic barrier
	Vertical Barriers	• Slurry wall • Grout curtain • Sheet pile cutoff wall
Physical/Chemical Treatment	Solidification/ Stabilization	• Cement solidification / stabilization • Chemical solidification / stabilization
	Chemical Separation	• Solvent/chemical extraction
	Physical Separation	• Dry soil separation • Soil washing • Flotation
	Vitrification	• In-situ vitrification • Ex-situ vitrification
	Apatite/Phosphate-Based Treatment	• Mixing/injection of crystalline minerals with wastes or groundwater
Biological Treatment	Phytoremediation	• Phytoextraction • Phytostabilization
Removal	Physical Separation	• Dry soil separation • Rotating screen – Trommel • Radiological Segregation/Separation
	Transportation (hauling of wastes and construction material)	• On-site off-road trucks • Off-site on-road trucks • Rail
	Disposal	• Off-site disposal in a licensed facility
Nuisance Control Technologies	Storm Water Management	• Best Management Practices (BMPs) to route runon around working areas • BMPs to minimize waste exposure to direct precipitation

General Response Action	Remedial Technology	Process Options
		• Enclose excavation with temporary structure • BMPs to collect, detain, treat, and release runoff
	Bird Nuisance Mitigation	• BMPs: excavation, staging, soil/tarp covers • Enclose excavation with temporary structure • Grids over exposed refuse • Visual deterrents • Auditory frightening devices • Chemical frightening agents or toxicants
	Fugitive Dust/Odor Control	• Best management practices to cover excavation and stockpile areas during non-working periods • Use of water spray/misting, foam, or chemical agents to minimize dust generation and control odors • Use of a temporary building over excavation or waste sorting/loading areas

4.3 Descriptions of Additional Technologies

The technologies and process options that were added in the SFS or the FFS to be considered as potential components of the full excavation and partial excavation alternatives are described and discussed in the following subsections.

4.3.1 Monitoring

Environmental monitoring is a technology used to assess the levels of chemical or radiological constituents in environmental media at a site.

4.3.1.1 Long-term Performance Monitoring

In addition to long-term groundwater and surface water monitoring, samples of landfill gas and radon could be collected at landfill gas monitoring probes installed around the periphery of those areas where solid waste and radionuclides would still be present after implementation of the remedy. Landfill gas monitoring is a potential component of all remedial alternatives if sufficient landfill gas is expected to be generated post-remediation to require such monitoring.

4.3.1.2 Short-term Monitoring During Construction

Short-term monitoring activities that might be required during implementation of any of the alternatives could include perimeter environmental media air monitoring, work zone monitoring, excavation guidance/clearance monitoring, waste acceptance monitoring, and post-cover construction radon flux monitoring. A detailed monitoring plan would be developed as part of RD of the selected remedy.

Perimeter and local area environmental media air monitoring would use: fixed monitoring stations containing low volume air samplers to collect airborne particulates and organic vapor samples for analysis of VOCs and radionuclide activity; continuous radon monitors; and radiation dosimeters. Air quality would be monitored during construction of the remedy. Concentrations of chemicals and radionuclides would be measured in areas where non-remediation workers might congregate and at the fence line. These measured air concentrations would be compared to air quality objectives for the remedy to assure that non-remediation workers who might be present in other portions of the Site, as well as members of the general public, would not be exposed to radiation from the remediation activities. It is anticipated that the air quality objectives for the remedy would be health-based standards designed to satisfy Missouri State (10 CSR, Chapter 6) and Federal (40 CFR Part 61) requirements.

Regarding remediation workers, work zone monitoring activities would involve surveillance of working conditions during remediation. Air quality would be monitored in work areas and the breathing zone surrounding individual workers using fixed and portable air samplers. Air samples would be analyzed for a variety of potential RIM constituents, including radionuclides in particulate form, radon, radon daughters, along with asbestos, selected metals such as arsenic, lead, and chromium, and explosive gases. Ambient radiation would be monitored using hand-held radiation detectors and personal dosimeters issued to individual workers. Remediation workers would participate in a medical monitoring program.

Excavation guidance/clearance monitoring would involve the use of walkover field radiological survey equipment and solids sampling to identify impacted materials above cleanup levels and to guide excavation equipment. To document that RIM has been removed, clearance monitoring would include final walkover radiological scans of exposed faces and bases of excavated areas as well as sampling of soil/MSW at the base of excavations.

If excavated RIM would be disposed off-site, waste acceptance monitoring would entail the scanning of each load of material removed from the Site to verify that the radiological waste acceptance criteria of the facility where the RIM would be disposed is met. The material would also be inspected and tested as necessary to determine whether the waste materials contain or could be classified as hazardous wastes or contain asbestos. Discussions with potential disposal facilities indicate that the facilities would conduct these inspections and testing, including providing the necessary personnel and equipment, since such testing is a requirement of their RCRA permits.

After construction is complete for the final cover systems associated with the ROD-selected remedy or the partial excavation alternatives, Large Area Activated Charcoal Canisters would be used to measure radon flux of the cover surface.

4.3.2 Containment

Because most radionuclides require long-term management, remedies for radioactively-contaminated sites usually employ containment technologies. Containment technologies are designed to isolate contaminated materials to prevent exposure to humans and the environment. Some containment technologies are designed to prevent horizontal contaminant migration, some to prevent vertical migration, and others to prevent any form of migration. Four containment technologies are included in the Technology Reference Guide for Radioactively Contaminated Media: capping and covers (containment in place); land encapsulation (excavation and disposal, on-site or off-site); cryogenic barriers (containment in place); and vertical barriers (containment in place) (EPA, 2007).

4.3.2.1 Capping and Covers

Covers, or caps, are the primary component controlling the release of contaminants from hazardous and radiological waste-disposal facilities to the environment (Smith, 1999).

A contaminated area can be capped by placing low permeability surface seal barriers such as caps and covers on top of the area. Capping of soil and waste could effectively limit airborne emissions and reduce precipitation-enhanced percolation, infiltration, and leaching. A variety of materials, including soils, admixtures, and synthetic membranes, can be used in the construction of caps and covers depending on the design considerations for the cap or cover. Factors influencing the selection of materials and the design include the desired functions of cover materials, waste characteristics, climate, hydrogeology, projected land use, and availability, service life, and costs of cover materials.

For Areas 1 and 2 of OU-1 at the West Lake Landfill, asphalt or concrete covers were screened out because of potential cost and maintenance requirements and because such materials are inconsistent with the cover design requirements of the UMTRCA and Subtitle D regulations. Synthetic membrane and multilayer/multimedia material covers were screened out during the original FS (EMSI, 2006) because they are inconsistent with the existing landfill cover and RCRA cover requirements. Such technologies were included in the FFS in conjunction with design of an UMTRCA cover and per a prior EPA requirement to evaluate alternative cover designs. The use of soil, clay, and vegetation layer covers were retained. Therefore, an engineered landfill cover consisting of natural materials such as soil, clay and vegetation layers was the primary type of landfill cap considered in the FS and the subsequent SFS. In addition, for Areas 1 and 2, surface preparation such as filling of surface depressions and overall grading (cutting and filling) is likely necessary to achieve minimum surface grades for drainage prior to any cap or cover placement.

The design of the landfill cover system considered in the FS (EMSI, 2006) and SFS (EMSI, 2011) was based on the requirements set forth in the RCRA Subtitle D regulations and the equivalent State of Missouri solid waste regulations, as supplemented by performance standards of UMTRCA. The standard RCRA Subtitle D (solid waste) landfill cover system may need to be enhanced as necessary to provide additional thickness for gamma shielding and/or radon attenuation, to prevent biointrusion by burrowing animals, and to provide some type of marker layer to identify the presence of waste materials. In addition, a geosynthetic liner such as a geosynthetic clay liner (GCL) may be incorporated into the cover design if needed, to provide for an even lower permeability layer to further restrict precipitation infiltration.

For the FFS, a cover system meeting the UMTRCA performance standards was developed and evaluated. There is no standard UMTRCA project disposal cell design, and such cells were designed specifically to perform properly for each individual site (Lommler, et al., 1999). The major objectives of an Uranium Mill Tailings Remedial Action (UMTRA)[26] project cell design are to provide stable encapsulation of uranium mill tailings, including containment of tailings materials (solids) for up to 1,000 years, reduction of radon emanations (gases) to below regulatory limits (20 pCi/m^2/sec), and protection of ground water from tailings fluid infiltration (liquid) (Lommler, et al., 1999).

Current goals of an UMTRA cover system are to limit infiltration of moisture and inhibit release of gases (Smith, 1999). The UMTRA Technical Approach Document Revision II (DOE, 1989) presented a "checklist" cover with the individual components selected on a site-specific basis. Objectives of the checklist cover from this UMTRA document are:

- Control erosion
- Limit infiltration
- Provide freeze-thaw protection
- Inhibit radon emanation

[26] The Uranium Mill Tailings Remedial Action (UMTRA) Project was created by the United States Department of Energy (DOE) to monitor the cleanup of uranium mill tailings under UMTRCA.

- Drain or shed precipitation
- Control biointrusion
- Be self-renewing and adaptable to climate change if vegetation is used.

An example profile of such a cover is provided as Figure 4-2.

4.3.2.2 Land Encapsulation: New On-Site Cell

Land encapsulation is a well-proven and readily implementable containment technology that is generally used at the disposal stage of radioactive waste management. Land encapsulation can either occur on-site or off-site if the waste is transported to an off-site land encapsulation facility (EPA, 2007).

As discussed in the SFS (EMSI, 2011), an on-site disposal alternative that includes a disposal cell located in the area of the current Bridgeton Landfill soil stockpile/borrow area may not be able to meet all of the location-specific ARARs and To-Be-Considered (TBC) criteria. Specifically, an on-site engineered disposal cell at that location would not meet a Federal Aviation Administration (FAA) advisory criterion (a TBC) for siting new MSW landfill units within certain distances of airports. In addition, siting the on-site engineered disposal cell at that location, which was the only available on-site location where a new disposal cell could be located on native ground and also the only location outside the geomorphic floodplain, also would conflict with the Negative Easement and Restrictive Covenant (Restrictive Covenant) held by the City of St. Louis. The Restrictive Covenant prohibits any new or additional deposition or dumping of municipal waste, organic waste, or putrescible waste above, upon, on, or under the West Lake property in order to reduce or mitigate wildlife hazards to aircraft and airport facilities. The Restrictive Covenant is not a federal or state regulation and so is not an ARAR, but may qualify as a TBC. A new on-site engineered disposal cell could meet the Missouri solid waste regulations for design, operation, closure and post-closure standards for a new solid waste landfill; however, it would not meet the prohibition against disposal in a solid waste cell of radioactively-contaminated material resulting from the cleanup of a radioactively-contaminated waste disposal site. There does not appear to be a basis for waiver of this requirement. In addition, the available space for construction of a new on-site disposal cell located in the soil stockpile/borrow area was previously thought to result in limitations on the available capacity such that there may not have been sufficient capacity to contain all of the RIM and associated cover materials included under the full excavation alternative. Re-evaluation of the conceptual design for a new on-site disposal cell in connection with this FFS, however, indicates that the cell should be able to be designed to provide sufficient volume.

For the foregoing reasons, technologies that were associated solely with an on-site disposal alternative that were presented, described and evaluated in the SFS were not originally discussed further in this FFS. However, with the recent inclusion of the new full excavation with on-site disposal alternative, which permits location of an on-site cell on the Site as long as it is outside the 100-year floodplain, these technologies may now be appropriate. These technologies are discussed in Section 5 of this FFS as part of the description of the full excavation with on-site disposal alternative (see Section 5.6).

4.3.2.3 Cryogenic Barriers

Cryogenic barriers provide containment and reduce the mobility of radionuclide contaminants by freezing contaminated subsurface soils to create an ice barrier around a contaminated zone. Rows of freeze pipes are inserted in an array outside and beneath the contaminated zone and the array of pipes connected to a refrigeration plant. Coolants typically consist of salt water, propylene glycol or calcium chloride. Cryogenic barriers are considered a good application for the containment of short-lived radionuclides such as tritium. Both a full-scale field test and full-scale demonstration project of this technology have been performed in the Oak Ridge, TN area (EPA, 2007a).

4.3.2.4 Vertical Barriers

A vertical barrier is a containment technology that is installed around a contaminated zone to assist in confining radioactive waste and any contaminated groundwater that might otherwise flow from a site. To be effective, vertical barriers should be constructed such that the bottom of the barrier is keyed into a relatively impermeable natural horizontal barrier (i.e., a groundwater aquitard), such as a clay zone or bedrock, to limit groundwater flow. The vertical barrier technology is often used where the waste mass is too large to practically treat and where soluble and mobile constituents pose an imminent threat to a drinking water source (EPA, 1992b). Vertical barriers are frequently used in conjunction with a surface cap to produce an above- and below-grade containment structure (EPA, 1988b). Vertical barriers can include slurry walls, grout curtains, and sheet pile cutoff walls.

4.3.2.4.1 Slurry Wall

Slurry walls consist of a vertically excavated trench filled with a slurry mix of soil, bentonite and water, or cement, bentonite and water. The slurry is pumped into the trench as the trench materials are being excavated, which provides short-term stability of the trench to prevent collapse of the side walls during excavation and, once completed, provides a barrier to groundwater flow. Soil-bentonite slurry walls have a wider range of chemical compatibility and a lower permeability than cement-bentonite slurry walls or walls with other slurry compositions, but soil-bentonite slurry walls have lower shear strength and are subject to greater settlement over time.

4.3.2.4.2 Grout Curtain

Grout curtains are thin vertical grout walls constructed by pressure-injecting grout directly into the soil at closely-spaced intervals around the waste mass. The spacing is designed so that each "pillar" of grout intersects the next, thus forming a continuous wall or curtain (EPA, 1988b). Grout curtains are generally used at shallow depths (*i.e.*, less than 30 to 40 feet). Grouting materials can include hydraulic cements, clays, bentonite, silicates, and polymers (sometimes preferable because they are impermeable to gases and liquids, resist radiation, and perform well in acidic and alkaline environments).

4.3.2.4.3 Sheet Pile Cutoff Wall

Sheet pile cutoff walls are used for excavation stability and to control groundwater flow. Sheet pile cutoff walls are constructed by driving interlocking steel or high-density polyethylene (HDPE) sheets into the ground. The joints between individual sheets are typically plugged with clay slurry for steel sheets or an expanding gasket for HDPE sheets. Sheet pile cutoff walls have not been demonstrated as a containment barrier at a radionuclide-contaminated site (EPA, 2007).

An evaluation of the potential application of sheet-pile cutoff walls or other excavation shoring techniques was performed in conjunction with the SFS and further evaluated as part of the FFS. The evaluation performed for the FFS is present in Appendix D-1. Results of this evaluation indicate that the use of sheet piling to stabilize excavation side slopes could potentially reduce the amount of material that may need to be removed; however, obstructions and uncertain geotechnical properties within the waste mass could greatly impact the ability to drive piles or installing and maintaining anchors for lateral support, thereby impacting the implementability of this technology. Use of sheet piles also poses several potential adverse impacts including potential for creation of sparks from metal on metal contact that could ignite a subsurface fire, or downward transport (dragdown) of RIM when sheet piles are driven through RIM areas. In addition, even if it were implementable, the use of sheet piling is expected to increase the overall construction schedule and add significant costs. Consequently, the potential benefit of using sheet piling does not appear to be commensurate with the additional construction risks, cost, and schedule extension (Appendix D-1). Application of the sheet pile technology for excavation stabilization is not considered to be implementable or cost effective for Areas 1 and 2.

Sheet pile or other excavation shoring techniques may be useful to stabilize excavation sidewalls adjacent to site infrastructure such as the transfer station or Site access road. For example, sheet pile shoring could be installed adjacent to the transfer station to allow for a vertical excavation boundary rather than a laid-back slope for excavation stability (Appendix D-1). Such a system would have to be installed a few feet out from the transfer station. Because the exact extent of RIM in the vicinity of the transfer station is not precisely known, it is possible that the sheet piles could be driven through RIM with the potential for dragdown and/or that some RIM could be left on the outside of the sheet pile wall. Because dragdown would likely only result in a thin film of material potentially containing radionuclides on the exterior or at the base of the piles, the effects of dragdown are expected to be minimal.

4.3.3 Physical/Chemical Treatment

The Technology Reference Guide for Radioactively Contaminated Media (EPA, 2007) includes six physical and chemical treatment technologies that can potentially be used to effectively treat wastes from radioactively-contaminated sites: solidification/stabilization, chemical separation, physical separation, vitrification, soil washing, and column and centrifugal flotation. Physical separation is discussed in Section 4.3.5.2 in conjunction with other physical removal related technologies. In addition, per the SOW for the FFS, apatite/phosphate based treatment technologies are also reviewed in this section.

4.3.3.1 Solidification/Stabilization

Solidification/stabilization technologies reduce the mobility of hazardous and radioactive contaminants in the environment through both physical and chemical processes. The goal of the solidification/stabilization process is to limit the spread of radioactive material via leaching, and to "trap" and contain radionuclides within a densified and hardened soil mass that has a high structural integrity. In stabilization, chemical reactions are induced between the stabilizing agent and contaminants. Solidification does not involve chemical interaction or chemical bonding between the contaminants and the solidification agent, but bonds them mechanically.

Solidification/stabilization can be employed in-situ or ex-situ. In-situ techniques use auger/caisson and injector head systems to apply agents to soils in-place, while ex-situ techniques involve excavating the contaminated materials and machine-mixing them with the solidifying agent. Ex-situ processes typically involve disposal of the resultant materials.

Solidification/stabilization techniques can involve either microencapsulation or macroencapsulation. Microencapsulation involves thorough and homogeneous mixing of small waste particles (typically 0.08 inches or less) with a liquid binder that then solidifies to form a solid, monolithic final waste form. Individual waste particles are coated and surrounded by the solidified binder to provide mechanical integrity and act as a barrier against leaching of contaminants. Macroencapsulation involves packaging large pieces of waste or containers of waste not suitable for processing by microencapsulation and surrounding the package with a layer of clean binder material. The binder forms a protective layer around the waste that provides structural support, prevents dispersion, and helps reduce migration of contaminants. EPA defines macroencapsulation as being appropriate for immobilizing low-level radioactive debris waste with dimensions greater than or equal to 2.5 inches (EPA, 2007).

Cement solidification/stabilization processes involve the addition of cement or a cement-based mixture, while chemical solidification/stabilization involves adding chemical reagents including thermoplastic polymers (asphalt bitumen, paraffin, polyethylene, polypropylene, modified sulfur cement), thermosetting polymers (vinyl ester monomers, urea formaldehyde, epoxy polymers), and other proprietary additives. Cement solidification/stabilization is best suited to highly porous, coarse-grained, low-level radioactive waste in permeable matrices, while chemical solidification/stabilization is better suited to fine-grained soil with small pores (EPA, 2007). After an extensive search of the literature, EMSI could not find an application of the solidification/stabilization technology to MSW.

4.3.3.2 Chemical Separation

Chemical separation using solvent/chemical extraction is an ex-situ chemical separation technology that separates hazardous contaminants from soils, sludges, and sediments to reduce the volume of hazardous waste that must be treated. The resulting process residuals require further treatment, storage, or disposal. Solvent/chemical extraction involves excavation and transferring soil to equipment that mixes the soil with a solvent. Solvents that have been used to remove radionuclide contaminants include complexing agents such as: ethylenediaminetetraacetic acid (EDTA); inorganic salts; organic solvents; and sulfuric, hydrochloric, and nitric mineral acids. Use of water alone as the solvent is referred to as soil washing (see Section 4.3.3.3).

Solvent/chemical extraction equipment processes contaminated soil either in batches for dry soil or as a continuous flow for pumpable waste. When the contaminants have been sufficiently extracted, the solvent is separated from the soil and is either distilled in an evaporator or column or removed from the leachate by precipitation. Distilled vapor consists of relatively pure solvent that is recycled into the extraction process. The liquid residue, which contains concentrated contaminants, undergoes further treatment or disposal. If the contaminants are precipitated, the sludge is dewatered with a filter press.

Not all radionuclides and solvent will be removed from the contaminated soil during the chemical extraction process, requiring further processing if the remaining concentrations are not below levels such that the soil can be returned to its original location. Results from 22 studies indicate contaminant removal rates using the solvent/chemical extraction process of 13% to 100% for soils contaminated with radioactive waste and heavy metals (EPA, 2007). Two studies (one pilot-scale and one full-scale) using sodium carbonate/sodium bicarbonate solution for uranium extraction achieved removal efficiencies of between 75% and 90% (EPA, 2007). A solvent/chemical extraction field demonstration project treating soil containing Ra-226 and Th-232 showed removals of 60% to 67% and 73% to 76%, respectively (EPA, 2007).

Soil properties such as particle size, pH, partition coefficient, ion exchange capacity, organic content, moisture content, and contaminant concentrations and solubilities are factors that affect the efficiency and the operability of solvent/chemical extraction (FRTR, 2002). Bench-scale testing is required. Soils with high clay, silt, or organic content might cause dewatering problems in the contaminated waste stream. Debris greater than 2.4 inches in diameter typically must be removed prior to processing, and chemical extraction is not practical for soil with more than 6.7% organic material. If multiple radionuclides or metals are targeted for removal, multiple solvent extraction steps may be required using multiple solvents. Interference from thorium could limit the application of EDTA in removing radium when both radionuclides are present (EPA, 1995).

4.3.3.3 Soil Washing

Soil washing is a process in which water, with or without surfactants, is mixed with contaminated soil and debris to produce a slurry feed. This slurry feed flows through a scrubbing process to segregate contaminated fine soil particles (silts and clays) from granular soil particles. Contaminants are generally bound more tightly to the fine soil particles and not to larger-grained sand and gravel. Separation processes such as mechanical screening are needed to divide excavated soils into the coarse- and fine-grained fractions, and for dissolving or suspending contaminants in the slurry feed wash. The sand and gravel fraction is generally passed through an abrasive scouring or scrubbing action to remove surface contamination. The fine fraction can be separated further in a sedimentation tank, sometimes with the help of a flocculating agent. The output streams of these processes consist of clean granular soil particles, contaminated soil fines, and process/wash water, all of which need to be tested for contamination. Soil washing is effective only if the process transfers the radionuclides to the wash fluids or concentrates them in a fraction of the original soil volume. In either case, soil washing must be used with other treatment technologies, such as precipitation, filtration and/or ion exchange, to recover the radionuclides. Clean soil (sands and gravels) can be returned to the excavation area, while the contaminated soil fines and process water are further treated and/or disposed.

Soil washing is most effective when the contaminated soil consists of less than 25% silt and clay and at least 50% sand and gravel; soil particles should be between 0.01 to 0.08 inches in diameter for optimum performance (EPA, 2007). Soil characteristics including particle size distribution, moisture content, ion exchange capacity, and contaminant concentrations and solubilities are factors that impact the efficiency and operation of the soil washing process. Despite many bench- and pilot-scale tests, soil washing has not been fully demonstrated as a technology for reducing the volume of radionuclide-contaminated soil (EPA, 2007). There also are no known treatability tests or applications of this technology to MSW.

4.3.3.4 Flotation

Flotation separates the radionuclide-contaminated soil fraction (usually the fine soil particles such as silts and clays) from the clean soil fractions (usually the large granular soil particles and gravel) in order to reduce the volume of soil requiring treatment or disposal. During flotation, radionuclide-contaminated soil is pretreated to remove coarse material and then mixed with water to form a slurry. A flotation agent (a chemical that binds to the surface of the contaminated soil particles to form a water repellant surface) is then added to the solution. Small air bubbles are then passed through the slurry. These air bubbles adhere to the floating particles, transport them to the surface, and produce a foam containing the radionuclide-contaminated soil particles. The foam is mechanically skimmed from the surface or allowed to overflow into another vessel. Residual radionuclide-contaminated soil fines and foam require further testing and treatment and/or disposal. After dewatering and drying, the clean soil can then be returned to the excavation area (EPA, 2007).

Soil-specific site considerations such as particle size and shape distribution, radionuclide distribution, soil characteristics (clay, sand, silt, and organic content), specific gravity, chemical composition, and mineralogical composition can impact the effectiveness of flotation. Flotation is most effective at separating soil particles in the 0.0004 to 0.004 inch size range. For soils that include a wider range of particle sizes, flotation can sometimes be part of a treatment train (e.g., soil washing). Although mining industry operations have consistently and successfully segregated metal-containing fines from soil using this process, the flotation technology has not been fully demonstrated for reducing the volume of radionuclide-contaminated soil (EPA, 2007). The effectiveness of floatation technology is dependent upon the degree to which the technology concentrates the radionuclide-contaminated soil/waste fraction.

4.3.3.5 Vitrification

Vitrification involves heating contaminated media to extremely high temperatures, then cooling them to form a solid mass. Upon cooling, a dense glassified mass remains, trapping the radioactive contaminants in a solid, inert form. The process can be applied to contaminated soil, sediment, sludge, mine tailings, buried waste, and metal combustibles. Although mobility is greatly reduced for contaminants trapped within the vitrified mass, the radioactivity of the radionuclide contaminants is not reduced. EPA has designated vitrification as a Best Demonstrated Available Technology (BDAT) for high level radioactive waste (EPA, 2007).

Vitrification can be performed both in-situ and ex-situ. Traditional in-situ vitrification uses a square array of four graphite electrodes that allows a melt width of approximately 20 to 40 feet and a potential treatment depth of up to 20 feet. Multiple locations, referred to as settings, can be used for remediation of a larger contaminated area. The electrode array is lowered progressively, as the melt grows, to the desired treatment depth. Depending on the amount and types of organics and metals (*e.g.*, mercury, lead, and cadmium) present in the soil or waste mass which may volatilize, off-gas treatment may be required.

In the ex-situ configuration, waste is fed to a furnace (*e.g.*, joule-process heating; plasma; electric arc; microwave; and coal-, gas- or oil-fired cyclone furnace) on either a batch or continuous feed basis. The ex-situ vitrified mass is then disposed off-site or returned to the area where the waste was excavated.

In-situ vitrification should generally not be used on waste or contaminated soils with organic contents higher than 10 percent by weight or highly reactive materials. To effectively immobilize radionuclides and heavy metals, soils should have greater that 30 percent glass-forming materials (*i.e.*, SiO_2). The waste and/or contaminated media must have sufficient alkali content (*i.e.*, Na_2O, Li_2O, and K_2O) to ensure the proper balance between electrical conductivity and melting temperature. Void volumes and percentages of metals, rubble, and combustible organics (*e.g.*, methane in landfill gas) need to be considered, as soils and waste that contain greater than 55 percent inorganic debris and/or rubble are difficult to treat with in-situ vitrification (EPA, 1997). The process is also not applicable to soils or waste containing sealed containers such as drums, tanks, or paint cans since pressurized gases will be released and may disrupt the melt (EPA, 2007). No information was identified regarding the potential applicability or previous application of this technology to MSW.

4.3.3.6 Apatite/Phosphate-Based Treatment

The EPA SOW (EPA, 2015b) required an evaluation of the potential feasibility of using apatite/phosphate-based treatment technologies for treatment of radionuclides in soil or groundwater. This section presents a summary of the evaluation of the apatite treatment technology. Additional details regarding this evaluation are presented in Appendix D-2.

Apatite is an isomorphic mineral. Specifically, apatite is a group of crystalline mineral compounds that have different chemical compositions but identical crystalline structures. Consequently, precipitation of apatite can result in incorporation of other elements into the mineral's crystalline structure. In an isomorphic mineral, certain ions or molecules will enter into the crystal lattice of a mineral solid without causing any marked change in the crystal morphology or other physical properties of the mineral. For simplicity, this process reflects two ions having similar but not equal atomic radii and the same charge, with the smaller ion being preferentially concentrated in the early formed specimens of a crystallizing mineral series.

Relative to the radionuclides at the Site, apatite or other phosphate-based materials or solutions would be added to groundwater containing radionuclides or to the solid phase materials containing the radionuclides in sufficient quantities and under appropriate geochemical conditions necessary to promote apatite crystallization. Such crystallization may result in incorporation of Site-related radionuclides such as thorium, radium and uranium into the apatite crystals. Incorporation of radionuclides into the crystalline matrix would reduce the potential for leaching of such radionuclides.

Radium and thorium, and to a lesser extent uranium, are the major radionuclides of concern at the Site relative to potential leaching to groundwater. Thorium is known to be highly insoluble and uranium is relatively insoluble under reducing conditions such as those that occur at MSW landfills. Uranium has not been detected at levels above its MCL. There is no MCL or other standard for thorium occurrences in groundwater, but as an alpha emitter, the monitoring results were compared to the gross alpha MCL, and it has not been detected at levels above that MCL. Therefore, radium would be the key constituent for treatment using apatite materials. Based on an extensive review of the literature regarding the use of apatite and/or other phosphate-based materials for treatment of radionuclides and metals in water, soil, sediments, tailings and landfill leachate (EMSI, 2016c), there is known applicability for treatment of groundwater containing strontium, uranium, and some metals, but no known applications for treatment of radium or thorium in groundwater.

There is no demonstrated application of use of apatite and/or other phosphate-based materials for treatment of MSW. Uncertainty exists as to whether apatite formation can be initiated synthetically under field conditions associated with MSW, including whether apatite solids or solutions can be delivered and homogeneously distributed within an overall heterogeneous matrix of MSW. Furthermore, although there is some uncertainty about the relationship of some of the deeper occurrence of RIM relative to the water table, the majority, if not all, of the RIM is located above the water table, and therefore unsaturated. This technology has not been used or demonstrated to be applicable for unsaturated zones. DOE technical representatives with extensive experience with bench- and pilot-testing of apatite under various geochemical conditions have expressed concerns about unintended consequences that could result from physical disturbance or modification of the geochemical conditions within the Site from application of apatite-based treatment technologies (Thompson and Wellman, 2012).

4.3.4 Biological Treatment

Biological treatment of radioactively-contaminated soils, sediments, and sludges involves stabilization of the contaminants in-place and/or removal via plant root systems. Phytoremediation is the use of plant systems to remove, transfer, stabilize, or destroy contaminants in soils, sediments and sludges. The contaminants are transferred to various parts of the plant, including the shoots and leaves, where they can be harvested. The mechanisms of phytoremediation applicable to solid media include enhanced rhizosphere biodegradation, phytoextraction, phytodegradation, and phytostabilization.

Because radionuclides do not biodegrade, the mechanisms applicable to remediation of radionuclides are phytoextraction and phytostabilization (FRTR, 2002). Phytoremediation is limited to shallow soils and sediments. Because growth of plants can be affected by climatic or seasonal conditions, this technology may not be applicable in areas with cold climates and short growing seasons.

Phytoextraction (also known as phytoaccumulation), is the uptake of contaminants by plant roots and the translocation/accumulation of contaminants into plant shoots and leaves. Phytoextraction will produce a harvested biomass residual waste that must be further treated and/or disposed as a radioactive waste. For phytoextraction to be effective, the root system of the selected plants should be able to penetrate the entire contaminated zone, and to be cost-effective, the rate of plant uptake must be greater than one percent of the plant’s weight per harvest and the time to complete the remediation process must be between two and 10 years. Phytoextraction has been pilot-tested to remove low levels of cesium and strontium from contaminated soils and sediments (EPA, 2007). EPA (2007) indicated that phytoremediation is applicable to uranium, cesium, strontium and cobalt in solids but that application of this technology is limited to shallow soils, that this technology is best suited to sites with lower levels of contamination only slightly above cleanup levels, and that this process can take several years or more for implementation. EPA (2007) further indicated that this technology has not been fully demonstrated for radioactive contamination in solids. EPA identified a bench scale demonstration for removal of thorium from soil but indicated that based on testing and field trials, the most promising candidates for phytoextraction appeared to be cesium-137 and strontium-90 (EPA, 2007). No information was identified regarding the potential applicability or prior application of this technology for removal of radium (EPA, 2007).

Phytostabilization is the production of chemical compounds by plants to immobilize contaminants at the interface of roots and soil. Contaminant transport in soil, sediments, or sludges can be reduced through: absorption and accumulation by roots; adsorption onto roots; precipitation, complexation, or metal valence reduction in soil within the root zone; or binding into organic humic matter through the process of humification. Although considerable research has been conducted on phytostabilization of metals, little research or field testing has been performed regarding phytostabilization of radionuclides (Pivetz, 2001).

Phytoextraction and phytostabilization all require the root systems of the plants to extend down through the zone of contamination. RIM in Areas 1 and 2 occurs at depths ranging 0 to 89 feet bgs in Area 1 and 0 to 42.5 feet bgs in Area 2. Therefore, application of phytoremediation technologies would require growing large trees on the surface of Areas 1 and 2 which is inconsistent with the objectives of the recently implemented non-combustible cover and would also be inconsistent with the ARARs associated with the Missouri solid waste regulations which require development of grasses and shallow rooted vegetation as part of a landfill cover.

4.3.5 Removal

Several removal technologies may be considered as components of alternatives to address the site characterization results, as well as to satisfy the RAOs associated with OU-1 at the West Lake Landfill. Removal technologies considered include excavation, physical separation, transportation, off-site disposal, and stormwater management.

4.3.5.1 Excavation

Excavation construction equipment includes back- and track-hoes, bulldozers, scrapers, and front-end loaders. This equipment would be used for cutting and filling of waste and fill materials to achieve surface grades, to excavate and move filled waste material, and to construct new site features such as stormwater retention/conveyance and cover systems.

4.3.5.2 Physical Separation

Physical separation technologies are a class of treatment in which radionuclide-contaminated media are separated into clean and contaminated fractions by taking advantage of the physical properties of the contaminants. These technologies work on the principle that radionuclides are associated with a particular fraction of a media which can be separated based on size and other physical attributes. In solid media such as soil or sediment, most radioactive contaminants are associated with smaller particles, known as soil fines (*i.e.*, clays and silts). Physical separation of the contaminated media into clean and contaminated fractions could potentially reduce the volume of contaminated media requiring further treatment and/or disposal.

4.3.5.2.1 Dry Soil Separation

Dry soil separation segregates radioactive particles from clean soil particles. The simplest application involves screening and sieving soils to separate finer fractions, such as silt and clay, from coarser fractions of the soil. Since most contaminants tend to bind to the fine fraction of a soil either chemically or physically, separating the finer portion of the soil can concentrate the contaminants to a smaller volume of soil for subsequent treatment or disposal (FRTR, 2002).

Radiological constituents at OU-1 Areas 1 and 2 occur in soil materials that are intermixed with and interspersed within the overall matrix of landfilled refuse, debris, fill materials, and soil and quarry spoils. Therefore, before a dry soil separation process could be considered, the interstitial soil materials would need to be separated from the other landfilled materials using a solids separation process. Solids separation processes can include hand picking for large bulky items and hazardous materials such as propane tanks; magnetic separation for ferrous metals and contaminants associated with ferrous metals; eddy current separation for non-ferrous metals (*e.g.*, inducing an electric current to separate aluminum cans from other recyclables); air classification for papers and plastics; and various fixed, vibrating, or rotating screens. Such separation would remove larger items, but would not result in separation of the soil containing radionuclides from other soil, the decomposed (composted) organic material, or other fine fractions of the waste materials in Areas 1 and 2.

4.3.5.2.2 Rotating Screen – Trommel

Trommel (revolving cylindrical sieve) screens are commonly used during landfill mining and reclamation (LFMR) projects to separate materials by size, with the soil fraction passing through the screen. Metal conveyor flights on the inside surface of the screen direct the non-soil fraction to the discharge end of the rotating cylinder. The size and type of screen used depends on the end use of the recovered material.

During LFMR projects, trommel screens are typically used downstream in series with a shear shredder with the recovered soil fraction directed to one side of the trommel. If the finer-grained (soil-sized) materials were to be separated from the landfilled waste materials, one or more mobile diesel-driven trommels would be used downstream of a shear shredder. A 1- to 1½-inch trommel screen size would likely be chosen to recover the most soil while passing through small pieces of metal, plastic, glass, and paper. This configuration of shear shredder and trommel in an LFMR pilot-test application is shown in Figure 4-3.

A comb and shaft shear shredder uses counter-rotating multi-edged knives or hooks rotating at a slow speed with high torque to shred materials fed into the inlet hopper. Shear shredders are employed prior to trommel screens in LFMR projects for three primary reasons:

- An approximate 30 percent volume reduction in waste material is achieved by shredding all filled material to a uniform 6- to 8-inch minus size. Separated material that is returned to the landfill is more easily compacted and takes up less volume than the original in-place waste material. It should be noted that very large landfilled objects such as white goods and steel beams, etc. are "hand-picked" from the waste stream prior to shredding.

- Shredding pretreatment breaks up pockets and clumps of organic and matted materials and soil; dislodges smaller materials that may be 'hidden" in among the larger materials; and pulverizes materials such as brick, concrete block, large chunks of concrete that contain rebar, and mattresses to provide a stream of more uniformly-sized material such that fines and the soil fraction of the waste can be more easily separated.

- Shear shredding reduces the size of materials (primarily from construction/remodeling and demolition of utilities, structures, and roads, including rebar and other pieces of steel, dimensional lumber and columns/beams, plumbing fixtures and piping, recycled asphalt, and electrical wiring and components) that would tend to clog, get hung up in, and increase the wear on the trommel screen and flights.

Use of a trommel, or other physical separation mechanism, would remove larger, non-soil sized items from the refuse mass, but would not result in separation of the soil containing radionuclides from the decomposed (composted) organic material and other fine fractions of the waste materials in Areas 1 and 2. Use of shredder prior to a trommel or other physical separation mechanism likely would result in an increase in the fraction of finer material potentially increasing the volume of "soil" material that would have to be managed as radiologically impacted.

The benefits or impacts of trommel screen or other physical separation technique, with or without use of a shear shredder, relative to maximizing separation of finer grained material including radiologically-impacted soil from solid wastes would need to be further evaluated as part of a pilot test during RD prior to full-scale implementation. Factors that require further evaluation to assess the potential effectiveness and implementability of such technologies include but are not limited to the following:

- Degree to which any radioactive material would be retained in or on the larger fraction materials and whether such retention would result in exceedance of a cleanup criteria;

- The extent of fouling of the shredding and screening equipment by larger items such as wire, wood material, plastic, etc. and the amount of down-time that would occur and any personnel time and associated exposure frequencies and durations required to clear such materials, along with the resulting short-term risk;

- The degree to which shredding or other pre-screening processes results in an increase in the volume of fine materials that would have to be processed; and

- The magnitude of any volume reduction that may be achieved by such physical separation techniques relative to the cost and potential risks associated with such methods.

A pilot test would require at least seven to nine months to perform, including at least three months to develop, review, approve, and finalize a work plan, one to two months for equipment mobilization and field testing, two months for lab testing, and one to two months for data evaluation and reporting.

Physical separation of larger items and non-soil-sized fractions of the waste material has the potential to reduce the volume of waste material that may need to be sent for off-site disposal. However, physical separation alone would not result in separation of the soil containing radionuclides from other soil, decomposed (composted) organic material, and other fine fractions of the waste materials in Areas 1 and 2. Even if a pilot test indicated that physical separation were potentially applicable, the cost-benefits of physical separation techniques would require additional evaluation during RD before a determination can be made regarding the potential effectiveness, implementability, and cost of such technologies for OU-1.

4.3.5.2.3 Radiological Segregation/Separation

A refinement of the dry soil separation process uses radiation detectors to further separate materials (EPA, 2001, Patteson, 2000, Patteson, Maynor and Callan, 2000, Thermo Nutech,1998, and Cummings and Booth, 1996). This technology offers a potential to segregate the soil containing radionuclides from the other soil, decomposed (composted) organic material, and other fine fractions of the waste materials in Areas 1 and 2.

For this technology, radionuclide-contaminated material would be excavated and screened to remove large rocks and debris. Prior applications included crushing of large rocks which were then placed with soil on a conveyor belt. Although large rocks may be present within the OU-1 waste mass, based on the understanding of the source of the radioactive materials at the West Lake Landfill, such rocks are not expected to contain radionuclides. In contrast, the waste materials in OU-1 are expected to contain large items and non-soil items that would need to be separated from the soil fraction prior to performing radioactive screening. Therefore, a radiological screening/segregation technology likely would need to be coupled with one or more physical separation/segregation technologies in order to removal larger items and non-soil-sized material prior to subjecting the finer fraction of the waste mass to radiological screening and separation.

The fine (soil) fraction material would be placed on a conveyor belt. The conveyor belt would carry the soil/fine material under radiation detectors that measure and record the level of radiation in the material. Radioactive batches of material on the conveyor belt are tracked and mechanically diverted through automated gates, which separate the soil/fine material into contaminated and clean segments. The radioactive materials then receive further treatment and/or disposal. This technology has the potential to reduce the volume of material that would need to be sent for off-site disposal under a full or partial excavation alternative. However, this technology would require extensive pilot-testing to determine the appropriate screening criteria to be used to segregate the material, and to demonstrate the implementability, cost, and potential effectiveness of the technique.

This system is best suited to sort any dry host matrix that can be transported by conveyor belts (EPA, 2003) and which is contaminated with no more than two radionuclides with different gamma energies (DOE, 1998). Large debris should be removed before processing the soil and large rocks, concrete, or asphalt must be crushed before being placed on the conveyor belt. Screening to size the feed material to diameters of less than 0.5 inches is desirable and material greater than approximately 1.5 inches in diameter cannot be processed without crushing. Optimal soil moisture content is between 5 and 15 percent (DOE, 1999).

Several case studies of application of this technology are available (EPA, 2001, Patteson, 2000, Patteson, Maynor and Callan, 2000, Thermo Nutech, 1998, and Cummings and Booth, 1996). Review of these case studies indicates that applications of this technology have been used for sorting of soil containing depleted uranium, natural uranium, plutonium or Cesium-137. Most of these applications involved use of the ThermoRetec (formerly Thermo Nutech) segmented gate system (SGS) which consists of a mobile, radiological soil assay system with motorized conveyor belts, a variable belt speed motor controller, air actuated segmented gates, a radionuclide assay computer system and two sets of radiation detector arrays, deployed across a 32-inch wide assay conveyor. Contaminated soil is fed into the SGS processing plant where oversized material (typically 1.5 inches) is removed. The remaining soil is conveyed at a constant speed beneath the detector arrays that are linked to a control computer which toggles pneumatic diversion gates located at the end of the sorting conveyor. Contaminated material that exceeds the criteria for radioactive materials is diverted to a separate conveyor from that used to convey non-contaminated material. The SGS is designed for detection of gamma-ray emitting radionuclides using NaI detectors; however, it can also be modified to detect some beta-emitting radionuclides (Patteson, 2000).

Advantages of the SGS are that it physically surveys the entire volume of soil processed and typically reduces the volume of soil requiring treatment or disposal by 50% to 90% (Patteson, 2000). Dry decontamination has been proven effective for free release of the system so generation of secondary waste is limited to personnel protective equipment (Patteson, 2000). A disadvantage of the SGS is that it is limited to gamma -emitting radionuclides. It is also limited to analyses of a maximum of two radionuclides with different gamma energies at a time (Patteson, 2000). Soil cannot be sorted for unknown radionuclides, so prior knowledge of the primary radioactive contaminants is required (Patteson, 2000). Material greater than 1.5 inches cannot be processed without pre-crushing (Patteson, 2000). The radioactive contaminants must also be heterogeneously distributed within the suspect soil.

A detailed summary of several case studies is presented in Patteson (2000). The SGS has been used at Sandia National Laboratories where, through initial processing and subsequent reprocessing, it was used to sort 662 cubic yards of soil contaminated with depleted uranium with a resulting volume reduction of 99% relative to a cleanup criterion of 540 pCi/g. Soil processed through the SGS was separated into contaminated (average uranium activity of 406.5 pCi/gm) and uncontaminated soil (average activity of 4.2 pCi/g). At the Pantex Plant in Amarillo, Texas, the SGS system was also tested for use in processing soil containing depleted uranium. A total of 294 cubic yards were processed through the SGS with a resultant volume reduction of only 38.5% relative to a cleanup criterion of 50 pCi/g. The SGS system was tested for sorting 333 cubic yards of plutonium contaminated soil at the Tonopah Test Range in Nevada using varying set-point values to activate the sorting gates with results ranging from 4% to 99% reduction. The SGS was used to process 2,526 cubic yards of soil containing natural uranium at the Los Alamos National Laboratory where it achieved separation efficiencies ranging from 75% to over 99% for separation points of 50 to 65 pCi/g. The SGS was also used at the Idaho National Engineering and Environmental Laboratory (INEEL) to process soil containing cesium-137. Only 442 cubic yards were processed before the project was terminated because it did not achieve the expected volume reduction. EPA reports that the system only achieved a 3% volume reduction (EPA, 2001).

As discussed above, the SGS is designed for detection and sorting of gamma-emitting radionuclides. A soil sorter process such as the segmented gate system that uses gamma radiation to identify contaminated soil is likely to have difficulty identifying soil with a Th-230 concentration that would allow for unrestricted use (*e.g.*, 5 pCi/g plus background) due to the lower gamma emissions associated with thorium decay. Experience gained through investigations (EMSI, 2017a) and the non-combustible cover removal actions indicate that Th-230 is the dominant and most widespread radionuclide at the Site. The NRC (1988) stated that "[b]ecause the controlling radionuclide (Th-230) has no characteristics that make it easy to measure quantitatively in place, as can be done for Ra-226 with its decay products, the large but variable ratio of Th-230 to Ra-226 and its decay products makes the delineation of cleanup more difficult." The presence and overall dominance of Th-230 in the waste material greatly restricts the use of gamma radiation detection-based systems for automatically or even manually sorting RIM from non-RIM waste containing low levels of primarily non-gamma-emitting radionuclides. Identification and removal of gamma-emitting radium could potentially leave behind undetected concentrations of thorium that would be subject to further in-growth and increasing risk over time. Therefore, it is likely this technology will not be effective for the full excavation alternatives, which requires segregation of material containing combined radium or combined thorium greater than 7.9 pCi/g. The technology may also not be effective for the 52.9 pCi/g criteria partial excavation alternative as it may not be possible to set the gamma detection trigger low enough to ensure that all soil/waste material containing thorium above 52.9 pCi/g is identified and segregated. Due to the general correlation between radium and thorium occurrences at higher levels (EMSI, 2017a), this technology may have some application relative to the partial excavation alternative based on the 1,000 pCi/g criteria as the detection trigger for gamma radiation (radium) could be set sufficient low (*i.e.*, below the level necessary to identify radium levels above 1,000 pCi/g including a factor of safety) so as to identify thorium levels above 1,000 pCi/g.

4.3.5.3 Transportation

Hauling of waste material on- and off-site would be conducted using on-road and off-road trucks, rail, or a combination of trucks and rail. Delivery of clean fill, liner and cover materials, and other materials and equipment associated with construction of the selected remedy also would be accomplished with a variety of trucks.

4.3.5.3.1 Hauling of Wastes and Construction Materials – On-site, Off-road and Off-site, On-road Trucks

Hauling of waste material by truck would be conducted off-site with on-road trucks and on-site with off-road trucks. Various off-site, on-road "highway" trucks would be used to haul clean fill material to the Site, haul waste material from the Site directly to a waste disposal facility, or haul waste material to a truck-to-rail transloading location where it would be transferred from the trucks to rail cars for subsequent rail hauling. If hauled off-site via trucks, wastes with radionuclides must be placed in appropriate containers and USDOT requirements for shipping must be met.

Highway trucks are equipped with tires suitable for long distances on flat surfaces and are used for transporting loose material such as sand, gravel, rock, asphalt, soil, or waste materials on roads and highways to and from construction sites, quarries, borrow pits, landfills, and waste disposal facilities. Typical configurations include the standard dump truck (truck chassis with dump body mounted to the truck frame); the semi-trailer or tractor-trailer equipped with flat-bed and bottom-, end-, and side-dump cargo trailers; and the transfer dump truck that pulls a separate dump (or "pup") trailer. Semi-trailer trucks equipped with flatbed or end-dump trailers as well as transfer trucks with pup trailers are typically used to haul waste material from a site to a truck-to-rail transloading operation at a rail spur location. Hauling of waste to a transloading facility can also be performed using 32-cubic-yard (20-ton) capacity DOT Industrial Packaging (IP)-1 metal intermodal containers (see 49 CFR Subparts A and B and 49 CFR § 173.410 for IP design requirements for low specific activity (LSA) materials) that can be placed on a flatbed truck, which can be hauled directly to a waste disposal facility via truck or taken to a rail loading facility and transferred directly to flatbed railcars.

On-site, off-road dump trucks or "haul trucks" resemble heavy construction equipment and are used strictly off-road for mining and heavy dirt or other construction materials hauling projects.

These vehicles employ large diameter off-road patterned rubber tires and can have large payload capacities. There are two primary forms: the rigid frame and the articulated frame or "Yuke."

4.3.5.3.2 Hauling of Waste Material - Rail

Hauling of waste material via rail is typically accomplished with 110-ton capacity gondola cars (railroad car with an open top but enclosed sides and ends, for transporting bulk commodities) or with DOT IP-1 intermodal containers that can be stacked onto flatbed railcars. Wastes hauled off-site to an off-site licensed facility via rail must be shipped in appropriate containers and USDOT requirements for shipping must be met.

If waste material is loaded directly into gondola cars, rigid lids are locked onto the open top prior to transport. Waste material can also be placed into 10- or 35- cubic yard IP-1 soft-sided shipping containers (bags), with the bags then loaded onto flatbed semi-trailers and trucked to a truck-to-rail transloading operation at a rail spur location where the containers are off-loaded from the flatbed into gondola cars. Nine to ten 10-cubic-yard bags will fit in a standard sidewall height (5½ feet) gondola car. Four 35-cubic-yard bags can be loaded into a larger volume 148-cubic-yard gondola. After the gondola cars are filled with soft-sided shipping containers, rigid lids or secured tarps are placed over the top of the car prior to shipment. After the railcars arrive at an off-site disposal facility, the contents are either discharged directly at the facility using a rotary car dumper or "excavated" from the gondolas and transferred to trucks at a rail transfer facility and subsequently hauled to the disposal facility.

Metal intermodal containers have a hinged top and one end of the container is also hinged. After a liner has been placed in the container, the waste material is loaded into the top of the container, the top is secured, and the container is lifted onto a flatbed trailer and hauled to a truck-to-rail transloading operation at a rail spur location, where the container is lifted off of the flatbed and stacked with other intermodals onto a flat railcar. At the off-site disposal facility, intermodal containers are lifted off of the railcar onto a truck, transported to the disposal cell, and the contents are discharged into the disposal cell through the hinged end of the container.

4.3.5.4 Disposal at an Off-Site Licensed Facility

The SFS evaluation included contacting low-level radioactive waste disposal facilities that could potentially accept the bulk debris-type of waste material to be excavated from the West Lake Landfill OU-1 areas. These facilities include the Energy Solutions facility in Clive, Utah; the US Ecology facilities in Grand View, Idaho and Robstown, Texas; the Waste Control Specialists facility near Andrews, Texas; and the Clean Harbors Deer Trail facility near Last Chance, Colorado. After the SFS was completed, US Ecology opened an additional facility in Wayne, Michigan, and therefore US Ecology was also contacted regarding this facility. US Ecology was contacted again during preparation of this FFS revision. The nature of the waste materials that may be shipped offsite, the services US Ecology would provide to support transportation and disposal, and the methods of transportation, assumptions and costs were discussed. The FFS text and cost estimates have been updated based on the results of these discussions.

As discussed in Section 3.14.3, prior to disposal, the waste material excavated from the Site would have to meet the waste acceptance criteria (WAC) of the respective disposal facility. A preliminary evaluation of the WAC for the various facilities relative to the activity of the RIM material indicates that only four–the US Ecology, Grand View, ID; US Ecology, Wayne, MI; Energy Solutions, Clive, UT; and Clean Harbors Deer Trail, CO facilities–could accept waste material from the Site. The locations of these facilities relative to the St. Louis, Missouri area are shown on Figure 4-4. Figure 4-4 also includes the various railroad lines that serve the areas where the various off-site disposal facilities are located. Because of the long distances between the facilities and the Site, rail transfer would be the most likely method of transporting waste materials for the full excavation with off-site disposal alternative; however, hauling by truck is also a potentially viable method for transportation of waste to the US Ecology, Wayne, MI facility (Figure 4-4).

Descriptions of these disposal facilities and the proposed methods of transportation of waste material from the Site are provided below. In addition to being permitted to accept low-level radioactive waste, each of these facilities is permitted to accept hazardous waste and low-level radioactive/hazardous mixed wastes if these wastes are encountered in Areas 1 and 2.

US Ecology: Grand View, Idaho. This 160-acre disposal facility (included within a 1,000-acre privately-owned buffer zone) is located 70 miles southeast of Boise in the Owyhee Desert, approximately 10 miles northwest of Grand View, ID. It has a permit from the State of Idaho to accept RCRA, NORM, TENORM, NRC, and mixed waste (Part B Permit # IDD073114654). Information for the facility can be found at http://www.americanecology.com/grand_view.htm.

Wastes are received at the US Ecology-Idaho facility by truck directly and by rail via their 130-car rail transfer facility located in Simco, Idaho, 36 miles from the disposal facility. Wastes shipped by rail are trucked from the rail transfer facility to the disposal facility. US Ecology has indicated that excavated material from the Site would be either: (1) loaded directly into bag-lined gondola cars if a rail spur could be extended across St. Charles Rock Road onto the Site; or (2) loaded into 35 cubic yard IP-1 DOT bags or 32 cubic yard IP-1 metal intermodal containers that would be placed on a semi-trailer, transported to a truck-to-rail transloading operation at a potential future leased rail spur located near the Site (assuming one could be located), and then loaded into gondola or flatbed rail cars in the case of the intermodal containers. Under either a direct-to-rail or truck-to-rail loading procedure in St. Louis, the bagged, excavated material in the gondola cars would be hauled by rail to the rail transfer facility east of Grand View, ID, then transferred from the gondola cars to transfer trucks with pup trailers and trucked the final 36 miles to the US Ecology facility for disposal.

The specific rail routes that would be followed from a potential future rail spur extended onto the Site or a truck-to-rail transloading operation at a potential future leased rail spur located near the Site to the US Ecology Grand View, ID facility are as follows: Burlington Northern Santa Fe

(BNSF) from Bridgeton, MO to Kansas City, MO; then Union Pacific from Kansas City, MO to Simco, ID. This route transits through the major cities of Bridgeton, MO, Kansas City, MO, Atchison, KS, Marysville, KS, Hastings, NE, North Platte, NE, Cheyenne, WY, Green River, WY, Salt Lake City, UT, Pocatello, ID, and Nampa, ID.

Approximately 2.5 million tons of waste material containing radionuclides, including 2 million tons of USACE FUSRAP waste containing uranium, radium, and thorium soils and debris, have been disposed at the Grand View, ID facility. Material containing radionuclides from SLAPS [634,000 tons], Latty Avenue [69,000 tons], and Denver Radium OU-8 (Shattuck Chemical) [243,000 tons] sites have also been disposed at this facility.

The WAC and RCRA Part B permit for this facility are included in Appendix C-1.

US Ecology: Wayne, Michigan. This 450-acre treatment and disposal facility is located approximately 30 miles west of downtown Detroit adjacent to Interstate 94 in Van Buren Township, Wayne County, MI (just northwest of Belleview, MI): 49350 N I-94 Service Drive, Belleville, MI 48111. US Ecology-Michigan operates the largest (by volume) stabilization and treatment facility in North America with the ability to process hazardous and non-hazardous materials through stabilization, chemical oxidation/reduction, deactivation, microencapsulation and other permitted technologies. The facility manages more than 600 federal and state waste codes, employs a Regenerative Thermal Oxidation (RTO) system, and is the only commercial hazardous waste landfill in Michigan and the only landfill in EPA Region V with a TSCA approval to accept PCB-contaminated wastes. It is permitted to accept solid waste, RCRA hazardous waste, and NORM and TENORM wastes under RCRA permits EPAID#MID000724831 (Treatment) and EPAID#MID048090633 (Landfill), which contain waste acceptance criteria relative to hazardous wastes. The NORM/TENORM Waste Addendum identifies waste acceptance criteria relative to radionuclides. The co-located solid waste transfer facility and processing plant (Michigan Disposal Waste Treatment Plant [MDWTP]) operates under the Michigan Department of Environmental Quality license number 9411. Information for the facility can be found at:
https://www.usecology.com/Locations/All-Locations/US-Ecology-Michigan.aspx

Wastes are received at the US Ecology-Michigan facility by truck directly (lined and covered end/side-dump semi-trailers or 32-cubic-yard IP-1 metal intermodal containers placed on a semi-trailer) and indirectly by rail. Wastes shipped by rail are transported in intermodal containers placed on flatbed railcars to a spur location near the US Ecology-Michigan facility (e.g., in Romulus, MI or the large switching yard in Melvindale, MI). At the spur location, the intermodals are transferred from the railcars onto semi-trailers and trucked from the rail spur transfer location to the disposal facility.

Because the US Ecology-Michigan facility is only 520 miles from the Site, US Ecology has indicated that wastes from the Site would most likely be transported by truck to this facility. The specific truck route that would be followed from the West Lake site to the US Ecology-Michigan would most likely be: Interstate 270, then Interstate 70 from Bridgeton, MO to Dayton, OH, then Interstate 75 from Dayton, OH to the intersection with Interstate 275 just north of Monroe, MI, then Interstate 275 to Interstate 94 at Romulus, MI, then Interstate 94 to Van Buren Township, MI. This route transits through the major cities of Bridgeton, MO, St. Louis, MO, Terre Haute, IN, Indianapolis, IN, Dayton, OH, and Toledo, OH.

The specific rail routes that would be followed from a truck-to-rail transloading operation at a potential future leased rail spur located near the Site (assuming one could be located) to the US Ecology-Michigan facility would be: Norfolk Southern from Bridgeton, MO to St. Louis, MO; then CSX from St. Louis, MO to a spur location near the US Ecology-Michigan facility. This route transits through the major cities of Bridgeton, MO, Saint Louis, MO, Terre Haute, IN, Indianapolis, IN, Sidney, OH, Toledo, OH, and Wayne, MI.

The WAC and RCRA Part B permit for this facility are included in Appendix C-2.

Energy Solutions: Clive, Utah. The 439-acre Energy Solutions Clive site is located in Utah's West Desert, approximately 75 miles west of Salt Lake City and about three miles south of Interstate 80, Exit 49. Information for the facility can be found at http://www.energysolutions.com/?id=OTkw. A video of the facilities at the Clive site can be found under the Media Room tab at this Website. The facility is authorized to receive Class A LLRW, NORM/NARM, Class A Mixed LLRW (i.e., radioactive and hazardous), 11e.(2) Byproduct Material, and Special Nuclear Material based on concentration limits under Radioactive Material License (RML) Number UT 2300249, as amended, and 11e.(2) Byproduct Material License Number UT 2300478, as amended. The facility has a separate license to receive and dispose of uranium and thorium mill tailings byproduct material as defined by section 11e.(2) of the Atomic Energy Act of 1954, as amended.

The Clive, UT facility receives waste shipped via bulk truck, containerized truck, enclosed truck, bulk railcars, rail boxcars, and rail intermodals. The disposal site is accessed year-round by the Union Pacific Railroad at Energy Solutions' 10 miles of private siding. A covered railcar rotary dumper and covered railcar decontamination facilities are also located at the disposal facility.

Energy Solutions has indicated that excavated material from the Site would be either: (1) loaded directly into gondola cars if a potential future rail spur could be extended across St. Charles Rock Road onto the Site; (2) loaded into 10-cubic-yard IP-1 DOT bags, with the bags placed on a flatbed semi-trailer and transported to a truck-to-rail transloading operation at a potential future leased rail spur located near the Site (assuming one could be located), and then loaded into gondola rail cars; or (3) bulk loaded into 25-cubic-yard intermodal containers, with the intermodal containers then placed on a flatbed semi-trailer and transported to a truck-to-rail transloading operation and multiple intermodal containers stacked onto flat railcars. The gondolas or intermodal containers would be transported via rail directly to the Clive, UT facility for disposal at the Energy Solutions facility.

The specific rail routes that would be followed from a potential future rail spur extended onto the Site or a truck-to-rail transloading operation at a potential future leased rail spur located near the

Site to the Energy Solutions Clive, UT facility are as follows: Norfolk Southern (NS) from Bridgeton, MO to Kansas City, MO; then Union Pacific from Kansas City, MO to Clive, UT. This route transits the major cities of Bridgeton, MO, Kansas City, MO, Atchison, KS, Marysville, KS, Hastings, NE, North Platte, NE, Cheyenne, WY, Green River, WY, Ogden, UT, Salt Lake City, UT, West Wendover, NV, and Clive, UT. Note that Energy Solutions uses a different rail route from Bridgeton, MO to Kansas City, MO than US Ecology.

Large volumes of soil and waste materials with low levels of radionuclides have been disposed at the Clive facility from the following projects: DOE – Fernald, OH Closure; DOE – Rocky Flats, CO Closure; DOE – Mound, OH OU-1 Landfill Closure; DOE Columbus Closure; USACE Maywood, NJ FUSRAP sites; USACE St. Louis FUSRAP sites; and Denver Radium, CO CERCLA site.

The WAC for this facility is included in Appendix C-3.

Clean Harbors (Deer Trail) – Last Chance, Colorado. This 325-acre treatment, storage, and land disposal facility is located in a rural area approximately 75 miles east of Denver and is licensed to accept NORM and TENORM wastes and debris, as well as landfillable mixtures of RCRA and NORM wastes under Colorado Department of Public Health and Environment Radioactive Materials License Number Colo. 1101-01 and Colorado RCRA Part B Permit renewed 2005, No. CO-05-12-21-01. A Fact Sheet for this facility can be downloaded from the Clean Harbors website at the following link: http://cleanharbors.com/locations/index.asp?id=55.

Wastes are received at the facility by truck directly and by rail via a trans-loading point located in Sterling, Colorado, approximately 73 miles from the disposal facility. Clean Harbors has indicated that Site wastes would be either: (1) loaded directly into lined gondola cars if a potential future rail spur could be extended across St. Charles Rock Road onto the Site, or (2) loaded into end-dump semi-trailers, transported to a truck-to-rail transloading operation at a potential future leased rail spur located near the Site (assuming one could be located), and discharged from the end-dump semi-trailers into lined gondola cars. The gondola cars would be hauled by rail to the trans-loading point in Sterling, transferred from the gondola cars to semi-trailer trucks, and trucked the 73 miles to the Deer Trail facility for disposal.

The specific rail routes that would be followed from a potential future rail spur extended onto the Site or a truck-to-rail transloading operation at a potential future leased rail spur located near the Site to the trans-loading point located in Sterling, CO for the Clean Harbors (Deer Trail) facility are as follows: NS or BNSF from Bridgeton, MO to Kansas City, MO; then Union Pacific from Kansas City, MO to Sterling, CO. This route transits through the major cities of Bridgeton, MO, Kansas City, MO, Atchison, KS, Marysville, KS, Hastings, NE, North Platte, NE, Julesburg, CO, and Sterling, CO.

The Rocky Mountain Low Level Radioactive Waste Compact has designated Deer Trail as the Low-Level Waste Facility for Colorado, New Mexico, and Nevada. Wastes from other states may be disposed at Deer Trail but an Application for Waste Import must be made to the Rocky

Mountain Low Level Radioactive Waste Board and an application fee paid. DOE FUSRAP wastes have been disposed at the Deer Trail facility.

The WAC for this facility is included in Appendix C-4.

4.3.6 Nuisance Control Technologies

Technologies for stormwater management, bird nuisance, and fugitive dust and odor emissions mitigation were also screened. These technologies are discussed further below.

4.3.6.1 Storm Water Management

During construction of the selected remedy, storm water management will be addressed by minimizing storm water flow into the working areas (also referred to as runon); by minimizing the surface area of disturbed ground that is exposed to direct precipitation; and by properly detaining and treating, if necessary, runoff that has contacted the working areas. A Storm Water Management Plan that incorporates appropriate diversion, conveyance, detention, and treatment measures would be prepared as part of the RD and implemented during the remedial action to ensure that appropriate effective measures are taken to limit runon, minimize waste contact with precipitation, and manage and monitor runoff in accordance with applicable regulations and a stormwater management plan (as necessary).

Applicable technologies that could be employed for storm water management include:

- Use of Best Management Practices (BMPs) such as diversion ditches, earthen berms, and culverts to divert storm water around the disturbed or working areas so as to prevent its contact with exposed waste material.

- Use of BMPs such as selective excavation, staging, daily soil cover or tarps, and covering truck loads during transportation to minimize the area of waste exposed to direct precipitation. In some cases, temporary sumps and pumps may also be used to augment conveyance of direct precipitation into runon diversion ditches.

- Use of temporary structures (*e.g.*, a tensioned fabric frame structure) erected above and around excavation and/or waste sorting/loading areas to shield waste from contact with direct precipitation. A temporary enclosed structure would require construction of a relatively flat foundation system (e.g., spread footings, drilled piers, driven piles, or grade beams) to support the predicted loads. The maximum width of commercially-available structures that can be relocated is approximately 150 feet, with a typical maximum width of 160 feet due to the significant increase in the size of the trusses and other structural components required for spans greater than 160 feet and the commensurate increase (approximately 50%) in the unit costs for larger spans. Therefore, for excavations with widths greater than 140 feet, a temporary structure would need to be moved multiple times, with each move involving excavation and earthwork to prepare the next area and install a new foundation prior to disassembling and reassembling the structure (see Appendix D-3). The geotechnical properties of buried refuse in Areas 1 and 2 would likely not support the loads induced by a temporary structure without an elaborate foundation system or localized ground improvement to strengthen the foundation materials. Concerns about relocating such a structure would not apply to its potential use for shielding of waste sorting/loading activities as these activities could be established in a single central area that would be used throughout implementation of potential remedial actions.

- Use of BMPs to collect, detain, treat, and release runoff as required by Missouri storm water regulations. These BMPs would include the use of sumps, pumps, pipelines, lined impoundments, and/or temporary storage tanks to collect, convey, and detain stormwater that has contacted waste material. If treatment is necessary, any radionuclides would likely be co-precipitated with and adsorbed to the particulates in the storm water and would be removed via gravity settling within a detention or stormwater pond or tanks and via filtration to meet direct or indirect (*i.e.*, to a Publicly-Owned Treatment Works [POTW]) discharge limits. Radon gas would be removed via liquid-phase granular activated carbon (LPGAC) adsorption, if necessary. In addition, conventional flow control devices such as a morning-glory spillway within, or fixed weir at, an outlet of a detention pond could be used to limit discharge rates to those of the design storm[27] or as allowed by State regulations.

4.3.6.2 Bird Nuisance Mitigation

Because the waste materials in Areas 1 and 2 would be re-graded as part of the containment remedies or subjected to excavation under the partial or full excavation alternatives, the nuisance attraction to and congregation by birds at and above the affected areas could be problematic unless effectively controlled. The main concern would be the potential for increased bird strikes to aircraft approaching and departing from Lambert-St. Louis International Airport.

Ongoing research by the US Department of Agriculture Animal and Plant Health Inspection Service (USDA, 2008) and the National Wildlife Research Center (NWRC, 2008) into bird control mechanisms at landfills, as well as practical experience by landfill operators, offer control strategies that may help mitigate bird congregation above and within excavation areas. If needed, an avian management plan that incorporates appropriate measures would be prepared by a qualified wildlife expert as part of the RD process to ensure that appropriate effective measures are taken during excavation to cost-effectively limit bird congregation in order to protect

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[27] The design storm represents the maximum rate at which stormwater can be discharged from the Site.

approaching and departing aircraft from increased risk of bird-strikes. Potential control strategies include:

- Use of BMPs based on practical experience by landfill operators. These BMPs would include the use of selective excavation and staging of waste material to minimize the area of exposed waste at any given time, and using daily cover consisting of soil or a tarp placed over the exposed waste.

- Removal of food sources by covering exposed refuse with a temporary structure (e.g., a tensioned fabric frame structure).

- Erecting grids over exposed refuse to prevent bird access using stainless steel wire, monofilament, or Kevlar line placed above the working area in parallel lines or in spoke configurations. Parallel spacings of between 10 and 50 feet have been effective for most gulls such as those that nest in Missouri. Lines would be placed above the maximum height of working equipment, which would be approximately 15 feet above the original ground elevations for Areas 1 and 2, assuming scrapers and/or bulldozers are initially used. Lines would need to be placed at higher levels when excavators and loaders are employed. Line length would depend on the strength of the wire/filament used and available space for support poles. The size of open excavations may limit the constructability of wire or monofilament grids.

- Use of predator birds such as falcons or visual deterrents such as effigies of predator birds.

- Use of auditory "frightening" devices such as pyrotechnics, propane exploders, bird alarm calls, or sound generators that produce noise that is irritating to birds.

- Use of chemical frightening agents or toxicants such as the EPA-registered gull toxicant DRC-1339 and/or Avitrol®. Effective full-scale and long-term application information regarding either chemical on gulls at landfills is not available in the literature. Use of chemical frightening agents or toxicants does not address the concern regarding congregating birds within the flight path of aircraft.

4.3.6.3 Fugitive Dust and Odor Control

Waste materials in OU-1 would be regraded during construction of the cover components under the containment (capping) remedies and excavated under the partial excavation or full excavation alternatives. Fugitive dust and odor could be generated during excavation, regrading, and final cover construction; as a result of construction vehicles or trucks operating on or traversing the Site; and from the staging of wastes and other construction materials. Methods for control of fugitive dust could include implementation of BMPs; misting/spraying of water or foams on exposed excavation surfaces, staged materials, and roads; enclosing the areas of excavation within a temporary structure; and enclosing excavated waste within a temporary structure during waste sorting and loading prior to transporting of waste off-site, as discussed further below.

- Use of BMPs based on practical experience of landfill operators and construction contractors. These would include the use of selective excavation and staging of waste material to minimize the area of exposed waste at any given time, temporary staging excavated waste in as small an area as practicable, daily covering of exposed waste using soil or tarps, and rapid re-covering of exposed waste whenever practicable.

- Fugitive dust, and to some extent odor, can be controlled through misting and spraying of exposed and staged wastes and permanent and temporary construction roads at the Site with water. Temporary misting systems would be set up above and around staged wastes. Water would be sprayed on exposed waste if the waste is dry and dust is generated during excavation. Water trucks with spray applicators would be used to spray roads to minimize dust generation. Viscous, water-based, non-hardening foams would be sprayed on exposed and staged waste to suppress fugitive dust and odor. Acrylic copolymer resin foams that penetrate the road surface to eliminate or reduce repeated watering can be applied to roads for dust and erosion protection.

- A temporary structure (see description and discussion above in Section 4.3.6.1 and in Section 4.4.1.1 below) could be erected above and around an excavation and/or waste staging area such that any fugitive dust or odor would be contained within the structure.

- For the partial excavation and full excavation alternatives, excavated waste that would be staged and sorted prior to shipment off-site for disposal could be enclosed within a temporary structure (*e.g.*, a tensioned fabric frame structure). Loading of trucks or intermodal containers for transport of RIM to the off-site disposal facility would also be performed in this structure. The structure would include a concrete floor working surface and be sized to house an appropriate volume of staged RIM to allow an uninterrupted rail transportation schedule. The structure would include ventilation and emissions control facilities to reduce/eliminate fugitive dust and odor concerns associated with staged waste. Workers inside the structure would wear appropriate PPE.

4.4 Implementability Screening of Remediation Technologies and Process Options

Potential remedial action technologies and process options that may be applicable to address the Site characterization results and satisfy the RAOs are described in Section 4.3 and are also summarized in Figure 4-1. The technologies are screened based on technical implementability in Figure 4-1. The following remedial technologies and process options were eliminated from further consideration based on the rationale discussed in the Implementability Screening Comments column in Figure 4-1.

General Response Action	Remedial Technology	Process Options
Containment	Land Encapsulation Cryogenic Barriers Vertical Barriers	• On-site: New cell • Subsurface cryogenic barrier • Slurry wall • Grout curtain • Sheet pile cutoff wall
Physical/Chemical Treatment	Chemical Separation	• Solvent/chemical extraction
	Physical Separation	• Soil washing • Flotation
	Vitrification	• In-situ vitrification • Ex-situ vitrification
Biological Treatment	Phytoremediation	• Phytoextraction • Phytostabilization
Removal	Storm Water Management Bird Nuisance Mitigation	• Enclose excavation with temporary structure • Enclose excavation with temporary structure • Chemical frightening agents or toxicants

Implementability screening comments in addition to those provided on Figure 4-1 are provided below for the use of a temporary structure to enclose an excavation for stormwater management or bird nuisance mitigation, and for the dry soil separation physical treatment process.

4.4.1 Implementability Comments: Temporary Structure and Dry Soil Separation Process

Discussions of additional factors affecting the potential implementability of temporary structures and physical separation technologies are provided below.

4.4.1.1 Temporary Structure

Use of a temporary enclosure to protect an exposed excavation from contact with stormwater or for a potential bird mitigation strategy or to provide an enclosure for loading of RIM was evaluated. Use of a temporary enclosure over excavation areas is evaluated in Appendix D-3. Application of this technology to an entire excavation area was eliminated from consideration in the SFS because of implementability concerns and the potential for adverse impacts. In addition, other potential process options would provide adequate stormwater controls or bird nuisance mitigation without the significant disadvantages (summarized below) of using a temporary enclosure. Use of a temporary structure over excavation areas and to cover a RIM loading facility has been re-evaluated in the FFS. Additional evaluation for the potential use of temporary structures for excavation areas has been developed and included in Appendix D-3.

A temporary enclosed structure would require construction of a foundation system (e.g., spread footings, drilled piers, driven piles, or grade beams) to support the predicted loads (in particular, wind loads) on the structure. The foundation alignment must also be relatively flat from side-to-side and end-to-end. Because the topography of the Site is variable, with slopes for drainage control, considerable earthwork would be necessary to prepare an area for foundation construction in advance of erecting the enclosed structure. This would likely include over-excavation for the foundation system that would support the structure. All of this earthwork would be performed without protective cover. In addition, the maximum width of commercially-available structures is approximately 250 feet, with a typical maximum width of 160 feet. Based on discussions with the vendor, Sprung Structures, the maximum width of a relocatable building that could be used over an excavation area is 150 feet. Although there are few areas where the excavation widths are small, for most of the excavation areas the width of areas to be excavated, including the RIM, associated overburden, and layback for excavation slope stability, range from approximately 250 feet to 1,050 feet. Thus, temporary structures used over excavation areas would need to be moved many times, with each move involving excavation and earthwork to prepare the next area and installation of a new foundation prior to disassembling and reassembling the structure. In addition, because the maximum width of the building will not accommodate graded side slopes for excavation stability, sheet piling or other shoring would need to be installed around the area to be excavated within the building. Finally, the geotechnical properties of the buried refuse would likely not support the loads induced by the structure without an elaborate foundation system or localized ground improvement to strengthen the foundation materials.

Beyond the construction difficulties, other complications would include (1) provision of proper ventilation inside the structure to protect workers from potential accumulation of radon, methane, hydrogen sulfide, heavy equipment exhaust, dust, and ambient heat, (2) provision of “explosion-proof” electrical conduit and fixtures within the structure because of the potential presence of landfill gas when wastes are excavated, (3) worker safety risk from assembling, disassembling, lifting, then reassembling the 30- to 40-foot-tall structures, (4) durability of the structure for multiple moves, and wear and tear on the components causing the likelihood for ongoing replacements, maintenance, and repair of the structure and associated construction delays, and (5) the need for construction of temporary drainage controls around the structure each time it is moved.

Overall, use of enclosed structures over the excavation areas, where they can be applied, would add considerable time to the remediation schedule because each move would necessitate a new foundation, removal of fabric, disassembly of the structure, crane lifts, reassembly, demobilization and remobilization of electrical and ventilation equipment, removal of old foundations, and construction of new drainage controls. Relocation of the structure would be required to address the areal extent of any excavation and the vertical depth of any excavation. Specifically, such a structure may need to be relocated in the same area several times for any alternative that requires excavation below depths of approximately 15 feet. Such relocation would result in exposure of previously excavated waste which would need to be covered with daily or intermediate soil cover. Consequently, for deeper excavations that require multiple relocations of the structure, use of a temporary structure would not eliminate the potential for exposed waste or the need for application of daily or intermediate soil cover. Appendix D-3 presents the anticipated sequence that would be required for initial placement, excavation, and relocation of a temporary structure for covering excavation areas. The sequencing of installation of sheet piling or other excavation support, erection of a temporary structure, excavation, disassembly of the temporary structure, and removal of the sheet piling is expected to double the amount of time required for the full excavation compared to what could be achieved without use of a temporary structure (Appendix D-3). Capital and O&M costs associated with the structures, mobilizing them to the Site, assembly/disassembly/reassembly, demobilizing them from the Site, foundations, capital and operating costs for electrical and ventilation equipment, and the additional carrying costs for the project due to schedule delays would likely be prohibitive for large areas or deeper excavations. A preliminary estimate of the cost associated with use of temporary structures located over excavation areas associated with the full excavation alternatives results in an estimated additional construction (unburdened cost without project management, remedial design, construction administration, and agency oversight) cost of approximately $141 million. Due to the issues associated with use of such structures on slopes, impacts to the overall duration and schedule of excavation work, increased costs, and increased risks to workers, use of temporary structures to contain all excavation activities, such as those associated with full excavation or other alternatives that entail large areas of deep excavations, is not considered feasible. Therefore, use of temporary structures to completely enclose all excavation activities is not considered feasible.

Although the use of temporary structures to contain all excavation areas is not considered to be effective, implementable, or cost efficient for alternatives that require large or deep excavations, use of such structures may be considered further for any alternative that entails only small areas of shallow depth excavations. In addition, use of a temporary structure may be appropriate in the event that materials are encountered that pose difficulty for control of air emissions, such as friable asbestos-containing material, drums or other vessels containing volatile or highly toxic materials, or possibly high levels of radionuclides, if standard procedures such as water mist, foam or other engineered techniques prove ineffective.

A temporary structure likely would be an appropriate means to control air emissions and to prevent contact with precipitation for RIM staging and loading operations. Use of a temporary rigid frame fabric structure erected in a fixed location for use as a facility within which excavated RIM would be staged prior to being transported to a licensed off-site disposal facility was retained as a remedial technology/process option for fugitive dust and odor control. RIM excavated from Areas 1 and 2 would be trucked from the excavation into one side of the “RIM staging/loading” building via articulated on-site construction trucks and be staged in the middle of the building for potential blending and subsequent loading into intermodals for transportation off-site. Lined intermodals transported on flat-bed highway trucks would be loaded with RIM and tarped/covered on the opposite side ("intermodal loading" side) of the RIM staging/loading building. Staging and loading of RIM in an enclosed structure would prevent precipitation from contacting excavated RIM, prevent bird access, and contain odor that would be associated with excavated MSW. Based on the estimated volumes of RIM to be excavated under the full and partial excavation alternatives (see discussion in Section 5), for costing purposes it is assumed that a 200 ft by 400 ft building would be constructed on approximately four acres of land within the Site on an area that has not been landfilled (*i.e.*, within OU-2). The building would be equipped with an air emissions/odor control system. For costing purposes, it is reasonably assumed (based on professional judgment) that between three and four building volume air changes per hour would be necessary and that emissions control would include vessels filled with activated carbon specifically developed to remove hydrogen sulfide as well as activated carbon developed to remove volatile organic compounds.

4.4.1.2 Dry Soil Separation

Although it is expected that use of the shear shredder/trommel equipment would be effective at separating the majority of soil from the non-soil solid waste, the degree of separation that may be achieved by this technology is uncertain. Prior applications of this technology have been focused on separating the bulk of the soil volume from an overall matrix of landfill wastes in order to implement waste-to-energy or waste composting operations or to recover the soil for reuse. These applications were not designed or expected to recover 100% of all of the soil in a landfill and were not concerned with the fractions of soil that were contained in or adhered to the segregated refuse. These applications also were not concerned with the creation of additional fine-grained fractions that would become mixed with the recovered soil as a result of use of a shear-shredder prior to a trommel. Consequently, the effectiveness of this technology at separating RIM (and only RIM) from the overall mass of solid wastes could not be determined without performance of a full-scale pilot test.

In Areas 1 and 2 of the Site, residual soil containing radionuclides that adheres to or is otherwise contained in the refuse after performance of waste segregation using a trommel screen could still produce processed waste exceeding the levels that would allow for unrestricted use. As a result, the effectiveness, implementability, and cost of this technology cannot be determined without performing a pilot test. Furthermore, although a trommel includes an exterior brush (Figure 4-3) to remove debris that may otherwise become entangled in the rotating screen, there would still be instances in which laborers would have to enter the screen and physically remove wire, rebar, plastic, wood, or other entangled debris. During these events, workers would be exposed to increased radiation emitted by RIM that adheres to or otherwise remains in the trommel. The frequency and duration of physical removal of debris cannot be estimated at this time; however, it is clear that use of a trommel would create an additional mechanism for worker exposures to the RIM.

Depending upon the production rate and dependability of the solids separation equipment, inclusion of a solids separation step as part of a process used for excavation and disposal of the RIM could become a factor relative to the daily production rates and project duration. In addition to the additional activities requiring workers and resultant exposures, use of such equipment is expected to extend the overall project schedule and increase the potential or amounts of stormwater accumulation, airborne emissions, and bird or other vector impacts due to a possible increase in the overall schedule.

In order to evaluate this technology, full-scale pilot testing of the shear shredder/trommel screen solids separation equipment for volume reduction (and, if appropriate, radiological screening/segregation techniques) would be required using representative material from Areas 1 and/or 2. Pilot testing is typically performed prior to LFMR projects in order to assess screening and trommel equipment sizing, estimate production rates, determine the fraction of soil that can be separated from the filled material using varying trommel screen opening sizes (and therefore maximizing the amount of soil that can be removed), and obtain an indication of the type of material that was filled (*e.g.*, construction and demolition debris such as bricks, concrete and rebar, dimensional lumber, and/or MSW). Of particular interest in conducting pilot testing of material from Areas 1 and 2 would be obtaining an estimate of the degree of RIM volume reduction that could be achieved, assessing the moisture content of the filled material, and determining the fraction of soil that would be contained in or adhered to the segregated refuse.

Assuming pilot test results show that physical segregation/separation alone or in conjunction with radiological segregation/separation has the potential to effectively and safely separate the radiologically-impacted soil fraction of RIM from the overall matrix of landfilled refuse, debris and fill materials, and unimpacted soil and quarry spoils, then additional dry soil separation and/or radiological segregation technologies might be considered to further reduce the volume of radiologically-impacted soil. However, if results of pilot testing indicate that the non-soil fraction of RIM that would be discharged out the end of the trommel exhibited radionuclide concentrations greater that those that would allow for unrestricted use, then the soils separation process would not be effective in reducing the volume of RIM that would be addressed under the full excavation alternatives or possibly even some of the partial excavation alternatives.

This technology, alone or possibly in combination with an SGS, may be effective for the partial excavation alternative based on the 1,000 pCi/g criterion. However, the additional costs required to implement this technology may not be supported by the overall lower volume of RIM to be excavated and disposed off-site under this alternative. Evaluation of cost, schedule impacts, and potential volume reduction that may be achieved is necessary to determine whether this technology would be beneficial for the 1,000 pCi/g partial excavation alternative. The effectiveness, implementability, and cost of this technology relative to the full excavation alternatives or the partial excavation alternatives based on the 52.9 pCi/g and 16-ft depth criteria or an industrial land use alternative cannot be ascertained from the available information. Pilot testing is required to determine the degree of separation and potential volume reduction that could be achieved by this technology, as well as the potential schedule impacts, short-term risks, and costs associated with this technology.

Because physical separation/segregation alone or in conjunction with radiological segregation/separation has a potential to reduce the volume of RIM that would need to be transported and disposed at an off-site facility, these technologies have been retained. However, because these technologies have not previously been demonstrated for use in separating radiologically impacted soil from MSW, and due to the uncertainties of the potential effectiveness, implementability and cost of such technologies, as discussed in this section and in Section 4.3.5.2, the potential application of such technologies for the full or partial excavation alternatives cannot be evaluated at this time. Therefore, they are not included as a process option for any of the alternatives described in Section 5 or in the detailed analysis of alternatives presented in Section 6.

4.5 Evaluation of Remediation Technologies and Process Options

Potential remedial action technologies that may be applicable to address the Site characterization results and satisfy the RAOs are described in Section 4.3 and are also summarized in Figure 4-1. The technologies are screened based on technical implementability in Figure 4-1. The resultant technologies are then evaluated in Figure 4-5 based on anticipated effectiveness, implementability, and relative cost to identify applicable technologies that might be used as components of the remedial action alternatives.

In addition to the technologies identified in the original FS report (EMSI, 2006) as being potentially applicable to the media and contaminants at the Site, the various technologies identified in this section as potentially applicable have been included as appropriate within the alternatives specified by EPA (2015b) for this FFS. Specifically, the following technologies or process options are considered for development and implementation of the remedial alternatives:

- Institutional controls;
- Access restrictions;
- Short- and long-term monitoring;
- In-situ containment;
- Capping and covers;
- Excavation;
- Disposal in an off-site licensed facility;
- Disposal in a new land disposal unit on-site;
- Physical/chemical treatment including solidification/stabilization and soil separation; excavation;
- Temporary structure to enclose a material handling area or small excavation areas where highly friable, volatile or toxic waste materials emissions from which cannot be controlled by other methods;
- Storm water management;
- Fugitive dust/odor control,

- Bird nuisance mitigation; and
- Truck and truck and rail transportation.

With the exception of physical/chemical treatment, all of these technologies have been incorporated into one or more of the remedial alternatives developed and described in the next section of this FFS and evaluated in detailed in Section 6.

As discussed earlier in this section of the FFS, physical separation of soil from MSW has been used at landfill mining projects; however, such projects were not concerned with separation of contaminated soil from MSW, only removal of the soil material to the degree needed for re-use of the soil and/or combustion of the MSW fraction as part of waste to energy projects. Therefore, the efficacy of such technologies for separation of soil containing radionuclides from MSW is unknown. Also, as discussed in this section, physical separation combined with radiological segregation has been used to separate soil containing radionuclides from non-radionuclide soil. Radiological screening/automated segregation may potentially be applicable for separation of materials containing levels of radium sufficiently high enough to be reliably detected and high enough to act as a surrogate for screening of thorium; however, this technology is not expected to be effective for separation of radionuclide concentrations that are close to background levels, such as those associated with unrestricted use criteria. Review of reports regarding prior applications of these technologies indicate that they have produced highly variable results in terms of their effectiveness for separating material containing radionuclides from non-radionuclide-bearing materials. Furthermore, there are no demonstrated or even identified applications of this technology having been used, much less used successfully to separate radionuclide-bearing-soil from non-radionuclide-bearing MSW and soil. Therefore, the potential effectiveness, implementability and cost of this technology for separating radionuclide-bearing soil from the MSW at West Lake Landfill cannot be evaluated based on the available technical literature. For those remedial alternatives that include off-site disposal of RIM, this technology could potentially reduce the volume of material that would need to be disposed at an off-site disposal facility. In addition, such a volume reduction would also meet the CERCLA preference for treatment. Therefore, this technology has been retained and is discussed as part of the development and detailed analysis of the alternatives. However, due to the lack of demonstrated application of this technology on waste materials similar to those at the West Lake Landfill and the limitations of this technology in identifying materials containing thorium, this technology is not included as part of any of the alternatives. An approximate cost estimate and estimated schedule for performance of a pilot test to evaluate the potential effectiveness, implementability and cost of physical separation/radionuclide segregation is included as part of the discussion of the potential costs of the various alternatives presented in Section 6 of this FFS.

5 REMEDIAL ACTION ALTERNATIVES

This section provides descriptions of the remedial alternatives evaluated in this FFS, including the following:

- ROD-selected capping remedy;
- UMTRCA cap alternative;
- Full excavation with off-site disposal alternative;
- Full excavation with on-site disposal alternative; and
- Three partial excavations with corresponding UMTRCA cap alternatives.

As part of preparation of this FFS, preliminary, conceptual-level designs were developed for each of the alternatives in order to: prepare estimates of the costs of construction, operation, maintenance, and monitoring; prepare preliminary construction schedules for each alternative; and evaluate the alternatives relative to the criteria specified in the NCP as described in Section 6. In addition to the conceptual designs of the alternatives, general procedures to be used for materials handling, surface water control, and methane gas management were also developed and are described in this section of the FFS. Any designs presented in this FFS are conceptual and for purposes of evaluation of potential alternatives only. Final designs and materials will be developed and approved in the Remedial Design Phase of work.

Table 1-1 presents a summary of the remedial alternatives evaluated in the 2006 FS, the 2011 SFS, and in this FFS. Sections 5.1.1 and 5.1.2, respectively, present descriptions of the remedial alternatives evaluated in the prior 2006 FS and the 2011 SFS. Section 5.1.3 presents a summary of the alternatives evaluated in this FFS. Detailed descriptions of these alternatives are presented in Sections 5.2 through 5.9.

5.1 Remedial Alternatives Previously Evaluated

This is the third evaluation of potential remedial alternatives for OU-1 of the Site. Prior evaluations of remedial alternatives were performed for the 2006 FS (EMSI, 2006) and 2011 SFS (EMSI et al., 2011).

5.1.1 Remedial Alternatives Evaluated in the 2006 FS

A range of remedial alternatives addressing waste materials and contaminated soil present in OU-1 was developed for, and evaluated in, the 2006 FS (EMSI, 2006). Per direction from EPA Region VII, these alternatives were developed in accordance with EPA's guidance on Presumptive Remedy for CERCLA Municipal Landfill Sites (EPA, 1993b) and "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA, 1991b). These guidance documents establish containment as the presumptive remedy for CERCLA municipal landfills. Part of the presumptive remedy approach for CERCLA municipal landfills includes a decision with respect to characterization and/or treatment of "hot spots," which represent discrete, accessible areas within the overall landfill that contain principal threat wastes which are large enough such that remediation would reduce the threat posed by the overall site but small enough that it is reasonable to consider removal (EPA, 1993b). An evaluation of potential occurrences of "hot spots" in Areas 1 and 2 was performed as part of the original (2006) FS. Based on the nature and extent of the radiological materials present within OU-1, that evaluation concluded that the additional risks involved with a hot spot removal exceed the risks of leaving the waste in place per the ROD-selected remedy.

The remedial alternatives developed in the FS address containment of the wastes (landfill alternatives) and management of radiologically-impacted soil on the Buffer Zone/Crossroad property (former Ford property). Detailed descriptions of the six landfill and four Buffer Zone/Crossroad property alternatives are presented in the FS report (EMSI, 2006).

The remedial alternatives developed and evaluated in the FS (EMSI, 2006) to address containment of the waste materials present in Areas 1 and 2 consisted of the following:

<u>Areas 1 and 2 Landfill Alternatives</u>

- Alternative L1 – No action
- Alternative L2 – Cover repair and maintenance, additional access restrictions, additional institutional controls, and monitoring
- Alternative L3 – Soil cover to address gamma exposure and erosion potential
- Alternative L4 –Regrading of Areas 1 and 2 (minimum slope of 2%) and installation of a Subtitle D cover system
- Alternative L5 – Regrading of Areas 1 and 2 (minimum slope of 5%) and installation of a Subtitle D cover system
- Alternative L6 – Excavation of material with higher levels of radioactivity from Area 2 and regrading and installation of a Subtitle D cover system

EPA (2008a) determined that all of the landfill alternatives except the No Action Alternative (Alternative L1) would protect human health and the environment by limiting exposure to the

Site's contaminants through engineering means and land use controls[28]. Due to the inclusion of engineering controls, EPA (2008a) determined that the landfill cover alternatives (Alternatives L3, L4, L5 and L6) offer much more reliable protection than Alternative L2, which is more reliant on land use controls. EPA (2008a) also determined that the more sophisticated design of a multi-layer landfill cover with infiltration barrier (Alternatives L4, L5 and L6) would provide greater overall protection than the soil cover (Alternative L3). In addition, EPA (2008a) determined that Alternatives L4, L5 and L6 comply with all ARARs while Alternatives L2 and L3 do not meet the basic cover design requirements found in the Missouri Solid Waste Rules for Sanitary Landfills (10 CSR 80-3.010) and therefore do not meet the NCP threshold criterion of compliance with ARARs.

In addition to the presence of RIM in Areas 1 and 2, the FS also developed remedial alternatives to address deposition of radiologically-impacted soil on the surface of the Buffer Zone/Crossroad Lot 2A2 property (former Ford property). The remedial alternatives developed in the FS (EMSI, 2006) to address management of contaminated soil on the Buffer Zone/Crossroad Lot 2A2 are as follows:

<u>Buffer Zone/Crossroad Lot 2A2 Property (former Ford property) Remedial Alternatives</u>

- Alternative F1 – No Action
- Alternative F2 – Institutional and Access Controls
- Alternative F3 – Capping and Institutional and Access Controls
- Alternative F4 – Soil Excavation and Consolidation in Area 2

EPA (2008a) determined that all of the alternatives for the Buffer Zone/Crossroad Lot 2A2 Property, except Alternative F1 (No Action), are protective of human health and the environment and would comply with ARARs.

Detailed evaluations of the six landfill and four Buffer Zone/Crossroad Lot 2A2 Property alternatives relative to the nine criteria specified in the NCP are presented in the 2006 FS report (EMSI, 2006).

EPA subsequently issued a Proposed Plan that identified alternatives L4 and F4 as the preferred alternatives. After holding several public meetings and obtaining public comments, EPA selected these alternatives, with the addition of rock armoring along the toe of the north and northwest boundaries of Area 2 to protect against potential erosion in the event of flooding from failure of the Earth City flood control system (levees and pumping) as the remedy for OU-1.

[28] EPA has subsequently advised that, based on the additional investigations, EPA no longer considers Alternatives L2 and L3 protective (in addition to not meeting state regulations) due to radionuclide activity identified at the surface of the landfill, and due to the new understanding of the potential for RIM to leach to groundwater.

EPA's selection was documented in the 2008 ROD. The proposed remedy was referred to as the ROD-selected remedy during subsequent evaluations (*e.g.*, the SFS and this FFS).

5.1.2 Remedial Alternatives Evaluated in the SFS

In a January 11, 2010, letter (EPA, 2010a) and accompanying SOW, EPA requested that the Respondents prepare an SFS to evaluate two complete rad removal alternatives. For purposes of the SFS, EPA directed that the two "complete rad removal" alternatives listed below be developed and evaluated in the SFS, in addition to the ROD-selected remedy:

1. Excavation of radioactive materials with off-site commercial disposal of the excavated materials (referred to as "complete rad removal" with off-site disposal alternative in the SFS); and

2. Excavation of radioactive materials with on-site disposal of the excavated materials in an on-site engineered disposal cell with a liner and cap if a suitable location outside the geomorphic flood plain could be identified (referred to as "complete rad removal" with on-site disposal alternative in the SFS).

EPA indicated (EPA, 2010a) that "complete rad removal" was defined to mean attainment of risk-based radiological cleanup levels specified in OSWER Directives 9200.4-25 and 9200.4-18.

These three alternatives (ROD-selected remedy plus two "complete rad removal" alternatives) were evaluated in the 2011 SFS (EMSI et al., 2011).

5.1.3 Remedial Alternatives Evaluated in the FFS

EPA's SOW for the RI Addendum and FFS (EPA, 2015) identifies three partial excavation alternatives and two other remedial alternatives which, in addition to the No Action Alternative, results in the following seven remedial alternatives to be evaluated in the FFS:

1. No Action – Required by the National Contingency Plan (NCP) and RI/FS guidance to provide a baseline against which all of the other alternatives are evaluated[29];

2. 2008 ROD-Selected Remedy (Former Alternative L4 and Alternative F4) – Containment consisting of regrading and installation of a new landfill cover and other remedial components for the landfill, and consolidation of any radiologically-impacted soil that

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[29] The SOW identifies an Alternative No. 3 "Leaving all RIM in place on-site." Subsequent discussions with EPA indicated that this alternative was the No Action Alternative.

may remain on the former Ford property (now known as the Buffer Zone and Crossroads Lot 2A2) into the containment areas in Area 1 and 2 prior to placement of additional fill and construction of the new landfill cover;

3. UMTRCA Cap Alternative - Overall, the conceptual UMTRCA cover alternative is similar to the ROD-selected remedy, but with some additional design features, including a compacted clay layer (CCL) designed to achieve a permeability of 10^{-7}, a geosynthetic clay liner (GCL) or other suitable geosynthetic liner in addition to the CCL, and the placement of the biointrusion layer on top of instead of below the CCL;

4. Full Excavation with Off-site Disposal – Excavation of all soil/waste containing combined radium (Ra-226 plus Ra-228) or combined thorium (Th-230 plus Th-232) with activity levels greater than 7.9 pCi/g and/or combined uranium (U-238 plus U-235 plus U-234) greater than 54.5 pCi/g and transportation to and disposal at an off-site disposal facility;

5. Full Excavation with On-site Disposal – Excavation of all soil/waste containing combined radium (Ra-226 plus Ra-228) or combined thorium (Th-230 plus Th-232) with activity levels greater than 7.9 pCi/g and/or combined uranium (U-238 plus U-235 plus U-234) greater than 54.5 pCi/g and disposal of this material in a new, engineered on-site UMTRCA disposal cell.

6. Partial Excavation 52.9 pCi/g – Excavation of all soil/waste containing combined radium (Ra-226 plus Ra-228) or combined thorium (Th-230 plus Th-232) with activity levels greater than 52.9 pCi/g down to a total depth of 16 feet beneath the 2005 topographic surface;

7. Partial Excavation 1,000 pCi/g – Excavation of all soil/waste containing combined radium (Ra-226 plus Ra-228) or combined thorium (Th-230 plus Th-232) with activity levels greater than 1,000 pCi/g[30]; and

8. Partial Excavation Based on Expected Land Use – Partial excavation of all soil/waste containing combined radium (Ra-226 plus Ra-228) or combined thorium (Th-230 plus Th-232) with activity levels greater than a risk-based level to be developed based on the reasonably anticipated future land use of the Site.

The EPA definition of full excavation is based on combined radium and combined thorium activities, as specified in OSWER Directives No. 9200-4.18 and 9200-4.25. Consistent with the

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[30] In all cases evaluated in the Baseline Risk Assessment, Th-230 and Ra-226 (plus decay products) accounted for more than 95% of the risk to the target receptors. Other radionuclides are co-located with Ra-226 and Th-230 and are projected to produce risks to the future groundskeeper receptor of $<10^{-7}$. Remediation of the Th-230 and Ra-226, by themselves, would reduce the total risks from RIM to below 10^{-4}. Any remediation of Ra-226 and Th-230 would also lower the negligible risks from these ancillary radionuclides still further.

findings in the RI Addendum and the revised baseline risk assessment, the radionuclides that account for the majority of the risk are radium and thorium. Therefore, these radionuclides are suitable for guiding remedial alternative evaluation and implementation. In addition to combined radium and combined thorium, the combined uranium activity will also be considered as appropriate. However, based on the prior SFS evaluations of the “complete rad removal” alternatives, uranium was not found to be a driver for identification of RIM because any locations/depth intervals that contained uranium above its criteria for “complete rad removal” (54.5 pCi/g) also contained radium and/or thorium activity levels greater than their respective criteria for unrestricted land use. In addition, no uranium equivalent criteria were identified by EPA for the partial excavation alternatives; therefore, these alternatives are based solely on the combined radium and combined thorium activity levels. As noted above, use of the combined radium and combined thorium activity levels to define the materials to be included in the scope of the partial excavation alternatives should also result in inclusion of any materials with commensurate uranium activity. Consistent with the RI investigations, any further sampling that may be performed to complete remedial design or final status survey sampling will include isotopic radium, thorium and uranium analyses to ensure remaining concentrations do not exceed the EPA acceptable risk range.

Based on comments provided by EPA on the 2016 draft of the FFS, an additional alternative, referred to in this FFS as the UMTRCA cover alternative, was developed and added to the FFS evaluations. As discussed in Section 4.3.2.1, the UMTRCA requirements are performance-based and are not prescriptive. UMTRCA cover systems are designed to perform properly for individual site conditions. Therefore, there is no standard UMTRCA disposal cell or cover system design. For purposes of the development and evaluation of an UMTRCA cover alternative, a conceptual design has been developed based on the UMTRCA Technical Approach Document – Revision II (DOE, 1989) “checklist” cover with the individual components selected based on the Site conditions. Overall, the conceptual UMTRCA cover alternative is similar to the ROD-selected remedy, but with some additional design features, including a compacted clay layer (CCL) designed to achieve a permeability of 10^{-7}, a geosynthetic clay liner (GCL) or other suitable geosynthetic liner in addition to the CCL, and the placement of the biointrusion layer on top of instead of below the CCL. The UMTRCA cover alternative also includes a drainage layer within the lower portion of the biointrusion layer, and may also include a rock mulch in the upper portion of the vegetation layer. Additional detailed evaluations of an UMTRCA cover system relative to the UMTRCA performance standards and other ARARs and TBCs will be performed as part of remedial design.

5.2 No Action Alternative

No additional engineering or institutional controls would be implemented under the no action alternative, and no monitoring would be performed. Per the NCP, a no action alternative is required and serves as a baseline for evaluation of the other alternatives.

5.3 ROD-Selected Remedy (with modifications)

Upon completion and EPA acceptance of the FS (EMSI, 2006) in June 2006, EPA developed a Proposed Plan (EPA, 2006a) and initiated a public comment period that opened on June 14, 2006 and remained open until December 29, 2006 (EPA, 2008). EPA subsequently re-opened the public comment period in March 2008 and closed this additional public comment period on April 9, 2008 (EPA, 2008). During these periods, EPA held three separate public meetings on June 26, 2006, September 14, 2006, and March 27, 2008 (EPA, 2008).

Based on the results of the RI and FS evaluations and the comments received during the various public meetings and comment periods, EPA prepared a Record of Decision (ROD) that identified the remedial actions that EPA selected for OU-1 (EPA, 2008).

The major components of the ROD-selected remedy for OU-1 (EPA, 2008) are as follows:

- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills, including enhancements consistent with the standards for uranium mill tailing sites (*i.e.*, armoring layer and radon barrier);
- Consolidation of radiologically-contaminated surface soil from the Buffer Zone/Crossroad Lot 2A2Property to the containment area;
- Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills;
- Control of surface water runoff;
- Gas monitoring and control including radon and decomposition gas as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides; and
- Long-term surveillance and maintenance of the remedy.

Prior to construction of the landfill cover, the areas will be brought up to grade using placement of inert fill and regrading of existing material as determined in the RD. Final grades will achieve a minimum slope of two percent. For purposes of this FFS, the total area to be contained by the engineered landfill cover under the ROD-selected remedy is estimated to be 876,000 square feet for Area 1 (20.1 acres) and 1,865,000 square feet for Area 2 (42.8 acres).

Modification of the ROD-Selected Remedy - The ROD (EPA, 2008) indicated that the landfill berm around Area 2 would be regraded through placement of additional clean fill prior to placement of the landfill cover, resulting in an estimated 100 lateral feet of additional material between the current landfill toe and the toe at completion of the RA. For purposes of this FFS, a modification of the ROD-remedy is evaluated. Specifically, this alternative entails regrading of the landfill slopes through relocation of waste material and construction of starter berms to reduce the slope of the landfill berm, rather than placement of additional fill material over the Buffer Zone and Lot 2A2 to reduce the landfill slopes.

The ROD (EPA, 2008) indicated that in this area, the landfill is built over the geomorphic flood plain that is now protected by the Earth City Levee.[31] In the unlikely event of levee failure during a 500-year flood event, the lowermost two feet of the toe of the landfill cover at the northwestern end of the Site could be impacted by the water. The Site is more than a mile from the river and no high-energy water would be expected. The flood protection needs of the toe of the landfill will be evaluated in design and appropriate bank protection methods will be used, *e.g.*, rock rip rap apron. The vertical height of the flood protection feature will include a margin of safety over the 1993 (500-year) flood level. Figure 12-1 in the ROD illustrates a conceptual cross-section of the Selected Remedy and indicates the approximate flood level at the toe of the landfill.

The ROD requires any radiologically-contaminated soil on the Buffer Zone/Crossroad Lot 2A2 Property to be consolidated in the area of containment (Areas 1 or 2) prior to placement of fill material or construction of the cover. However, the ROD also indicates that construction of the landfill cover would require the toe of the landfill berm to be extended over the impacted area on the Buffer Zone/Crossroad Lot 2A2 Property. As noted above, for purposes of this FFS, a modification of the ROD-selected remedy is evaluated that entails regrading through relocation of waste material and construction of starter berms to reduce the slope of the landfill berm rather than placement of additional fill material over the Buffer Zone and Lot 2A2 to reduce the landfill slopes. Any soil containing radionuclides above levels that would allow for unrestricted use would be removed from the Buffer Zone and Lot 2A2 under either approach. Gamma scans and soil sampling will be used to support the RD and document the existing conditions. Any soil outside the footprint of the landfill will meet remediation goals that support unlimited use and unrestricted exposure and will be subject to verification sampling. Any excavation of contaminated material will include dust suppression and work place monitoring to ensure there is no release of fugitive dust.

The ROD requires landfill cover, gas control, runoff control, long-term groundwater monitoring, and post-closure inspection and maintenance to meet (at a minimum) the relevant and appropriate requirements found in the Missouri Solid Waste Rules for sanitary landfills. Consistent with the requirements for uranium mill tailing sites, the ROD requires the proposed landfill cover to incorporate a rubble or rock armoring layer to minimize the potential for biointrusion and erosion and increase longevity. The landfill cover will also be designed to provide protection from radioactive emissions, *i.e.*, gamma radiation and radon. Figure 12-2 of

[31] These areas were subsequently filled such that the surface elevations of these areas are now located above of the 500-year flood level for the area protected by levees (FEMA, 2015). However, the surface of the Buffer Zone and Lot 2A2 are within the area identified as being protected by levees from a 500-year (0.2 recurrence interval) flood.

the ROD shows a conceptual cross-section of a sanitary landfill cover that has been augmented to include a crushed concrete or rock biointrusion layer. Figure 12-3 of the ROD plots the cover thickness necessary to shield a person on the surface of the cover from gamma exposure.

The ROD requires surface drainage diversions, controls, and structures to be designed and constructed to expeditiously route stormwater runoff to the water drainage systems, which are presently subject to state National Pollution Discharge Elimination System permits.

Landfill gas characterization during the RI indicated the sporadic presence of decomposition gases (*e.g.*, methane) and radon in Areas 1 and 2. Radon gas needs only to be detained for a few days until it decays to its solid progeny, and a landfill cover designed to act as a diffusion barrier is generally sufficient to control radon. However, decomposition gases must be handled differently. Typically, gas generation in municipal solid waste increases for the first five or six years after placement in the landfill and then declines thereafter. Because these areas have been inactive for at least 40 years, decomposition gas generation is relatively low and expected to continue to decline over time. However, even at low generation rates, placement of the landfill cover creates the potential for these gases to be trapped and accumulate under the cover. To prevent pressure build up under the landfill cover and/or lateral migration, the ROD states that gas control systems may be required. Gas control measures may involve passive venting or active collection. The need for and nature of the gas control measures will be evaluated and defined as part of the RD. The plans for the control and/or treatment of landfill gas will consider the presence of radon and be developed accordingly.

The ROD requires the landfill cover system to be routinely inspected and maintained to ensure the integrity of the remedy over time. In addition to surveillance of the physical remedy, the periodic site inspections will include administrative functions such as monitoring of institutional controls and coordination with key stakeholders, including the Earth City Levee District regarding management of the flood control system. See Section 5.1 of the ROD (EPA, 2008) for a description of the levee maintenance program.

The ROD requires the O&M Plan[32] to be developed and submitted for approval as part of the RD/RA process. The O&M Plan is to cover all the long-term remedy management functions including groundwater monitoring plans, site inspection, maintenance and repair, institutional control monitoring and enforcement, 5-year reviews, notification and coordination, community relations, health and safety, emergency planning, activity schedules, reporting, etc.

The detailed descriptions of the engineering components, groundwater monitoring objectives and institutional controls components of the ROD-selected remedy are summarized below along with additional information and details developed during preparation of this FFS.

[32] Operations and Maintenance (O&M) Plan is referred to elsewhere in this report as the OM&M (Operations, Maintenance and Monitoring) Plan.

5.3.1 Engineering Components of the ROD-Selected Remedy

The ROD-selected remedy includes both engineered and non-engineered components. The engineered components of the ROD-selected remedy include:

- Regrading of the existing landfill surface to comply with minimum and maximum slope angles of 2% and 25% respectively either through placement of additional inert fill or through relocation of existing waste material and construction of starter berms along the toe of Areas 1 and 2;
- Surveying and removal of radiologically-impacted soil from the Buffer Zone/Crossroad Property;
- Construction of a multi-layered, engineered landfill cover over Areas 1 and 2;
- Installation of rock armoring for flood protection along the toe of the northern portion of Area 2;
- Installation of stormwater/surface water runoff management structures;
- Landfill gas monitoring and, if needed, installation and operation of a landfill gas control system;
- Long term inspection and maintenance of the engineered components of the remedy; and
- Environmental monitoring during and after construction of the remedy.

5.3.1.1 Regrading of the Landfill Surface for the ROD-Selected Remedy

Prior to construction of the landfill cover, the surfaces of Areas 1 and 2 would be recontoured to meet the applicable slope requirements using placement of inert fill and/or regrading of existing material as determined in the RD. Final grades would achieve a minimum slope of two percent (2%) and a maximum slope of twenty-five percent (25%). Final grades would be achieved through placement of additional material, regrading of existing waste materials or a combination of the two. The specific procedures to be used would be determined as part of RD based on site constraints, minimization of the amount of material to be moved or placed, other design requirements, health and safety considerations, cost, and other factors as appropriate.

As part of the development of the SFS, a preliminary evaluation of potential alternative regrading designs was developed and evaluated. The specific options examined included:

1. Use of a fill-only approach for the regrading of the interior portions of Areas 1 and 2;

2. Elimination of the stormwater basins in the northern corner of Area 1 and in the Buffer Zone that were included in the scope of the ROD-selected remedy described in the Remedial Design Work Plan (RDWP);

3. Construction of a 10-ft-high perimeter earthen berm/access road embankment (*i.e.* starter berm) with an external slope angle of 40 degrees along the northern (adjacent to the landfill access road), eastern (adjacent to St. Charles Rock Road) and western (adjacent to the transfer station) portions of Area 1 and the northern (adjacent to Crossroads property and St. Charles Rock Road) and western (adjacent to Crossroads property, Buffer Zone, and Old St. Charles Rock Road) portions of Area 2 so as to reduce the amount of waste excavation required for these areas; and

4. Use of a 3:1 (33⅓ %) slope for that portion of the final landfill cover along the perimeter of Area 2. This would require the completion of a detailed slope stability analysis (as discussed in Section 6.2.1.2.1 of the SFS).

Evaluation of these options as part of preparation of the SFS (EMSI et al., 2011) indicated that excavation of portions of the toe of the landfill in Areas 1 and 2 and construction of a perimeter (starter) berm composed of clean fill material (Option 3 above) is the best approach for achieving the required surface grades while minimizing the amount of waste regrading that needs to be performed. Additional details regarding the various grading options and the results of the prior evaluations are presented in Section 5.2.1.1 and Appendix E of the SFS (EMSI et al., 2011). Based on these evaluations and discussion with EPA, it was determined that the starter berm (Option 3) would be used for purposes of the SFS evaluations. EPA has indicated that it considers this approach to be different from the approach described in the ROD. Therefore, for purposes of this FFS, this alternative is described as a modification of the ROD-selected remedy.

Under this approach, an approximately ten-foot-high starter berm would be constructed along portions of the outer boundaries of Areas 1 and 2. Construction of the starter berm would require excavation of waste materials present at the toe of the landfill in these areas. These materials would be replaced by earthen material that would provide the base for a perimeter access road and perimeter drainage features, incorporate rock armoring for flood control to the extent required, and through use of steeper side slopes for the soil/rock material (in contrast to those allowed for waste materials) would result in greatly reducing the amount of waste material that would need to be regraded under the ROD-selected remedy. Detailed design and agency approval of the starter berm approach would be performed as part of the RD phase; however, based on initial agency comments, it was determined that incorporation and use of the starter berm approach for the ROD-selected remedy was appropriate for the SFS evaluations.

Based on the results of the SFS evaluations, the use of a starter berm has been incorporated into the evaluation of the ROD-selected remedy and other remedial alternatives evaluated in the FFS.

Although inclusion of starter berms reduces the amount of regrading that would otherwise be required, use of this approach does not eliminate the need to regrade the existing waste material. Regrading is needed to increase the grade of the surface of Areas 1 and 2 to achieve the minimum 2% slope (see discussion in Section 3.1.3.4 for the basis for using a 2% minimum slope), to create space for the starter berms necessary to reduce the slope angle along the margins of Areas 1 and 2 (especially along the northern berm of Area 2), and to create space for construction of stormwater basins to detain the increased runoff expected to occur from Areas 1 and 2 with the removal of the vegetative cover and increase in the surface grade. The estimated volume of material to be excavated (cut) and re-located under the ROD-selected remedy is approximately 127,000 bank cubic yards (bcy) (also referred to as "in-place" yards) including a total of 112,000 cubic yards of waste materials and 15,000 cubic yards of soil (12,000 yards for creation of a stormwater basin in the Buffer Zone and approximately 3,000 yards of radionuclide-impacted soil from Lot 2A2 and the Buffer Zone). Of the 112,000 yards of waste to be excavated, a total of approximately 35,000 yards are expected to be cut to regrade inert fill (*e.g.*, concrete rubble) piles, approximately 4,000 yards will be cut to achieve the minimum surface slope and promote drainage from the surfaces of Areas 1 and 2, 12,000 yards are expected to be cut to create space for construction of the starter berms, approximately 39,000 yards are expected to be cut to reduce existing perimeter slopes to below 25%, and approximately 23,000 yards are expected to be cut to create space for construction of a surface water detention basin in Area 1. Alternative designs that could potentially reduce the amount of regrading that may be necessary, including, for example, alternative stormwater detention structures or elimination of the stormwater detention basins, increase in height of the starter berms, or possibly purchase of additional property to allow for placement of the starter berms outside of the existing landfill footprint, could be evaluated during RD.

Approximately 750 yards of the material to be relocated in Area 1 and approximately 15,000 yards of the material to be relocated in Area 2 in connection with regrading of the Site is anticipated to contain RIM. This material would be relocated to areas requiring additional fill material in order to achieve final grades. Because the protectiveness of the cover system was evaluated based on the projected ingrowth of Ra-226 after 1,000 years of decay of Th-230 based on the 95% UCL values for these isotopes, relocation of this material is not expected to affect the protectiveness of the cover system. Because the higher levels of radionuclides were identified at deeper depths (e.g., borings 1D-7, 5-3 and WL-210) that will not be subject to regrading, it is expected that the average radionuclide levels in the material to be regraded will not exceed the 95% UCL values. This assumption will be verified during remedial design, and in the event that this material does contain average levels of radionuclides that exceed the 95% UCL values, the design would include appropriate adjustments to ensure the protectiveness of the cover is achieved.

5.3.1.2 Management of Materials During Recontouring

It is anticipated that any waste that is excavated (cut) to create space for construction of the starter berm or as needed to regrade the surface of Areas 1 and 2 to meet the minimum and maximum slope requirements would immediately be placed in another portion of Area 1 or 2 and therefore no temporary stockpiling of excavated waste would be required for implementation of the ROD-selected remedy. In the event that temporary stock-piling of some of the regraded waste material is necessary, it is anticipated that such stockpiling would be performed on other portions of Areas 1 and 2.

The amount and duration of any waste material stockpiling would be minimized. Any stockpiled waste material would be managed to control odors. For example, these materials would be covered with tarps, soil cover, or foams/chemical agents to suppress odor emissions and reduce the potential for windblown debris and dust, vectors (*e.g.*, rodents and birds), and precipitation infiltration. All stockpiles of waste materials or imported construction materials would be managed to prevent dust emissions and stormwater impacts. They could be covered with tarps and would be located away from drainage courses and stormwater drop inlets so as to reduce windblown erosion and sediment runoff. Sediment netting, berms, straw bales, or equivalent measures would be employed to reduce sediment runoff from the stockpile(s) to the adjacent areas, as well as to prevent runon contact with exposed waste. Water, tarps or other forms of dust suppression would be used to prevent wind erosion of soil stockpiles. The construction contractor would be responsible for ensuring that the stockpiles are stabilized from wind erosion at night and during non-construction days. A plan for stockpiling of waste materials including identification of actual or potential areas for temporary stockpiles, temporary covers, runon-runoff controls, ongoing inspection and maintenance requirements, and other factors would be developed as part of the RD. A Stormwater Pollution Prevention Plan (SWPP) would be prepared prior to commencement of construction activities and would provide a detailed plan for the location and maintenance of the stockpiles.

Application of a temporary cover (*e.g.,* clean soil or other means) to the landfill surfaces being regraded at the end of each workday would help to mitigate odors during non-working periods. This would also reduce radiological exposures to potentially exposed non-radiological workers in the vicinity, and would reduce the attractiveness of the exposed waste to birds and vermin. As such, the conceptual design of the ROD-selected remedy includes application of daily cover and the volume of additional soil to be added as a result of placement of daily cover has been incorporated into design of the grading plans and cost estimates for the ROD-selected remedy (Appendices M and K).

Much of the area requiring re-contouring is outside the area covered by the Negative Easement. Even in those portions subject to the Negative Easement, the re-contouring activity would not be prohibited since the Negative Easement mandates that the facility at all times "comply with all applicable federal, state and local laws and regulations regarding proper landfill cover." Because the re-contouring is necessary to comply with the slope requirements of the Missouri Solid Waste regulations, it is consistent with the terms of the Negative Easement.

The nuisance attraction to and congregation by birds at and above the Site if its contents are exposed could be problematic unless effectively controlled. If necessary, an avian management plan that incorporates best management practices (BMPs) such as daily soil cover and/or tarping, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, could be prepared and implemented prior to and during regrading of waste containing municipal refuse. In addition, for regrading required for the ROD-selected remedy, the area of regrading will be minimized and immediate replacement utilized as much as possible in order to minimize potential exposure of waste.

Off-site disposal of any RIM that may be encountered during regrading of the landfill surfaces was not included in the scope of the ROD-selected remedy. As part of the evaluation of potential short-term and long-term risks associated with the ROD, the 95% UCL values were calculated for the material to be relocated and for all of the material in Areas 1 and 2 (see Appendix H). The calculated 95% UCL values for the material to be relocated was less than the 95% UCL values for all materials. The evaluation of the landfill cover thickness and design and the evaluation of the long-term protectiveness of this alternative were based upon the 95% UCL for all materials (see Section 6.2.2.3). Therefore, relocation of any material that is regraded is not expected to affect the long-term protectiveness of this alternative since the cover system was designed to be protective of higher values. If appropriate, the potential for off-site disposal of this material can be further evaluated during the RD phase.

5.3.1.3 Removal of Radiologically-Impacted Soil from the Buffer Zone/Lot 2A2 Property

Although the nature and extent of radionuclide occurrences on the Buffer Zone/Lot 2A2 Property were previously investigated, due to subsequent grading activities conducted in these areas after the latest set of samples were obtained, the precise nature and extent of contaminated soil on these properties is currently unknown. Any impacted soil above unrestricted levels or levels determined to be protective of public health found within the Buffer Zone and/or Lot 2A2 would be removed to meet remediation goals that support unlimited use and unrestricted exposure. A design-phase investigation would be performed to evaluate the nature and extent of occurrences of radionuclides beneath Lot 2A2 of the Crossroads Property and the Buffer Zone (Figure 2-15). The survey would be conducted in accordance with the EPA guidance related to the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (EPA, DOE, NRC, DOD, 1997). The remediation control and waste characterization surveys for the Buffer Zone/Lot 2A2 property are discussed in Section 3.3.1.1 of Appendix G.

Any radiologically contaminated soil with activity levels above those that would allow for unrestricted use that are identified by the survey would subsequently be removed as necessary to meet the standards established by 40 CFR 192 Subpart B. This soil would be consolidated in the area of containment (Areas 1 or 2) prior to placement of fill material or construction of the cover over that portion of the Site. Prior sampling of the Buffer Zone and Lot 2A2 only detected low levels of radionuclides, below the 95% UCL levels used for development of the conceptual design of the engineered cover system. Therefore, placement of this material on Area 2 should not impact the protectiveness of the cover system. This will be verified during remedial design based on the results of the RD radiation survey and sampling of the Buffer Zone and Lot 2A2.

Excavation of contaminated material would include dust suppression and monitoring (see Appendix G) to ensure there is no release of fugitive dust.

Off-site disposal of any radiologically contaminated soil excavated from the Buffer Zone or Lot 2A2 was not included in the scope of the ROD-selected remedy. As part of the evaluation of potential short-term and long-term risks associated with the ROD, the 95% UCL values were calculated for the material to be relocated and for all of the material in Areas 1 and 2 (see Appendix H). The calculated 95% UCL values for the material to be relocated was less than the 95% UCL values for all materials. The evaluation of the landfill cover thickness and design and the evaluation of the long-term protectiveness of this alternative were based upon the 95% UCL for all materials (see Section 6.2.2.3). Therefore, relocation of any material that is regraded is not expected to affect the long-term protectiveness of this alternative since the cover system was designed to be protective of higher values than this regraded material would contain. If appropriate, the potential for offsite disposal of this material can be further evaluated during the RD phase.

5.3.1.4 Engineered Landfill Cover for the ROD-Selected Remedy

The extent of the new engineered landfill cover included as part of the ROD-selected remedy is presented on Figure 5-3. The overall area to be included within the new landfill cover is estimated to be 876,000 sq ft (20.1 acres) for Area 1 and 1,865,000 sq ft (42.8 acres) for Area 2 (See p. 3 of Appendix K-9.2). Figure 5-4 presents a profile of the new engineered landfill cover that would be installed under the ROD-selected remedy and would consist of the following layers (from top to bottom):

- A one-foot-thick layer of soil capable of sustaining vegetative growth;
- A two-foot-thick infiltration layer of compacted USCS CL, CH, ML, MH, or SC soil-type with a coefficient of permeability of 1×10^{-5} cm/sec or less; and
- A two-foot-thick biointrusion/marker layer consisting of well-graded rock or concrete/asphaltic concrete rubble.

Specifically, the landfill cover to be installed over Areas 1 and 2 would consist of (from bottom to top): 2 feet of rock consisting of well-graded pit run rock and/or concrete/asphaltic rubble ranging from sand sized up to 4 inches such that upon placement would contain minimal void spaces; 2 feet of compacted clay or silt that when compacted at optimum moisture content possesses a coefficient of permeability of 1×10^{-5} cm/sec or less; and 1 foot of soil capable of supporting vegetative growth. The thicknesses of these layers are based on the requirements of the Missouri Solid Waste Rules and the description of the cover system included in the ROD. This conceptual design was used for purposes of estimating the costs for the ROD-selected remedy and evaluation of the other NCP criteria. Ultimately, any engineered landfill cover will need to meet all required performance standards and design criteria of the identified ARARs, including the UMTRCA longevity requirements.

Additionally, as part of this FFS, detailed calculations were performed to select a design cover thickness that meets the remedial action objective for control of radon gas and to ensure that the cover provides sufficient shielding from gamma radiation (Appendix F). Consistent with the UMTRCA requirements and EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) May 2009 memorandum (EPA, 2009b), these evaluations were performed using the expected levels of radon, radium, and thorium that would result from 1,000 years of thorium and radium decay, radium in-growth, and radon generation based on the 95% upper confidence limit (UCL) values for radium-226 and thorium-230. Design of the landfill cap must ensure that risks from exposure to gamma radiation and radon do not exceed the EPA acceptable risk range and are minimized to the extent necessary to comply with the identified ARARs. These design requirements would apply to the top, outerslopes, and toe of the regraded landfill.

Measured radon flux values obtained after placement of the Non-Combustible Cover indicate that the radon-222 emissions from the surfaces of Areas 1 and 2 are currently less than 10% of the regulatory limit of 20 pCi/m^2/s, averaged across OU-1 (EMSI, 2016b). To evaluate potential future radon emission, the 95% UCL values for radium-226 were input into the computer program RAECOM (Radiation Attenuation Effectiveness and Cover Optimization with Moisture) to estimate the current and future (1,000 years) radon emanation rates and surface emissions from Areas 1 and 2 (Appendix F). These calculations indicated that a 1-foot-thick compacted clay layer would provide sufficient radon attenuation to ensure compliance with the radon emission standards (UMTRCA and NESHAP) under both current and future (1,000 year) conditions. Although only 1 foot of compacted clay is required to control radon emissions, 1.7 feet of material is necessary to meet dose-based ARAR requirements. The engineered cover designs for all of the remedial alternatives provide for a five-foot thick cover layer, including a two-foot-thick compacted clay layer. The combined cover thickness will attenuate both radon flux and gamma radiation to levels below the ARARs and protectiveness criteria. A one-foot thick clay layer will reduce both current radon flux and the projected future radon flux after 1,000 years and 9,000 years of ingrowth of radium from thorium decay over time.

Surface exposures from gamma radiation potentially penetrating the cap were also evaluated. These calculations were performed using the gamma pathway in EPA's web-based risk calculator for radionuclides[33] based on the projected radium-226 levels after 1,000 years, and the design specified in the ROD[34] that is based on the Missouri Solid Waste Regulations (CSR 80-3.010(17)(C)(4)(A)) cover design requirements for closure of unlined solid waste landfills, with the additional enhancement of a 2-ft concrete rubble/rock layer, as described above. This cap design would provide sufficient protection from surface radiation exposures, would achieve the UMTRCA radon standard, and would be protective of a potential future maximally exposed

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[33] Provided on https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search.

[34] A minimum thickness of 2 feet of compacted clay with a coefficient of permeability of 10^{-5} cm/sec. or less, overlain by a soil layer (minimum thickness of 1 foot) capable of sustaining vegetative growth.

individual under reasonable maximum exposure levels throughout the 1,000-year simulation period (Appendix F). Specifically, a minimum clay layer thickness of 0.5 feet is required to meet the UMTRCA radon standard, and a minimum total thickness of 3 feet is required to reduce gamma levels sufficiently to result in an acceptable dose[35] (Appendix F).

Results of these evaluations indicated that the ROD-specified cover design would have sufficient thickness and characteristics to be protective against gamma radiation and radon emissions in both Areas 1 and 2 (Appendix F). Cover design will be performed during the RD phase to ensure the cover design complies with the applicable and relevant and appropriate requirements of other environmental regulations including the UMTRCA longevity requirements. The design of the landfill cover, as well as the gas control, runoff control, long-term groundwater monitoring, and post-closure inspection and maintenance components, would at a minimum meet the relevant and appropriate requirements found in the Missouri Solid Waste Rules for sanitary landfills. Consistent with the requirements for uranium mill tailing sites, the landfill cover would also incorporate a rubble or rock armoring layer to minimize the potential for biointrusion and erosion and increase the overall longevity of the cover. The landfill cover would also be designed to provide protection from radioactive emissions (*i.e.*, gamma radiation and radon). Figure 5-4 shows a conceptual cross-section of a sanitary landfill cover that has been augmented to include a crushed concrete or rock biointrusion layer.

A significant amount of earthen material would need to be obtained from an off-site source and delivered to the Site for use in constructing the new landfill cover. Specifically, it is anticipated that all of the final cover system components, materials for construction of the biointrusion layer, low permeability soil (clay) layer, and vegetative layer, will need to be purchased and delivered to the Site. FS-level design projections determined that approximately 820,000 loose cubic yards of soil material will be required from off-site sources for implementation of the ROD-selected remedy. All earthen material used in constructing a final cover system must meet design specifications to be determined during the RD process.

There are several options for how this material could be managed. Depending upon the rate of landfill cover construction compared to the anticipated rate of delivery of the various soil materials, the required materials could be delivered directly to the work area and incorporated into cover construction, thereby avoiding the need to stockpile the materials. If the rate of material delivery does not match the rate of material required for landfill cover construction, then stockpiling may be necessary or advantageous to help prevent construction delays. The time required to deliver the necessary materials needed for construction of the new landfill cover represents a significant portion of the anticipated total construction schedule (Appendix J).

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[35] The Superfund recommendation regarding a protective dose is 12 mrem/yr (OSWER Directive 9285.6-20 – EPA, 2014e), was used as a preliminary criterion to evaluate the necessary cover thickness (see Appendix F). This criterion was used in conjunction with exposure parameters used in the BRA for the outdoor storage yard worker in Area 2, who was identified in the BRA as being the maximally-exposed individual (MEI) for potential future risks. The resulting designs were evaluated to ensure that potential risks were within EPA's acceptable risk range of 10^{-4} to 10^{-6} (see Appendix F).

Therefore, in order to shorten the anticipated duration of construction activities for the ROD-selected remedy, it may be advantageous to import and stockpile the required materials in advance of the time they are needed for cover construction. Subject to Site owner/operator approval, these materials could be stockpiled on inactive portions of the Site such as the on-site soil borrow stockpile area (subject to requirements associated with OU-2 construction schedules), the Closed Demolition Landfill, and/or on portions of Areas 1 and 2 not contemporaneously subject to regrading (Figure 5-5). The feasibility, implementability, costs, and impacts to construction schedules associated with stockpiling of materials are addressed as part of the detailed evaluation of the ROD-selected remedy.

5.3.1.5 Rock Armoring/Flood Protection of the Toe of the Landfill

Portions of the Site were developed over the geomorphic flood plain, but these areas were subsequently filled such that the surface elevations of these areas are now located outside of the 500-year flood plain (FEMA, 2015). These areas are currently protected by the presence of the 500-year levee and supporting flood control system of the Earth City Levee District. In a scenario where the levee fails or ceases to exist, current evaluation of a 500-year flood event may cause approximately two feet of flood waters to contact the toe of Area 2. Because the Site is currently located more than 1.3 miles from the Missouri River, no high-energy water flows are expected if flood waters reached the Site in the near term. Since design considerations need to account for ARARs and extend 200 – 1000 years into the future, in addition to protecting public health through the maximum potential toxicity (which is 9000 years into the future), the geologic and anthropogenic uncertainties associated with longer time intervals should be considered as part of design of the rock armoring in the area of the toe of the landfill. The vertical height of the flood protection feature would be a subject of design phase evaluations, but is expected to include a margin of safety over the 1993 (500-year) flood level. As indicated in the May 2009 memorandum from EPA's Office of Superfund Remediation and Technology Innovation (EPA, 2009b), flood control measures should meet or exceed design standards for a 500-year storm event under the assumption that the existing levee system is breached.

5.3.1.6 Stormwater Management/Surface Water Runoff Control

Management of stormwater during and after construction would be addressed in the Storm Water Pollution Prevention Plan (SWPP) that would be prepared during RD of the selected remedy. Potential methods for control of stormwater were developed for this FFS in order to develop preliminary cost estimates for the ROD-selected remedy and other alternatives. For purpose of this FFS, the following best-management practices have been identified for use during construction:

- Temporary berms and/or ditches would be constructed as needed at the downstream edge of the existing landfill cover or the edges of any interim daily cover in excavation areas, to direct stormwater away from open excavations;

- Other practices may include installation of silt fencing and sedimentation barriers; slope minimization; stabilization of temporary waste stockpiles; use of plastic tarps, mulching, or hydro-seeding on areas not being actively graded or completed and that would be exposed for extended periods (*i.e.*, longer than 45 days); construction and stabilization of stormwater ditches and down chutes; and planting of permanent native vegetative cover when construction is complete. Additional prevention measures would include performing heavy equipment fueling and storing any hazardous materials in designated areas, as well as parking vehicles and locating waste stockpiles away from stormwater drainage points;

- Stormwater that contacts the existing surfaces of Areas 1 and 2, daily cover soil during regrading or excavation in Areas 1 and 2, and the surfaces of cover material as the covers over Areas 1 and 2 are being constructed would be managed as non-contact stormwater and directed offsite via the existing stormwater drainage system; and

- Stormwater that contacts exposed waste during regrading activities would be considered contact stormwater, requiring treatment and/or disposal as discussed below. Any accumulated contact stormwater would be pumped out of the low points in depressions created by the excavation and backfilling activities using portable pumps and directed via a new pipeline to a series of tanks (*e.g.*, frac tanks).

The stormwater tank farm would be sized to accommodate the maximum historical 24-hour rainfall over the anticipated maximum area of exposed waste. Accumulated stormwater would be pumped out of the tanks at a steady flow rate and directed to treatment equipment prior to discharge to the Metropolitan St. Louis Sewer District (MSD) in accordance with MSD procedures and discharge limitations. It is assumed that treated stormwater could be introduced to the MSD sanitary sewer system using the force main that is currently used to convey leachate from the Bridgeton Landfill or via tie-in to an MSD manhole in the vicinity of the West Lake Landfill. Representatives of MSD were contacted during preparation of the SFS, at which time they indicated a willingness to accept perched water/leachate encountered during construction, and stormwater generated during construction, subject to their standard approval procedures and discharge limitations. MSD has in the past accepted or is currently accepting similar waters from the Weldon Springs, SLAPS, and SLDS sites.

Given the variability of the waste, it is not possible to predict the quality of the stormwater that could come in contact with exposed waste during regrading at this time. It is anticipated that any radionuclides would be associated with particulates in the stormwater and might include isotopes of uranium, radium, radon-222, and various radon decay products. It is not anticipated that there would be a significant amount of alpha activity actually dissolved in the stormwater, and as such removal of particulates should be sufficient for treatment of the stormwater.

For purposes of preparing cost estimates for the alternatives in this FFS, it is assumed that 0.2 acres of exposed waste (based on an assumption that the total area of exposed waste at any given time would be approximately 20 acres and that the majority [99%] if this area would be covered by tarps, daily cover or other means) would be subjected to an 8.8-inch rainfall (maximum 24-hour rainfall for August 1946; NOAA, 2011) over a 24-hour period and that this stormwater would be pumped to the stormwater tank farm. This volume of stormwater would be pumped out of the tank farm, treated, and discharged to the MSD sanitary sewer system. Treatment would consist of bag filtration to remove particulates and liquid-phase granular activated carbon (LPGAC) to polish the filtered stormwater and remove any remaining radon and organics. Because any radionuclides that may be present in stormwater would most likely be associated with suspended sediment, it is assumed that these treatment processes would be sufficient to meet the discharge criteria. Two treatment trains would be provided for redundancy and in order to have a back-up system available at all times. It is anticipated that the treatment facilities would be located in a building adjacent to the tank farm. Used filter bags and exhausted LPGAC would be tested and disposed at the appropriate facility according to the analytical test results.

5.3.1.7 Landfill Gas Monitoring and Control

The presence and levels of radon and landfill gas would be monitored both during and after construction of the ROD-selected remedy. Monitoring for radon may include performance of radon monitoring along the perimeters of Areas 1 and 2 during and immediately after completion of construction. Measurement of radon flux from the surface of the new engineered landfill cover would be performed after completion of construction. The need for and scope of any long-term radon monitoring program would be developed during RD.

Measures to control potential accumulations and/or migration of explosive or toxic gases would be taken as needed both during and after construction. As part of RD, specifications for a Methane Gas Emergency Monitoring and Action Plan would be prepared. The contractor selected to perform the remediation would be required to provide a detailed plan that meets those specifications and they would be required to incorporate both methane gas monitoring procedures and emergency response actions into their operational Health and Safety Plan. Methane gas monitoring would be performed in any and all areas where waste materials are exposed or where methane could potentially occur or accumulate. In the event that methane monitoring indicated the presence of methane concentrations which exceed the standard permitted by the Plan in any of the work areas, all work in that area would be immediately stopped and all personnel and equipment would be immediately withdrawn from the area. Methane monitoring would continue to be performed along the margins of the subject area to identify the extent of the area containing the methane exceedance and to assess changes in methane levels over time. In the event that the methane levels declined to below the clearance level of the Plan, work in the area could proceed subject to the results of ongoing and continuous methane monitoring demonstrating that the results remain at the acceptable level. In the event that methane levels again rose above the trigger level, work would again be stopped until the levels declined at which point one or more of the following mitigation procedures could be deployed:

- Work in the subject area could be delayed until methane levels dissipate on their own;

- Equipment could be used to remotely open up and aerate the waste materials to enhance dissipation of the methane; and/or

- Industrial fans could be brought to the work area to dissipate any methane occurrences.

A post-construction landfill gas monitoring program would be developed during the RD phase and implemented as part of the long-term monitoring program. The need for and scope of the landfill gas monitoring program, including the exact number and locations of gas monitoring points and measurement frequency, would be determined in the RD documents for the selected remedy for OU-1. Final landfill gas monitoring well locations and spacing would be based on geologic conditions and proximity to property boundaries and adjacent features. Section 4.1.2 in Appendix G discusses the assumed number and location of sub-surface landfill gas monitoring probes to be installed as part of the post-construction baseline monitoring program for the ROD-selected remedy. Long-term landfill gas monitoring is described in Section 4.1.2 of Appendix G.

Installation and operation of a landfill gas extraction system is included as a contingent action for the ROD remedy, in the event that the perimeter landfill gas or radon monitoring indicate that lateral migration of either explosive gases or radon is occurring along the Site boundary. This would be evaluated by comparing the landfill gas or radon levels at the perimeter of Areas 1 and 2 under the ROD-selected remedy to the appropriate performance standards. Due to the overall age of the landfill waste, along with the relatively low levels of methane detected during the RI (EMSI, 2000), high levels of methane are not expected to occur in Areas 1 and 2.

If it is determined that a contingent landfill gas control system is necessary, it is expected that such a system would consist of either passive or active gas control wells, and in the event that an active gas control system is determined to be necessary, a gas extraction blower and off gas treatment system (a landfill gas flare, or granular activated carbon adsorption in the case of radon) would also be required. A contingent landfill gas control system would be implemented in accordance with the substantive requirements standards established by the MDNR Solid Waste Management regulations (10 CSR 80-3(14)(C)(5)), the Missouri Statutes (Chapter 643 RSMo) and corresponding rules and regulations governing air quality, and the UMTRCA regulations (40 CFR Part 192). Operation of a landfill gas extraction and treatment system would include monitoring of the emissions from any vents, pipes, or flares that discharge to the atmosphere. Results of this monitoring would be compared to the substantive requirements of the above-cited regulations and/or to a site-specific risk-based value.

5.3.1.8 Management of Subsurface Liquids During Construction

It is not anticipated that groundwater will be encountered during regrading of the waste materials under the ROD-selected remedy. The potential does exist that perched layers/lenses of leachate may be encountered during waste regrading. Although the additional investigations conducted in 2013 – 2015 did not encounter any leachate or perched water in Area 1 or 2, inspection of Area 2 indicates that the Area 2 seep identified by McLaren/Hart still exists. Therefore, perched liquid would be likely to be encountered if any waste materials were to be removed from this area as part of an excavation alternative. The current conceptual design for the ROD-selected remedy includes placement of additional waste material in the area of the seep (see Appendix M). Therefore, only minimal perched water is expected to need to be managed from this area.

Any perched liquid that may be encountered during implementation of the ROD-selected remedy would be pumped into temporary holding tanks (*e.g.*, frac tanks), tested to determine whether treatment or pre-approval by MSD prior to discharge is required, and then would be discharged to MSD after authorization is granted. In the event that this liquid cannot be discharged to MSD, it would be hauled to an offsite disposal facility.

5.3.1.9 Regulated Materials Management During Construction

As part of RD, a regulated materials identification and classification plan would be developed to address procedures to be employed in the event that suspected hazardous wastes or regulated asbestos containing material (RACM) are encountered during implementation of the ROD-selected remedy. Components of this plan would include training of the Site health physicists in procedures and criteria to be used to identify potential hazardous wastes or RACM that may be encountered during waste regrading. The contractor's construction manager (CM), health physicist (HP), and construction quality assurance officer (CQAO) would be instructed on the requirements for compliance with 40 CFR Part 61.154(j), 10 CSR 10-6.241, and St. Louis County Ordinance 612.530, all of which pertain to excavating/disturbing asbestos. Specifically, the HP and/or CQAO would complete the required MDNR certification: Missouri State Certificate for Asbestos-Related Occupations. The materials identification plan would also address procedures to be used for segregation, stockpiling, and testing of possible hazardous wastes or RACM and procedures to be used for on-site or off-site disposal of the materials based on the results of the testing.

In the event testing of suspected hazardous wastes indicates that such materials are hazardous waste, these materials would need to be identified, classified, manifested and shipped to an off-site hazardous waste facility for treatment (*e.g.*, solidification, stabilization, micro- or macro-encapsulation, incineration, etc.) in accordance with the Land Disposal Restrictions and associated Universal Treatment Standards of the RCRA Hazardous Waste regulations, and corresponding Missouri regulations. If any identified hazardous wastes also include radionuclides above levels that would allow for unrestricted use, these waste materials would need to be treated and disposed of as "Mixed Wastes" in a RCRA permitted disposal cell at one of the radioactive waste disposal facilities identified in Section 4.3.5.4 of this FFS (U.S. Ecology Idaho, U.S. Ecology Michigan, Energy*Solutions*, or Clean Harbors-Deer Trail). In the event that RACM is encountered during remedy implementation, this material would need to be managed and disposed in accordance with applicable state regulations (see discussion in Section 3).

5.3.1.10 Long-Term Operations, Maintenance, and Monitoring for the ROD-Selected Remedy

Long-term operations, maintenance, and monitoring (OM&M) activities would be performed upon completion of the remedy construction. An operations, maintenance and monitoring plan (OM&M Plan) would be developed and submitted for approval as part of the RD/RA process. The OM&M Plan would cover all the long-term remedy management and monitoring functions including groundwater monitoring plans; site inspection, maintenance and repair; notification and coordination; community relations; health and safety; emergency planning; activity schedules; reporting; etc. In practice, the OM&M Plan may be developed as a compilation of more focused plans.

Under the ROD-selected remedy, RIM would remain onsite, and accordingly, the post-closure operations, maintenance and monitoring period would exceed the 30-year period specified in the Missouri Solid Waste Rules for a solid waste landfill. For purposes of this FFS, cost estimates for both 30 years and 1,000 years of OM&M have been developed as part of the detailed analysis of alternatives (Section 6).

The final landfill cover system would be routinely inspected and maintained to ensure the integrity of the remedy over time. The inspections would focus on identifying any erosion of the landfill cover, the condition and coverage of vegetation on the landfill cover, the presence of material, vehicle, or equipment storage, vehicle tracks, burrowing animals, or any other activities that could affect the integrity of the landfill cover. Periodic mowing or brush-hogging of the vegetative cover would also be performed as part of long-term OM&M in order to control weed and woody plant growth on the landfill cover and to provide for an aesthetically pleasing appearance of the landfill area.

Inspections would also be performed to assess the integrity and overall condition of the perimeter security fencing around Areas 1 and 2. Any impacts to the integrity of the fence caused by activities on adjacent properties, snow accumulation, or other factors would be repaired. Any trash, debris, or woody vegetation that may accumulate along the fence would also be removed.

The various stormwater management structures (detention and sedimentation basins, diversion berms and ditches, runoff ditches, let-down structures, etc.) would be inspected for damage or the presence of erosional features or excessive sediment accumulation. Repairs to these features would be made as necessary.

In addition to surveillance of the physical remedy, the periodic site inspections would include administrative functions such as monitoring of institutional controls and coordination with key stakeholders, including the Earth City Levee District regarding management of the flood control system.

5.3.1.11 Environmental Monitoring for the ROD-Selected Remedy

The ROD-selected remedy would include monitoring activities that would be performed during and after construction of the remedy. The exact scope of this monitoring would be developed as part of the RD effort, but a preliminary description of the scope of potential monitoring activities was necessary to assess the anticipated effectiveness of a monitoring system as well as to provide the bases for estimated monitoring costs. The scope of potential monitoring activities is provided as Appendix G (Conceptual Bases for Costs of Occupational and Environmental Monitoring Associated with each Remedial Alternative) and includes monitoring activities with a limited duration that would be performed during construction (short-term monitoring), post-construction baseline monitoring, and longer duration monitoring activities performed following remedy construction (long-term monitoring).

Short-term monitoring activities that would be performed during construction of the ROD-selected remedy (and the other remedial alternatives) were divided into two categories: (1) health-based monitoring; and (2) remediation control monitoring. Data quality objectives (DQOs) would be different for each category of short-term monitoring activity. Health-based monitoring activities would be designed to evaluate potential emissions and human exposures that may occur during construction of a given alternative. The remediation control monitoring program would be designed to guide the construction contractor during construction of the ROD-selected remedy. Both of these categories of monitoring and survey activities would be limited to the period of construction. Short-term monitoring activities are described in Section 3 of Appendix G.

Post-construction baseline monitoring would be conducted to confirm that the remedial action was completed as designed and to provide initial post-construction values that could be compared to long-term monitoring results. Post-construction baseline monitoring activities are described in Section 4 of Appendix G.

Long-term monitoring activities are described in Section 5 of Appendix G and include landfill gas, groundwater, and surface water as well as post-construction site inspections that would be conducted after remedy construction to verify that the constructed remedy was performing as designed. The frequency of inspections and monitoring activities will be established in the OM&M plan.

Four types of radiological surveys are expected to be conducted to guide the implementation of any capping remedy as described in Appendix G. In general, these surveys would include scoping surveys, remediation support surveys and sampling, and final status surveys and necessary sampling or the equivalent. For the ROD-selected remedy, it is anticipated that surveys would be performed to guide the excavation and relocation of RIM from the Buffer Zone/Crossroad Property onto Area 2 and to obtain regulatory approval that final cover placement over Areas 1 and 2 meet design criteria. These methods of remediation control monitoring for the ROD-selected remedy are described in Section 3.3.1 in Appendix G.

5.3.2 Non-Engineered Components of the ROD-Selected Remedy

In addition to the various engineered components of the ROD-selected remedy, non-engineered activities including implementation, maintenance and monitoring of institutional controls and periodic reviews by EPA and MDNR of the effectiveness and protectiveness of the remedy would be performed.

5.3.2.1 Institutional Controls Included in the ROD-Selected Remedy

Land use restrictions would be maintained and/or implemented as needed for Areas 1 and 2 and the Buffer Zone to limit future uses and to prevent any allowable future uses from impacting the effectiveness or integrity of the remedial action, taking into consideration the presence of long-lived radionuclides. The restrictions must be maintained until the remaining hazardous substances are at levels allowing for unlimited use and unrestricted exposure. Due to the presence of long-lived radionuclides at OU-1, the restrictions would need to be maintained indefinitely. The existing Negative Easement and Restrictive Covenants on the West Lake Landfill (Appendix A) would also remain applicable as institutional controls.

The following long-term use restrictions would potentially apply within the boundary of the cover systems for Areas 1 and 2:

- Prevent development and use for residential housing, schools, childcare facilities, or playgrounds;
- Prevent development and use for industrial or commercial purposes such as manufacturing, offices, storage units, parking lots, or other facilities that are incompatible with the function or maintenance of the landfill cover;
- Prevent construction activities involving drilling, boring, digging, or other use of heavy equipment that could disturb vegetation, disrupt grading or drainage patterns, cause erosion, or otherwise compromise the integrity of the landfill cover or manage these activities such that any damage to the cover is avoided or repaired;
- Prevent use of groundwater under these areas (for any purpose other than monitoring); and

- Provide for access necessary for continued maintenance, monitoring, inspections, and repair.

Property use restrictions have already been implemented at the Site through the placement of institutional controls on the individual parcels as discussed in Section 2.1.4. Design and implementation of any additional institutional controls that may be necessary would be addressed as a component of the RD planning process. Where appropriate, multiple mechanisms or a layered approach would be used to enhance the effectiveness of the institutional control strategy. Access controls such as fences and gates would also be used to support the use restrictions.

At the Site, the affected properties are privately owned and the use restrictions must be maintained for an indefinite period of time. Therefore, recorded covenants would be used because they generally run with the land and are enforceable. The Missouri Environmental Covenants Act (MECA), Mo. Rev. Stat.§ 260.1012, et seq., specifically authorizes environmental covenants and authorizes the State to acquire property interests for the purpose of ensuring long term compliance with such covenants. An environmental covenant pursuant to MECA is a potential instrument for use at the Site because such covenants are specifically designed to support use restrictions at contaminated sites.

The Site has been listed by MDNR on the State's Registry of Confirmed, Abandoned, or Uncontrolled Hazardous Waste Disposal Sites in Missouri (Uncontrolled Sites Registry). The registry is maintained by MDNR pursuant to the Missouri Hazardous Waste Management Law (Mo. Rev. Stat. § 260.440). Sites listed on the registry appear on a publicly-available list. A notice is filed with the County Recorder of Deeds and notice must be provided by the seller to any potential buyers of the property. Parties are not permitted to change the use of a listed site without approval of MDNR.

The OM&M Plan would contain procedures for surveillance, monitoring, and maintenance of the institutional controls. The OM&M Plan would provide for notice to EPA and the State of any institutional control violations, planned or actual land use changes, and any planned or actual transfers, sales, or leases of property subject to the use restrictions.

EPA has stated that financial assurance will be required to provide for operation, maintenance and monitoring of the remedy after construction.

5.3.2.2 Five-Year Reviews

The ROD-selected remedy would also include performance of a 5-year review by EPA as required by Section 121 of CERCLA and the NCP. The specific questions to be addressed by each 5-year review include the following:

1. Is the remedy functioning as intended by the decision documents?

2. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?

3. Has any other information come to light that could call into question the protectiveness of the remedy?

EPA and/or the State would perform a 5-year review at a minimum of every five years after initiation of remedial action at the Site or, if determined by EPA to be necessary, at more frequent intervals. The 5-year review would include an overall statement regarding the protectiveness of the remedy.

5.4 Engineered Cover – UMTRCA Standards Remedial Action Alternative

EPA directed that the original 2006 FS be prepared consistent with EPA's Presumptive Remedy approach for CERCLA Municipal Landfills (EPA, 1993b and 1991b). The resulting ROD evaluated and ultimately selected a containment remedy consistent with EPA's Presumptive Remedy guidance, and the ROD-selected containment remedy was previously evaluated in the SFS. In 2017, EPA advised that "The Operable Unit 1 (OU1) remedy will not be based on a presumptive remedy for a Resource, Conservation, and Recovery Act (RCRA) Subtitle D Municipal Landfill." EPA further stated that "Unless RIM is fully excavated, the controlling Applicable or Relevant and Appropriate Requirement (ARAR) for any cap evaluated as part of a remedial alternative is a cap design that meets the Uranium Mill Tailings Radiation Control Act (UMTRCA) standards, which are performance based."

The UMTRCA Standards are presented in 40 CFR 192.02 and were discussed in Section 3.1.3.1 of this FFS. These standards require:

> Control of residual radioactive materials and their listed constituents shall be designed[36] to:
>
> (d) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,
>
> (e) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
>
> (1) Exceed an average[37] release rate of 20 picocuries per square meter per second, or

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[36] Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) and (b); however, post-remediation monitoring may be necessary to ensure protectiveness over the long-term.

(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

1. Provide reasonable assurance of conformance with the following groundwater protection provisions:

(3) The Secretary shall, on a site-specific basis, determine which of the constituents listed in Appendix I to Part 192 are present in or reasonably derived from residual radioactive materials and shall establish a monitoring program adequate to determine background levels of each such constituent in groundwater at each disposal site.

(4) The Secretary shall comply with conditions specified in a plan for remedial action which includes engineering specifications for a system of disposal designed to ensure that constituents identified under paragraph (c)(1) of this section entering the groundwater from a depository site (or a processing site, if residual radioactive materials are retained on the site) will not exceed the concentration limits established under paragraph (c)(3) of this section (or the supplemental standards established under § 192.22) in the uppermost aquifer underlying the site beyond the point of compliance established under paragraph (c)(4) of this section.

(5) Concentration limits:

(i) Concentration limits shall be determined in the groundwater for listed constituents identified under paragraph (c)(1) of this section. The concentration of a listed constituent in groundwater must not exceed:

(D) The background level of that constituent in the groundwater; or

(E) For any of the constituents listed in Table 1 to subpart A, the respective value given in that Table if the background level of the constituent is below the value given in the Table, or

(F) An alternate concentration limit established pursuant to paragraph (c) (3) (ii) of this section.

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[37] This average shall apply over the entire surface of the disposal site and over a least a one-year period (note: Areas 1 and 2 would be considered separately for purposes of calculating average release rates). Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

TABLE 1 TO SUBPART A OF PART 192—MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION

Constituent concentration [1]	Maximum
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Nitrate (as N)	10
Molybdenum	0.1
Combined radium-226 and radium-228	5 pCi/liter
Combined uranium-234 and uranium-238 [2]	30 pCi/liter
Gross alpha-particle activity (excluding radon and uranium).	15 pCi/liter
Endrin (1,2,3,4,10,10-hexachloro-6,7-exposy-,4,4a,5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer).	0.004
Methoxychlor (1,1,1-trichloro-2,2′-bis(p-ethoxyphenylethane)).	0.1
Toxaphene (C10 H10 Cl6, technical chlorinated camphene, 67–69 percent chlorine).	0.005
2,4-D (2,4-dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-trichlorophenoxypropionic acid).	0.01

[1] Milligrams per liter, unless stated otherwise.
[2] Where secular equilibrium obtains, this criterion will be satisfied by a concentration of 0.044 milligrams per liter (0.044 mg/l). For conditions of other than secular equilibrium, a corresponding value may be derived and applied, based on the measured site-specific ratio of the two isotopes of uranium.

The engineered cover – UMTRCA standards remedial action alternative will include many of the same components as the ROD-selected remedy including:

- Regrading of the existing landfill surface to comply with minimum (2%) and maximum (25%) slope angles pursuant to the Missouri Solid Waste Rules either through placement of additional inert fill or through relocation of existing waste material and construction of starter berms along the toe of Areas 1 and 2;

- Surveying and removal of radiologically-impacted soil from the Buffer Zone/Crossroad Lot 2A2 Property;

- Construction of a multi-layered, engineered cover over Areas 1 and 2 that meets the UMTRCA performance standards;

- Installation of rock armoring for flood protection along the toe of the northern portion of Area 2;
- Installation of stormwater/surface water runoff management structures;
- Landfill gas monitoring and, if needed, installation and operation of a landfill gas control system;
- Long-term inspection and maintenance of the engineered components of the remedy; and
- Environmental monitoring during and after construction of the remedy.

These components are discussed in detail in Sections 5.3.1.1 through 5.3.1.11 above, and will not be repeated here.

Similar to the ROD-selected remedy with modifications, the UMTRCA cover alternative includes regrading of the toe of the Area 1 and 2 landfill units through excavation and relocation of waste material from the toe area to other portions of Areas 1 and 2. The estimated volume of material to be excavated (cut) and re-located under the UMTRCA cover alternative is approximately 127,000 cubic yards, including a total of 112,000 cubic yards of waste materials and 15,000 cubic yards of soil (12,000 yards for creation of a stormwater basin in the Buffer Zone and approximately 3,000 yards of radionuclide-impacted soil from Lot 2A2 and the Buffer Zone). The 112,000 yards of waste to be excavated and relocated includes:

- Approximately 35,000 yards to be cut to regrade inert fill (*e.g.*, concrete rubble) piles;
- Approximately 4,000 yards to be cut to achieve the minimum surface slope and promote drainage from the surfaces of Areas 1 and 2;
- Approximately 12,000 yards to be cut to create space for construction of the starter berms;
- Approximately 39,000 yards to be cut to reduce existing perimeter slopes to below 25%; and
- Approximately 23,000 yards to be cut to create space for construction of a surface water detention basin in Area 1.

Alternative designs that could potentially reduce the amount of regrading that may be necessary, including, for example, alternative stormwater detention structures or elimination of the stormwater detention basins, increase in height of the starter berms, or possibly purchase of additional property to allow for placement of the starter berms outside of the existing landfill footprint, could be evaluated during RD.

In accordance with direction from EPA on October 12, 2012 (EPA, 2012), December 9, 2015 (EPA, 2015c), and August 4, 2016 (EPA, 2016c), the FFS is to include an evaluation of an alternative landfill cover design as set forth in the Revised Work Plan for Alternative Cover Design (EMSI, 2014c), which EPA approved on September 9, 2014. An evaluation of alternative landfill cover design was performed and documented in the January 27, 2015 "Evaluation of Alternative Landfill Cover designs (EMSI, 2015c), which indicated that, as a substitute for the 2-foot compacted clay/silt liner (CCL) included in the ROD-selected remedy cover description, a geosynthetic clay liner (GCL) could instead be implemented at the Site and could provide greater effectiveness at minimizing infiltration at comparable cost. EPA indicated (EPA, 2016c) that this option should be included in the FFS. The alternative landfill cover design considered in the evaluation of the UMTRCA cover system includes a 2-foot CCL and incorporates a GCL.

The only difference between the UMTRCA cover alternative and the ROD-selected remedy is the design of the cover system; specifically, the specific nature, ordering of, and specifications for the individual layers. The UMTRCA final cover system is anticipated to include the following layers/materials (from top to bottom):

- vegetative (topsoil) layer (1-foot thick);
- bio-intrusion/erosion protection layer (1.5-feet thick);
- sand drainage layer (0.5-foot thick);
- geomembrane;
- geosynthetic clay liner (GCL); and
- compacted soil layer (2-feet thick @ $k \leq 1x10^{-7}$ cm/s).

Conceptual profiles of the engineered covers included in the ROD-selected remedy and under the UMTRCA cover alternative are presented on Figures 5-4 and 5-6, respectively. As with the ROD-selected remedy, for purposes of this FFS, the total area to be contained by the engineered landfill cover under the UMTRCA cover alternative is estimated to be 876,000 sf for Area 1 (20.1 acres) and 1,865,000 sf for Area 2 (42.8 acres).

The UMTRCA cover includes re-location of the biointrusion layer included in the ROD-selected remedy from below the low permeability (clay) layer to above the low permeability layer. Relocation of the biointrusion layer above the low permeability layer would reduce the potential for burrowing animals to penetrate into or through the low permeability layer and thereby provide for potential increased longevity of the clay layer in order to address the standard specified in 40 CFR 192.02(a) as described above. In addition, the specification for the compacted clay layer (CCL) under the UMTRCA cover would be reduced from the maximum value of 10^{-5} cm/sec included in the ROD-selected remedy to a maximum of 10^{-7} cm/sec. The UMTRCA cover would also include a GCL or other suitable low permeability material such as a flexible membrane liner (to be evaluated further during RD) within or on top of the clay layer to further reduce the potential for infiltration of precipitation through the cover system. The reduced permeability of the CCL and the inclusion of the GCL or equivalent material would address the UMTRCA groundwater protection standard requirement for engineering specifications for a system of disposal designed to ensure that constituents entering the groundwater will not exceed the concentration limits in groundwater beyond the point of compliance, as specified in 40 CFR 192.02(c)(2)[38].

The biointrusion layer is intended to provide long-term protection against burrowing animals and erosion in order to address the longevity standard specified in 40 CFR 192.02 (a). The UMTRCA cover design would replace the lowermost 6 inches of the biointrusion layer with a drainage material to prevent infiltration from accumulating on top of the CCL. This will further reduce infiltration and provide a capillary break between the vegetation and biointrusion layers and the underlying CCL and GCL. In addition to reducing the percolation of precipitation into the drainage layer, the capillary break may also reduce the potential for vegetation roots to extend through the upper layers of the cover and into the underlying CCL and GCL. Lastly, a rock mulch may be added to the uppermost portion of the vegetation layer to create a surface layer for the cover that is more resistant to erosion in the event that vegetation is lost during periods of extreme drought or other future events that might cause a temporary loss in the vegetative cover. Inclusion of the rock mulch is also intended to provide erosion protection during periods of drought or other times when the vegetation alone is not sufficient to prevent erosion; the inclusion of the rock mulch thus addresses the longevity standard. Inclusion of the rock mulch will be further evaluated during the remedial design.

This conceptual design was used for purposes of estimating the costs and evaluation of other factors for the UMTRCA cover alternative. Ultimately, any engineered landfill cover will need to meet all required performance standards and design criteria of ARARs, including the UMTRCA longevity requirements. Design of the landfill cap must also ensure that risks from exposure to gamma radiation and radon do not exceed the EPA acceptable risk range and are minimized to the extent necessary to comply with ARARs. These design requirements would apply to the top, outerslopes, and toe of the regraded landfill. Design of an UMTRCA cover system would be further evaluated during RD and would include consideration of information contained in EPA's (Draft) Technical Guidance for RCRA/CERCLA Final Covers (EPA, 2004b).

The conceptual designs of both the UMTRCA cover (Figure 5-6) and the ROD-selected remedy (Figure 5-4) were developed to include sufficient thicknesses of cover material to protect against potential exposures to gamma radiation under both current and future conditions, including consideration of the increased levels of radium-226 that will occur from decay of thorium-230 over time. Evaluation of the required cover thickness to protect against gamma radiation

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[38] EPA has indicated that although the UMTRCA groundwater protection standard only applies to the uppermost aquifer beneath a site, per CERCLA, the groundwater standard must be met in all aquifers at the point of compliance.

associated with current and future radium levels, including radium in-growth over a period of 1,000 years, are presented in Appendix F. Design of the cover systems to reflect the radium activities, and the associated gamma radiation levels, that will occur after 1,000 years of radium in-growth is intended to address the UMTRCA longevity standard.

The conceptual designs of both the UMTRCA cover (Figure 5-6) and the ROD-selected remedy (Figure 5-4) were developed to include sufficient thicknesses of low permeability material to reduce the radon flux to below the 20 pCi/m^2/sec standard specified by 40 CFR 192.02 (b) and to be protective against potential exposures to radon under both current and future conditions, including consideration of the increased levels of radon generation resulting from in-growth of radium-226 from decay of thorium-230 over time. Evaluation of the required cover thickness to limit the radon flux is presented in Appendix F. Design of the cover systems to reflect the radium activities, and the associated radon flux levels, that will occur after 1,000 years of radium in-growth is intended to address the UMTRCA longevity standard.

The conceptual design of the UMTRCA and ROD-selected remedy cover systems were also developed to ensure that potential exposures to the current or future maximally exposed individuals (*e.g.*, storage yard worker working on the surface of Area 1 or Area 2) from the reasonable maximum exposures (95% upper confidence limit values) would not exceed the CERCLA acceptable risk range of 10^{-4} to 10^{-6}. Evaluation of the protectiveness of the UMTRCA and ROD-selected remedy cover systems is also presented in Appendix F. These evaluations are also based on the current and projected future (1,000 year) radium-226 activities that would result from radium in-growth from decay of thorium-230 over time.

5.5 Full Excavation with Off-Site Disposal Alternative

This section of the FFS describes the RIM volumes to be addressed under the full excavation with off-site disposal alternative, RIM excavation procedures and associated activities; short-term, post-construction, and long-term monitoring associated with the full excavation with off-site disposal alternative; and describes the specific components of the full excavation with off-site disposal alternative. Final grading, capping and closure of Areas 1 and 2 after RIM removal are also described. Many, but not all, of the descriptions presented in this section would also apply to the full excavation with on-site disposal alternative, which is discussed later in this FFS (Section 5.6).

Per EPA's December 9, 2015 letter and attached SOW (EPA, 2015a), the FFS is to include a full excavation with off-site disposal alternative consisting of excavation of RIM with off-site commercial disposal of the excavated materials. This alternative is essentially the same as the "complete rad removal" with off-site disposal alternative that was previously evaluated in the SFS (EMSI et al., 2011), although the extent and volume of the RIM included in the full excavation with off-site disposal alternative has been updated to reflect the results of the additional characterization performed during 2013-2016.

EPA previously indicated (EPA, 2010a) that "complete rad removal" (now termed full excavation) was defined to mean attainment of risk-based radiological cleanup levels specified in OSWER Directives 9200.4-25 and 9200.4-18. Although this alternative has been termed full excavation, it must be recognized that implementation of this alternative would not result in complete removal of all radionuclides from the Site, but instead would remove radionuclides from Areas 1 and 2 such that additional engineering and institutional controls would not be required based on the radiological content of these areas. In addition, because these areas would still contain solid wastes after removal of the radiologically-impacted materials, regrading, capping and establishment of institutional controls related to the presence of solid wastes would still be required.

Activities associated with the full excavation with off-site disposal alternative would include the following components:

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of material from the OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use relative to the presence of radionuclides;
- Survey and identification of the presence and extent of soil on the Buffer Zone and Lot 2A2 property that contains radionuclides at levels above those that would allow for unrestricted use;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading and transport of any RIM and impacted soil from the Buffer Zone and Lot 2A2 property and disposal of these materials at an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for sanitary landfills;
- Landfill gas monitoring and control, as necessary;

- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site; and

- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Several components of this alternative have been addressed above in the ROD-selected remedy and will not be repeated here; however, because all of the radionuclides above levels that would allow for unrestricted use would be removed under this alternative, several significant differences exist including:

- The engineered cover for the full excavation with off-site disposal alternative would not require the biointrusion layer included for the other alternatives, or the GCL or other geosynthetic included for the UMTRCA cover alternatives (also included in the partial excavation alternatives);

- No radon flux testing would be required upon completion of installation of the engineered cap;

- Any institutional controls specifically associated with the presence of radionuclides would not be necessary and other institutional controls may not be required to remain in place as long; and

- Operations, maintenance and monitoring could only be needed for a shorter time period, that is, until the landfill does not present a threat to human health or the environment at the point of exposure for humans or environmental receptors (i.e., achieves functional stability).

The following subsections address excavation, loading and transport of RIM and impacted soil for disposal at an off-site facility.

5.5.1 RIM Volumes for the Full Excavation Alternative

As previously discussed in Section 2.2.5, the total volumes of RIM contained in Areas 1 and 2 were estimated based on geostatistical evaluations as described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017). The total volumes of RIM to be removed under the full excavation alternative were estimated as follows:

Area 1 RIM (7.9 pCi/g criteria)	58,700 bank cubic yards (bcy)
Area 2 RIM (7.9 pCi/g criteria)	251,000 bcy

Total RIM (7.9 pCi/g criteria)	309,700 bcy

Figures 5-7 and 5-8 display the estimated extent of RIM that would be excavated from Areas 1 and 2 under the full excavation alternative.

The volumes of non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM were estimated to be as follows:

Area 1 overburden (7.9 pCi/g criteria)	818,000 bcy
Area 2 overburden (7.9 pCi/g criteria)	693,000 bcy
Total overburden (7.9 pCi/g criteria)	1,511,000 bcy

These values are based on the more detailed engineering evaluations performed in conjunction with the development of preliminary design plans (Appendix M) and therefore represent a refinement of the estimated overburden volumes developed from the geostatistical evaluations (SSP&A, 2017).

Removal of all of the RIM containing combined radium or combined thorium levels greater than 7.9 pCi/g would require removal, stockpiling and ultimately replacement of a large part of the above-grade mass of the North Quarry portion of the Bridgeton Landfill in order to access the RIM in that portion of Area 1 that lies beneath the above-grade portion of the North Quarry (*e.g.*, RIM in the vicinity of boring 1D-7 which is located at a depth of 80 to 85.5 feet bgs). In addition, the Bridgeton Transfer Station, LLC solid waste transfer station building would need to be relocated to allow for removal of RIM located in close proximity to the transfer station (*e.g.*, GCPT 1-2, GCPT 1C-2R, and GCPT 1C-6, GCPT 1C-6T, GCPT 1C-6T1, and boring 1C-6). The only usable space for relocation of the transfer station is the area currently occupied by Simpson Asphalt pursuant to a 99-year lease, which would require buyout of the Simpson lease (if possible). Use of shoring techniques adjacent to the transfer station in order to minimize the potential impacts of excavation on the geotechnical and structural integrity of the transfer station foundation and overlying structure would be evaluated during RD. Use of shoring or other stabilization methods would likely result in a need to leave some RIM in place as any RIM located between the shoring system and the transfer station foundation would not be removed.

A discussion of the methods and supporting calculations used to estimate the extent and volumes of RIM above levels that would allow for unrestricted use, as well as the non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM is described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017).

The characterization of large regions of the subsurface at any site is always accompanied by uncertainty. This stems in part from the necessity of estimating the continuous extent of properties of interest within the subsurface (here, total volume of RIM) from a number of discrete sample locations. Due to the nature of interpolation, highly accurate estimates can only be obtained based upon the collection and interpolation of point sample results on a small scale. Notwithstanding its limitations, however, interpolation is a reasonable method to apply here. Consistent with this knowledge, the RIM and associated overburden and setback volume estimates were performed to a level of accuracy consistent with the objectives of a feasibility study.

Additional extensive characterization was performed in 2015 pursuant to direction from EPA (EPA, 2015g), to augment previous studies by collecting additional data to assist with further characterizing the nature and extent of the RIM. At this time, a large number of borings have been drilled and a large number of samples have been collected and analyzed from both Areas. This has greatly increased knowledge of the presence and concentrations of RIM in borings in both Areas, and data obtained from these investigations provides a substantial basis for identifying the extent of RIM (particularly for purposes of a feasibility-study-level evaluation) throughout each Area. Nevertheless, this data is subject to various limitations that result in certain uncertainties in the calculation of the volume of RIM. This site characterization information was determined to be sufficient to characterize the potential risks posed by the Site and to identify and evaluate potential remedial alternatives.

For example, because the precise configuration and volume of RIM that lies between the borings that would be the subject of any excavation alternative is, by its very nature, uncertain, the estimated volume of RIM in Areas 1 and 2 is likewise subject to uncertainty. This is compounded by the fact that, as corroborated by the 2015 field investigations, the concentration levels and spatial distribution of radionuclides within the RIM are highly variable due to the inherent heterogeneity of the waste and the variable locations where RIM is concentrated.

In addition, over time, the waste materials have decomposed and associated settlement and consolidation has occurred. Consequently, the depths and elevations of some of the older (e.g., NRC and McLaren/Hart) samples have likely changed over time and presumably are now deeper/lower than reported for the earlier investigations. How much these depths and elevations have changed is uncertain. The prior (SFS) estimate of the RIM volume and the current geostatistical evaluation of the RIM extent and volume attempted to address this issue by pro-rating changes in the surface elevations over time to adjust the depths/elevations of earlier samples, while assuming equal consolidation throughout the waste mass column (an assumption that cannot be tested or validated). It is probable that the majority of any additional settlement and/or consolidation affected the more easily decomposable or compressible layers (e.g., organic matter as compared to construction and demolition materials), or alternatively affected the shallower materials more than the deeper materials.

Sample density is also factor in the uncertainties present in the volume calculations. Past subsurface investigations focused on providing information on the general nature and extent of occurrences of RIM. That level of characterization was determined to be sufficient to characterize the potential risks posed by the Site and to identify and evaluate potential remedial alternatives (EMSI et al., 2011). The intent of these prior investigations was not, however, to accurately define the three-dimensional extent of the RIM for detailed quantity estimates. Although significant sampling has been performed, including substantial sample collection and analyses performed in 2015 for the purposes of providing additional data for the evaluation of potential partial excavation alternatives and to support updated calculations of the volume of RIM at the Site (EPA, 2015c), the data are still not definitive, nor could they ever be. For example, 88 soil borings have been drilled in Area 2, which encompasses 47.3 acres: therefore, each boring on average represents approximately 0.54 acres. A total of 135 independent soil samples (*i.e.*, exclusive of field and laboratory duplicate and split sample results) have been collected and analyzed from Area 2, which contains approximately 1,443,000 cubic yards of waste material. Therefore, each sample represents on average approximately 10,700 of cubic yards of waste.

Similarly, the indirect data readings, while good qualitative indicators of RIM, also have limitations with regard to estimating volumes. The most densely sampled information available to identify RIM comprises the downhole gamma measurements and, to a lesser extent, the core gamma and core alpha data. As detailed in the geostatistics report (SSP&A, 2017), high gamma readings correlate with elevated radium and, to a lesser degree, elevated thorium concentrations. While substantial amounts of analytical data have been obtained to characterize thorium-230 occurrences and activity levels, thorium (unlike radium) cannot be characterized based on the results of the indirect ("soft") data measurements such as the downhole gamma logs or the GCPT data. Accordingly, the geostatistical evaluation was conducted in a manner that maximized the use of the existing data, but much of the data (such as the downhole and core gamma described above) are most directly related to occurrences and levels of radium-226 and only indirectly reflect occurrences of thorium-230. Even though the gamma and alpha measurements are imperfect indicators of RIM, their relative abundance versus the "hard" sample data renders these "soft" data highly informative for identifying RIM, and likely mitigates potential upward bias arising from appropriately targeted soil sampling. Nonetheless, use of these data has at least two implications. First, because the correlations are imperfect, the use of these data imparts uncertainty in the RIM estimates. This uncertainty was accommodated, to some extent, in the geostatistical analysis (SSP&A, 2017) by expressing a different strength of association with the soft data when kriging the radium versus the thorium data. Second, the radioactivity measurements provide a non-unique indication of the concentration or mass of radionuclides in the waste. For example, an elevated downhole gamma reading at a particular depth in a boring may indicate a small mass of a gamma emitter (such as radium) at that depth in that boring but could also reflect a larger mass of a gamma emitter in material located outside of, but in proximity to, the boring. Similarly, a thick interval of elevated downhole gamma readings could result from (a) occurrences of gamma emitters throughout the identified depth interval with the greatest occurrence corresponding to the peak gamma level; (b) the presence of a thin concentrated interval of highly-concentrations gamma emitters that cause increasing levels of gamma emissions as the gamma logging tool approaches, passes, and moves below this interval; or (c) any intermediate condition representing an intermediate thickness of RIM.

Beyond the inherent uncertainties associated with the "hard" radium and thorium analytical data, and the correlation between these data and the "soft" gamma and alpha measurements, there exists uncertainty in the estimation of the total RIM extent and volume using these "point" sample data. These uncertainties include (1) the impact of the assumption of stationarity; (2) imperfect knowledge of the variogram; and (3) effects stemming from the degree, strength and consistency of correlation between the "hard" and "soft" data types (see "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*", SSP&A, 2017, for additional discussion of these terms and issues). Uncertainties associated with the geostatistical estimates of RIM extent and volume are illustrated in the report documenting the geostatistical evaluation of RIM (SSP&A, 2017). Specifically, "best" estimates of the volume of RIM were prepared based on a 50% probability of RIM occurrence at any given location, and the sensitivity of these volume estimates was then evaluated through comparison to estimates based on a 25% and a 75% probability of RIM occurrence. These evaluations indicated that RIM volume estimates are not symmetric about the best-estimate, and could vary by a multiplicative factor of 2 or greater (i.e., in relative terms, by 100% or greater) based on the probability used (*e.g.*, 25%, 50%, or 75%) to identify RIM. Although from a purely statistical standpoint, the 50% estimate represents a "likely" value, for the reasons detailed in the geostatistics report, the results obtained based on the 50% values likely underestimate the actual amount of RIM and the volumes of material that would need to be excavated and disposed of to remove the RIM. Indeed, experience with excavation remedies at other sites, from practitioners under contract to the Respondents, and from representatives of the USACE, suggests that estimates based on a 25% probability may be more representative of the *actual* volume of material that would need to be excavated, transported and disposed of off-site if an excavation remedy were implemented. The following table presents a comparison of the estimated volumes of RIM based on the 25%, 50% and 75% probabilities of RIM occurrence:

Area/Volume (cy)	25% Probability	50% Probability	75% Probability
Area 1	18,700	58,700	166,000
Area 2	105,000	251,000	629,000

Furthermore, because the purpose of any excavation alternative would be to remove all of the RIM that exceeds the trigger level, it is unlikely that such removal would under-excavate material, thereby leaving RIM behind, but rather more highly likely that in order to achieve the remediation goal, there will be a tendency to over-excavate material in order to ensure that all of the RIM above a specified level is removed. This tendency will also contribute additional volumes of material to be handled and shipped to an off-site disposal facility beyond those uncertainties described above or addressed by the cost estimates.

Thus, although the various investigations were designed to make maximal use of existing data and in some instances, were targeted to reduce uncertainties, and the geostatistical approach used to estimate the volumes of RIM was intended to incorporate all available data to help mitigate bias, significant uncertainty remains with respect to the extent and volume of RIM. For purposes of the FFS, the volumes cited and used for the cost, schedule and other evaluations are based on the 50% estimates.

Consequently, the estimates of the amounts and volumes of overburden materials that would need to be removed to access the RIM, the actual volumes and configurations of the RIM that would need to be removed, and the relative amounts and distributions of soil and waste materials within the RIM remain uncertain. For purposes of this FFS evaluation, the extent and volume of RIM may be the single largest uncertainty affecting the estimated costs and schedules for the full and partial excavation alternatives, and some contributors to this uncertainty might not be greatly reduced even through collection of a very large number of additional samples. Although none of the uncertainties encountered characterizing Areas 1 and 2 are unique to the Site, when combined they do result in remaining uncertainty regarding the extent and volume of RIM, and at West Lake these uncertainties have substantial cost implications. Although uncertainty exists regarding the precise volume of RIM and overburden material that would have to be removed under the full excavation alternative, the estimated values provided above are considered sufficient for purposes of a feasibility level evaluation of this alternative.

5.5.2 RIM Excavation and Associated Activities

This section describes the various activities associated with the full excavation with off-site disposal alternative. Activities associated with regrading and installation of a new landfill cover over Areas 1 and 2 after removal and off-site disposal of the radioactively-impacted materials in Areas 1 and 2 are described in Section 5.3.1.

5.5.2.1 RIM Excavation Procedure and Sequencing

The RIM excavation process would be performed in a systematic manner in order to allow for efficient removal of the RIM and to minimize excavation quantities to the extent practicable. The remainder of this subsection describes the RIM excavation process. The logistics of RIM excavation sequencing in an affected area is illustrated on Figure 5-9. As shown, a grid-system would be marked in the field in an affected area. Using field radiological monitoring supplemented by on-site laboratory and/or off-site laboratory data, health physics (HP) technicians would guide the excavator operator where to remove materials in a progressive manner from grid-to-grid, removing a specified layer thickness from each grid. The radiological surveys that would be conducted to guide excavation of RIM are described in Section 3.3.1.1 of Appendix G.

The details of the excavation, excavation control, and sampling procedures would be addressed in RD; however, identification of RIM is expected to be one of the more challenging aspects of any alternative that entails removal of RIM. As a first step, field measurements would be made using hand-held instruments to identify materials with elevated gamma radiation levels which will clearly indicate the present of RIM. However, the alternative result, that is, a lack of gamma signature, cannot be used to indicate the absence of RIM. The presence of thorium-230 (a primary radionuclide of concern), which only emits low-energy gamma radiation, will make use of hand-held instruments and field identification of RIM difficult, especially at low action levels such as the 7.9 pCi/g criteria associated with the full excavation alternatives, difficult, if not impossible. Therefore, for material that does not contain significant levels of radium or other gamma emitters (but which may contain thorium above action levels) segregation of RIM from the rest of the landfill material will be controlled by sampling and laboratory analyses. Collection of field measurements to guide excavation activities will necessary result in a reduction in the rate of excavation compared to those experienced for standard construction projects. Further reliance on sampling and laboratory analyses to guide excavation work will further reduce the excavation production rates due to the time required to collect the samples and perform the analyses. At a minimum, delays associated with collection and analysis of samples would result in either standby (non-production) time for the excavation equipment or a need to relocate the equipment to other areas while awaiting the results of sample analyses followed by subsequent relocation of the equipment back to the original area.

If overburden material is present, the excavator would remove the overburden and the survey technicians would screen the material to ensure no RIM is present. Such removal may be performed at large scale if no RIM is expected to exist, but in areas where RIM may be present, overburden would need to be removed in smaller increments (*e.g.*, 6-inch layers) to avoid potentially mixing RIM and non-RIM material. Further characterization of areas where RIM is not expected may be needed to confirm that these materials do not contain RIM. The design and scope of this characterization will be developed as part of the remedial design. This characterization is expected to include alpha and gamma surveys and, to the extent necessary, analytical sampling to confirm RIM is not present in these areas. If no RIM is encountered, an additional thin layer of material would be removed and the area resurveyed. If RIM is encountered, field gamma surveys would be used to guide the removal of RIM. If the survey does not identify gamma signatures indicative of radioactivity above levels that would allow for unrestricted use in a particular excavation area where RIM is anticipated to occur, the survey technicians would direct the excavation to continue to another grid while the analytical results of soil/waste samples are obtained to determine if all of the RIM above unrestricted use criteria has been removed. Sufficient quality control procedures must be designed and implemented to ensure that an appropriate scanning height and scanning speed are maintained during scans that will result in minimum detectable concentration results for the scan that are low enough to identify RIM at or below the appropriate concentration levels.

As thin layer excavation progresses within the affected area, the HP technicians would follow the excavator at a close but safe distance to survey the surface. It is assumed that Ra-226 and its radioactive progeny will serve as a suitable surrogate for the activity for the initial excavation activities because the survey equipment would be able to detect < 3 pCi/g in the top few centimeters. However, because thorium-230 does not emit measurable gamma radiation, use of handheld measurement devices alone is not expected to be sufficient to confirm the presence or absence or RIM. Rather, it is anticipated that collection and analysis of physical samples will be required to confirm the presence or absence of thorium activities at levels above those that would allow for unrestricted use. The excavation would continue across the edge of the suspected RIM zone as guided by the radiation surveyors. It is anticipated that HP technicians would conduct periodic small-scale hand excavations when measurements indicated the presence of RIM just beneath the surface. If, based on the results of field measurements and/or laboratory analyses, the RIM zone was judged to be relatively thin, these hand excavations could be used to attempt to verify the RIM thickness.

Surveys of excavators and other equipment, also known as remedial action support surveys, will be utilized as necessary to ensure cross-contamination does not occur between survey units. These surveys should include handheld scanning and swipe sampling. Excavators and other equipment are anticipated to undergo decontamination and release surveys after excavation of RIM and prior to excavation of overburden material, to the extent practical; however, in many cases, the difference between overburden and RIM will not be readily identifiable in the field. Therefore, once a piece of equipment enters either Area 1 or Area 2, or otherwise is in contact or potentially in contact with RIM, it will be considered potentially contaminated until the results of a free-release survey indicate otherwise. Additional details regarding equipment management, decontamination, remedial action support surveys, and free-release surveys will be developed as part of RD.

During the excavation and surveying in the RIM zones, some soil or soil/debris could be collected and analyzed in an on-site or off-site analytical laboratory to validate the field survey measurements. Determination of whether to use an on-site laboratory, off-site laboratory, or both to support RIM excavation activities would be evaluated as part of RD based on analytical detection limits, turnaround time for lab results, cost and other factors. Regardless of which method is used to guide the excavation activities, samples would be collected from any areas of RIM excavation that are determined in the field to contain radionuclide activities below those that would allow for unrestricted use, for laboratory confirmation. If an on-site laboratory is used to make this determination, a specified percentage of the samples would also be sent to an off-site laboratory to independently verify the results obtained by the on-site laboratory. The quality assurance and quality control procedures that will be followed by any on-site laboratory will be developed during remedial design to ensure analyses are conducted appropriately.

As stated above, field surveys and measurements would need to be augmented with laboratory analyses from an on-site or off-site laboratory in order to verify that thorium levels were below the unrestricted use criteria. As noted by the NRC (1988), thorium does not possess characteristics that make it easy to measure quantitatively in place, as can be done for Ra-226 and associated decay products that have an identifiable gamma signature. Therefore, laboratory analyses are the only method for determining thorium levels with a relatively high degree of certainty. Excavation activities for the full excavation alternative can be generally guided by field measurements, but because of the need for lab analyses for accurate detection of thorium, ultimately collection and analysis of samples will be required. Collection and laboratory analyses of samples will increase both the time required for and the cost of excavation activities. Evaluations as part of the remedial design are expected to include optimizations related to the presence of, and associated characteristics of, thorium-230.

The shaded area in Figure 5-9 is a hypothetical scenario that portrays the zone of RIM (in two dimensions) and the potential approach to excavation along the edge of the RIM zone. Ideally, the excavation would continue along the edges of the RIM zone until the extent of the zone was delineated and the uncontaminated soil/debris on top of it removed. Conditions of the materials surrounding the RIM might limit how to proceed once the RIM zone was identified. The decision as to how to proceed would be made by the construction manager with input from the HP technicians.

The process of excavating the RIM would continue laterally and with depth, following a similar procedure as described above. If possible, the excavator would remain outside the RIM zone and reach into the RIM zone to lift out the RIM. If the RIM zone was very thin, it could be removed by a single pass, and then the process used to delineate the RIM could be followed. The excavator would still remain on the uncontaminated surface reaching out with the bucket to excavate RIM soil/debris. HP technicians would follow the excavation to verify the absence of radioactivity above levels that would allow for unrestricted use.

For areas where RIM may be present in a thicker or deeper band, it could be necessary to move the excavator into the RIM zone. Efforts would be undertaken to limit direct contact between the RIM and the excavator. A set of wooden tracks or construction mats placed in front of the excavator tracks or a platform for the tracks would be considered.

As RIM is excavated, the nuisance attraction to, and congregation by birds at and above the excavation could be problematic unless effectively controlled. This can potentially be exacerbated by the need to keep larger areas of the Site open while awaiting confirmatory analytical sample results. An avian management plan that incorporates use of excavation BMPs such as daily soil cover and/or tarping, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, would be prepared prior to and implemented during excavation of the RIM.

5.5.2.2 Material Handling

It has been estimated that approximately 58,700 and 251,000 bank cubic yards of radiological material would be excavated from Area 1 and Area 2, respectively, under the full excavation alternative. In addition, it is estimated that approximately 818,000 and 693,000 bank cubic yards of non-radiological material waste overburden and setback material would need to be excavated from Area 1 and Area 2, respectively, to access the RIM waste for the full excavation alternative. In order to access the underlying radiological material, this non-radiological overburden material would be removed, temporarily stockpiled, and ultimately placed back into Areas 1 and 2.

Characterization data generated during the RI and supplemental investigation phases of this project (EMSI, 2017a) indicated that the materials expected to be encountered during the excavation would consist of:

- Solid waste consisting of varying amounts of household wastes, commercial/industrial wastes, and construction and demolition debris;
- Daily/intermediate soil cover, including some soil that has been mixed with leached barium sulfate residues;
- Final soil cover, possibly including some soil that has been mixed with leached barium sulfate residues; and
- Anything in the landfill that has been radiologically impacted above the definition of RIM.

The levels and distribution of radionuclide activity within the radiological material is known to be highly variable. Consequently, precise estimates of the amounts and volumes of overburden materials that would need to be removed to access the radiological material, the actual volumes and configurations of the radiological material, and the relative amounts and distributions of soil and waste materials within the radiological material cannot be made at this time. Until actual excavation commences and field screening and visual observation begin, the extent and volume of overburden and radiological material that would be removed under the full excavation alternative can only be estimated using the available data.

As discussed in Section 4, physical separation of the soil and solid waste is a technology that can potentially reduce the amount of waste material that would have to be transported and disposed off-site under the full excavation with off-site disposal alternative. As discussed in Section 4, although physical separation has been used to separate soil from refuse in old landfills, it has never been used to separate radiologically-impacted material from solid waste. Consequently, the degree to which this technology could effectively separate all or most of the soil, such that the remaining solid waste materials would not contain radionuclides at levels greater than those that would allow for unrestricted use, is unknown. Therefore, this technology, although a proven application for "mining" of old landfills, has never been applied and its performance has never been tested or demonstrated for the type of application associated with the full excavation alternatives. Pilot-scale testing of the degree of separation and resultant radionuclide activity levels within the separated fractions (*i.e.*, garbage and soil) as well as other factors such as dust generation and air quality of the generated dust, worker maintenance activities and resultant radionuclide exposure levels to workers and the community, among others, would need to be evaluated through performance of a pilot scale test as part of RD activities before a determination of the potential applicability, effectiveness, impacts, and costs of this technology could be made. Pilot testing would include mobilizing a trommel unit to the Site, excavating several test tracts, performing physical separation using the trommel, and testing the resultant separated materials for radioactivity levels. Particulate samples would also be collected in order to examine potential dust emissions. Performance of a pilot test, evaluation of the test results, and, if appropriate, integration of this technology as part of the remedial action would therefore increase the time and cost required for completion of the RD phase for this alternative.

Regardless of whether physical separation techniques are employed, the excavated RIM would need to be segregated, stockpiled and loaded in a manner that ensures that the material shipped offsite meets the waste acceptance criteria (WAC) of the receiving facility (see prior discussion in Section 3.1.4.3). To achieve this, the full excavation with off-site disposal alternative includes construction and operation of a RIM staging and loading building (Figure 5-10). Excavated RIM would be delivered to this building and staged based on activity levels. Loading of RIM into transportation containers would be performed by selecting materials from higher and lower activity materials in a manner that would ensure that each container would meet the disposal facility's WAC. This is procedure is not the same as the waste segregation and volume reduction activities described above, but rather would consist of blending of RIM of varying activity levels to ensure that each contain meets the WAC.

5.5.2.3 Material Stockpiling

As previously noted, excavation of the RIM under the full excavation alternative would require removal and stockpiling of non-RIM waste materials that overlie the RIM (overburden wastes) or that would otherwise need to be removed to provide stable side-slopes for excavation areas. For the full excavation alternatives, excavated non-RIM overburden waste would be temporarily stockpiled adjacent to the excavation(s) or elsewhere onsite until areas containing RIM had been completely excavated and cleared of radiation, and final samples confirm that all materials with radionuclide activities above levels that would allow for unrestricted use had been removed. Subsequently, the non-RIM overburden waste would be placed back into the excavations upon completion of the RIM removal activities. As discussed previously, approximately 818,000 and 693,000 bank cubic yards of non-RIM waste overburden would need to be excavated from Area 1 and Area 2, respectively, in order to implement the full excavation alternatives.

For the full excavation alternatives, a significant amount of earthen material would also need to be delivered on-site and stockpiled for use in construction of the final landfill cover over Areas 1 and 2 once the RIM was removed. The overall preference would be to stockpile the required construction materials on portions of Areas 1 and 2 that would not be subject to excavation or that would not be contemporaneously subject to excavation activities. However, due to the limited size of Areas 1 and 2 and the extensive amount of excavation associated with the full excavation alternatives, it is likely that implementation of the full excavation alternatives would require some stockpiling of materials (non-RIM waste, imported backfill, daily cover, and/or final cover construction materials) outside of Areas 1 and 2. Figure 5-5 illustrates potential locations where stockpiles could be established. These locations potentially include the surface of the northern portion of Area 2 (during performance of excavation in Area 1) and on top of the Closed Demolition Landfill. These locations appear viable for this preliminary feasibility-level evaluation, but their actual locations would vary depending on the results of the detailed design and in consideration of issues such as: the final excavation layouts, limits, and procedures; discussions/agreement with the Site owner and operator; and potential interference with existing utilities, roads, vehicular traffic patterns, or structures.

The low permeability soil and vegetative cover material for the cover to be placed over Areas 1 and 2 after RIM removal would be purchased and delivered to the Site. A portion of this soil would be stockpiled to avoid delay in construction activities. A biointrusion layer is not included as part of the cover for the full excavation with off-site disposal alternative. FS-level design projections determined that approximately 1,710,000 loose cubic yards of soil material would be required from outside sources. These materials could be stockpiled on the Closed Demolition Landfill, on portions of Areas 1 and 2 not contemporaneously subject to RIM excavation, and/or the current on-site soil stockpile area (subject to requirements associated with implementation of the OU-2 remedy).

Stockpiled non-RIM waste material would be managed to control odors. For example, these materials would be covered with tarps, soil cover, or foams/chemical agents to suppress odor emissions and reduce the potential for windblown debris and dust, vectors, and precipitation infiltration. The stockpiles would be managed to prevent dust emissions and stormwater impacts; for example, by applying water or other dust suppressants, and by strategically locating the stockpiles away from Site drainage features to the extent possible. A plan for stockpiling of waste materials including identification of actual or potential areas for temporary stockpiles, temporary covers, runon-runoff controls, ongoing inspection and maintenance requirements, and other factors would be developed as part of the RD. A Storm Water Pollution Prevention Plan (SWPPP) would be prepared prior to commencement of construction activities and would provide a detailed plan for the location and maintenance of the stockpiles.

While the non-RIM overburden waste is excavated and stored on-site, the nuisance attraction to and congregation by birds at and above the excavation and non-RIM overburden waste stockpiles could be problematic unless effectively controlled. An avian management plan that incorporates use of excavation BMPs such as daily soil cover and/or tarping, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, would be prepared prior to and implemented during excavation of the non-RIM overburden waste.

5.5.2.4 Radiological Surveys during RIM Excavation

Based on evaluations conducted in preparation of the prior SFS, it is expected that eight types of radiological surveys would be conducted to guide the excavation and verify that the RIM had been removed during and after the RIM excavation process. These surveys are described in detail in Sections 3 and 4 of Appendix G. Excavation surveys and verification sampling would be performed during and upon completion of excavation activities in each area, as described in Section 5.5.2.4 and 5.5.2.9 and in Appendix G.

5.5.2.5 Application of Daily Soil Cover

In order to minimize odors, vectors, windblown debris, and precipitation infiltration, a nominal thickness of six (6) inches of soil would be applied as daily cover over grading, excavation, waste stockpile, and waste placement areas. Daily cover would be applied to the stockpiles of non-RIM waste overburden material as well as the RIM excavation areas.

For cost purposes, the daily cover is assumed to be soil because it is the most conventional and widely-used material for this purpose. The amount of daily cover included for each of these activities was estimated to be equal to 10% of the volume of the waste materials subject to daily cover. This value is based on professional experience with the development of design and operations plans for solid waste landfills and with monitoring of in-place waste and soil volumes during landfill development. The actual amount of soil required for use as daily cover would be a function of the size and configuration of the various cut and fill areas, waste excavation areas, and overburden stockpiles that would be subject to daily cover under each of the remedial alternatives addressed by the FFS as well as the physical configuration of the material to be covered. The amount of soil required for daily cover is also a function of equipment operator expertise and desired production rates. Considering all of these factors, the actual amount of soil required could be slightly less (as low as 8%) or substantially more (as much as 20%) than the 10% estimated in this FFS.

Application of daily cover to the waste excavation areas would increase the volumes and mass of the RIM-impacted waste materials to be addressed in the full excavation and partial excavation alternatives. Daily cover placed over the RIM excavation areas could mix with and become part of the volume of RIM, thereby increasing the volume and mass of RIM that would be sent for off-site disposal. Therefore, remedial design will include evaluation of potential best management practices, or BMPs, that could be developed to minimize or prevent the placement of soil cover from mixing with RIM and the use of materials other than soil as daily cover. This evaluation will include an optimization analysis that accounts for any differences in costs, schedule, and short-term risks that may be required in order to implement any identified BMPs or with the use of materials other than soil for daily cover.

It may be possible to place tarps or foam over the non-RIM and RIM excavation areas and non-RIM overburden stockpiles under the full and partial excavation alternatives in lieu of using soil as the daily cover material. The ability to use tarps or foam in place of soil as a daily cover material would be a function of: the size and configuration of the various areas requiring cover, the ability of the tarps and foam to withstand wind loads; potential worker exposures during placement and removal of the tarps and/or foam; and various other factors that can only be evaluated and/or tested during design, or possibly during the initial stages of remedial action implementation at the Site.

To the extent that application of daily soil cover alone proves insufficient to address the nuisance attraction to and congregation by birds at and above the excavation, additional measures may need to be taken. These measures could include some or all of the technologies identified in

Section 4, including minimization of areas of exposed wastes, use of tarps or additional thickness of daily cover material over areas of exposed waste, placement of wire or monofilament grids positioned over exposed refuse to prevent bird access, and/or implementation of visual deterrents (simulated predators) or frightening devices (noise makers) to deter bird activity.

5.5.2.6 Removal of Radiologically-Impacted Soil from the Buffer Zone/Lot 2A2

Except for the ultimate disposition of such soil, the identification, characterization, and removal of soil on the Buffer Zone or Lot 2A2 that contains radionuclide levels above those that would allow for unrestricted use would be performed in the same manner as was previously described for the ROD-selected remedy (see Section 5.3.1.3). Under the full excavation with off-site disposal alternative, any such soil would be disposed off-site.

5.5.2.7 Management of Subsurface Liquids During RIM Excavation

It is not anticipated that groundwater would be encountered during excavation of RIM; however, the waste deposits do extend down to near the water table, and some of the deeper intervals of RIM may be located near the water table. In addition, perched leachate present in the waste mass may be encountered during implementation based on the extent and depths of excavation associated with the full and partial excavation alternatives. Those excavation alternatives that require removal of the overlying area of the North Quarry may be more likely to encounter leachate given the newer age of the waste. Any groundwater or leachate that may be encountered during remedy implementation would be pumped into temporary holding tanks (*e.g.*, frac tanks), tested to determine treatment requirements, if any, with the test results submitted to MSD for approval, and subsequently treated, if necessary, prior to discharge to MSD. In the event that this liquid cannot be discharged to MSD, it would be hauled to an off-site disposal facility.

5.5.2.8 Regulated Materials Management During RIM Excavation

Management of suspected hazardous wastes or RACM encountered during implementation of the full excavation and partial excavation alternatives would be conducted in the same manner described in Section 5.3.1.9 for the ROD-selected remedy.

5.5.2.9 Radiological Surveys after RIM Excavation

Final status surveys that would be conducted for completed RIM excavation areas and for the unexcavated areas involved with the movement and handling the RIM and overburden storage locations are described in Appendix G.

5.5.3 Loading and Transportation of RIM to an Offsite Disposal Facility

RIM that would be excavated from Areas 1 and 2 and the Buffer Zone/Crossroad property under the full excavation with off-site disposal alternative would be hauled to one of the off-site disposal facilities described in Section 4.3.5.4. Because of the long distances between the Site and any off-site disposal facility, the large volume of RIM estimated to be excavated under the full excavation with off-site disposal alternative, and considerations related to effectiveness, safety, and cost, direct hauling of RIM to the disposal facility using trucks was eliminated as a transportation technology for all the off-site disposal facilities, possibly excepting U.S. Ecology's Wayne Disposal facility in Michigan. For all the off-site disposal facilities, again possibly excepting U.S. Ecology Michigan, RIM would be hauled to the disposal facilities via rail.

As described in Section 4.3.5.3, there are several methods for containment of waste material for rail transport, including:

- RIM loaded directly into gondola cars, if a potential future rail spur could be extended onto the Site;
- RIM loaded into an open 35-cubic-yard soft-sided U.S. DOT Industrial Packaging (IP)-1 shipping container bags that had been placed in an end-dump semi-trailer, the bag closed and trucked to a truck-to-rail transloading operation at a leased rail spur location near the Site (assuming a location could be identified during the design phase), the trailer backed onto a transload ramp, and the bag dumped into the gondola car;
- RIM could be placed into 10-cubic-yard soft-sided IP-1 shipping container bags located near the excavation area, the bags loaded onto flatbed semi-trailers with a forklift or crane and trucked to a truck-to-rail transloading operation at a leased rail spur location near the Site; and the containers off-loaded from the flatbed and into gondola cars with a forklift or crane; or
- RIM could be loaded into lined metal intermodal containers with a secured lid and the intermodal containers would be lifted onto a flatbed trailer and hauled to a truck-to-rail transloading operation at a leased rail spur location where the containers would be lifted off of the flatbed and stacked with other intermodals onto a flat railcar.

Based on discussions with and recommendations from U.S. Ecology, for purposes of the FFS, intermodal containers are assumed as the representative process option for transport of waste material. Selection of intermodal containers over DOT IP bags or direct transfer from truck into gondola cars was based on the anticipated density of the material relative to the weight and volume restrictions associated with each mode of transport. Intermodal containers were identified by US Ecology as being a better option for lightweight materials. At an assumed density of 1,000 lbs per yard, a 30-cubic-yard intermodal container can accommodate 30,000 lbs.

or 15 tons. A maximum of eight intermodals can be loaded on an individual rail car and therefore each rail car could haul 240 cubic yards. In contrast, a gondola car can haul 108 tons or 100 cubic yards of material. Gondola cars are generally a better option for transport of heavier material such as soil, as the weight limit will be reached before the volume of a gondola car is exceeded. Selection of the specific containment method for transport of RIM would be evaluated further as part of the RD effort.

Loading of the intermodal or shipping bag containers at the Site would occur within an enclosed structure equipped with dust, odor, and vapor emission control equipment (Figure 5-10). Conceptually, the RIM staging and loading building is anticipated to be constructed in the current Bridgeton Landfill surplus/reclaimed material and equipment storage ("boneyard") area (Figure 5-11). Trucks arriving at the Site carrying empty intermodal or shipping bag containers would first be weighed and then would enter one (the "loading") side of the building. A liner would be placed in any intermodal containers and the truck with the empty intermodal or shipping bag containers would pull forward to the center of the building where RIM would be placed in the containers by a front-end loader. The loading of RIM would be supervised by a representative of the disposal facility to ensure that the material meets the disposal facility's waste acceptance criteria. Upon completion of the RIM loading, the truck would pull to the far end of the building where the outer portions of the liner would be placed over the top of the RIM and the container would either be sealed, covered with a tarp, or alternatively if equipped with a metal lid, the lid would be placed over the top and sealed before the truck exits the building. The truck would then exit the building, where it would be scanned for radioactivity and decontaminated as necessary. The truck would then proceed to the scale to be weighed and the waste manifest would be completed prior to leaving the Site. The truck would then transport the containers of RIM to a truck/rail transloading facility where the containers would be loaded onto rail cars (flat cars for intermodal containers or gondolas for DOT IP bags) for transport to the waste disposal facility. The RIM staging and loading building would be equipped with air emissions controls consisting of exhaust blowers that would discharge air through sulfur dioxide odor control media and vapor phase granular activated carbon media (Figure 5-10).

Identification of a truck-to-rail transfer facility for rail transport would be made as part of the RD effort. Extending a rail spur onto the Site, if possible, and loading RIM material directly onto railcars would reduce material handling steps, reduce risks associated with the intermediate step of transporting RIM via trucks to a leased rail spur location near the Site, and probably reduce transportation costs. Extending a spur would likely require the following activities and facilities, as shown on Figure 5-11:

- Purchase or long-term lease of portions of the PM Resources, Inc. and CP III Properties, LLC properties located across St. Charles Rock Road from the Site entrance (Figure 5-11);
- Approvals to construct a rail spur across private property located to the east of St. Charles Rock Road, across St. Charles Rock Road, and along the Site access roads to near the area of the existing solid waste transfer station and asphalt plant operations at the Site;

- A new switch and tie-in to the existing spur located on CP III Properties, LLC property;
- Removal of trees and brush in the wooded area between the tie-in and St. Charles Rock Road;
- Assessment of whether the wooded area is a designated wetland and, if so, obtaining approvals and potential wetlands mitigation;
- Laying of flat track in the cleared area between the tie-in and St. Charles Rock Road;
- Installation of an electrically-gated and signed crossing and flat track across St. Charles Rock Road (Missouri State Highway 180) including appropriate coordination with and approval from local and state authorities;
- Installation of flat track on the Site on surfaces that have not been landfilled, including north of and along the Site access road, between the OU-2 Closed Demolition and Inactive Sanitary Landfills on the north and the OU-1 Area 1 and the transfer station on the south, and parallel tracks to the west of the asphalt plant area[39];
- Two switches on the tracking within the Site;
- Renegotiation of the long-term lease for the asphalt plant, which leases land south of the solid waste transfer facility and whose property would be impacted by the on-site spur;
- Installation of a reinforced concrete (estimated as at least a 100 ft by 100 ft area) loading platform at the edge of Area 2 where excavated RIM would be placed by articulated trucks and then loaded into gondola rail cars with front-end loaders.[40]
- Installation of a tensioned fabric frame structure over the loading platform such that loading of rail cars can be performed regardless of weather conditions;
- Installation of a scale within the loading platform structure; and
- Purchase of a "trackmobile" (small rail locomotive) to be used to move empty and loaded gondola rail cars around on-site.

[39] It is assumed that two sets of tracks would extend onto the Site to provide enough room for switching and staging of empty gondola cars during simultaneous loading of gondola cars, to maximize the volume of RIM that could be removed per day.

[40] It is anticipated that the loading platform would be placed in one permanent location adjacent to Area 2 and the smaller volume of RIM from Area 1 would be transported via articulated on-site trucks to the loading platform.

A detailed evaluation of the above issues (including whether an on-site rail spur extension is technically or economically feasible) is beyond the scope of this FFS, and would need to be conducted during the RD phase.

Based on discussions with U.S. Ecology that indicated a larger volume could be transported using intermodal containers on flat bed railcars compared to gondola cars (see above discussion in this subsection), it was decided that for the purposes of FFS evaluations it is assumed that excavated RIM would be loaded into 30-cubic-yard lined metal intermodal containers. The intermodal containers would be hauled via flatbed truck to a truck-to-rail transloading operation at a rail spur location within a 10-mile radius of the Site. The intermodal containers would be loaded onto flatbed rail cars at the transloading facility for shipment to one of the off-site disposal facilities described in Section 4.3.5.4.

The cost and schedule for RIM transport are highly dependent upon the ability to maintain a more-or-less continuous rate of RIM transport, at least for a period of many months at a time. This would allow for intermodal containers and railcars to be dedicated to the project and for regular scheduling of RIM shipments. In contrast, U.S. Ecology has indicated that if the volumes of RIM shipped become highly variable or become intermittent instead of continuous, additional costs and delays will likely be incurred to demobilize and mobilize containers, to acquire and schedule trucks, and to obtain and schedule railcars for shipping the waste material.

5.5.4 Stormwater and Landfill Gas Monitoring and Control

In addition to the surfaces that stormwater could contact under the ROD-selected remedy, stormwater under the full excavation alternatives could contact: (1) exposed waste during excavation of overburden and RIM from Areas 1 and 2; (2) daily cover soil that has been placed over areas of exposed overburden or RIM after excavation; and (3) surfaces of cover material as the covers over Areas 1 and 2 are being constructed. Due to the substantially greater area that would be disturbed under the full excavation alternative, the magnitude of the stormwater management activities required for this alternative are expected to be greater than those that would otherwise be required for a containment alternative.

Stormwater management for the full excavation with off-site disposal alternative would be performed in the same manner as was described in Section 5.3.1.6 for the ROD-selected remedy, except for possible variations in the locations and size of the stormwater control structures due to the greater area of disturbance and creation of topographic depressions during construction of the full excavation alternative and due to the greater period of stormwater management resulting from the longer duration required for implementation of the full excavation with off-site disposal alternative.

Landfill gas monitoring and control during construction would be performed in the same manner as was described in Section 5.3.1.7 for the ROD-selected remedy. Long-term monitoring of landfill gas monitoring along the perimeters of Areas 1 and 2 would performed in the same manner as was described in Section 5.3.1.7 for the ROD-selected remedy, except that radon monitoring would not be required because all the RIM is expected to be removed from the Site under the full excavation with off-site disposal alternative. Radon monitoring would be required during implementation of the full excavation with off-site disposal alternative to monitor levels of radon within or emitted from the RIM staging and loading building to ensure the safety of remediation workers and the general public.

Installation and operation of a landfill gas extraction system as described above for the ROD-selected remedy is also included as a contingent action under the full excavation with off-site disposal alternative in the event that the perimeter landfill gas monitoring indicates that lateral migration of explosive gases is occurring along the Site boundary. This would be evaluated by comparing the landfill gas levels at the perimeter of Areas 1 and 2 under the full excavation alternative to the appropriate performance standards. Due to the overall age of the landfill waste, along with the relatively low levels of methane detected during the RI (EMSI, 2000), high levels of methane are not expected to occur in Areas 1 and 2. However, because so much material would be disturbed and exposed to atmospheric air (oxygen), additional microbial activity could be stimulated resulting in a temporary increase in landfill gas production. Additionally, the full excavation with off-site disposal alternative would impact the existing landfill gas collection and control system for the Bridgeton Landfill due to removal of the portion of the Bridgeton Landfill overlaying the southeast corner of Area 1. Because of the relatively new age of that waste, landfill gas collection and control would be needed following replacement of that overburden waste, requiring replacement of the landfill gas collection components that were removed in conjunction with the waste excavation and possibly installation of additional components (*e.g.,* additional gas extraction wells).

5.5.5 Final Grading and Engineered Landfill Cover

Because only the RIM would be removed, non-RIM waste materials would still remain on site in Areas 1 and 2. Regrading and construction of a final cover would be performed for Areas 1 and 2 in compliance with ARARs. Since RIM would be removed, performance requirements of the UMTRCA cap would no longer be relevant and appropriate, and therefore, performance and design requirements of state solid waste regulations would control design of the cover, which result in a lower cost for construction of an engineered landfill cover compared to the other alternatives. (See additional discussions in Sections 6 and 7.2.5 relative to costs of the remedial alternatives). Long-term inspection and maintenance of the final cover would be required. After RIM had been removed from Areas 1 and 2, only waste materials below the appropriate rad screening level would remain in these areas. The presence of waste materials would require a final RCRA Subtitle D cover to be constructed over these areas. MDNR regulations (and in particular, 10 CSR 80-3.010(17)(C)(4)(A)) would govern the requirements for the landfill cover over Areas 1 and 2.

In order to safely access and remove RIM as described previously, it would be necessary to temporarily excavate and stockpile solid wastes (overburden wastes) that currently lie on top of the RIM. Once removal of RIM over the levels permitted for unrestricted use has been verified, this overburden waste material would be returned to the excavated areas. These wastes would then be graded and a new Subtitle D landfill cover installed. It is envisioned that the overburden wastes would be suitable for backfilling into the excavations of Areas 1 and/or 2, which would aid in the proper regrading of the excavations and promote positive drainage from the two areas. The design criteria specified for MSW landfills (*e.g.*, minimum 5% and maximum 25% slopes) would also apply to design of the final grades for any waste materials that would remain after excavation of the RIM.

Consistent with MDNR regulations for existing solid waste landfills without liners (10 CSR 80-3.010(17)(C)(4)(A)), the cover for Areas 1 and 2 would consist of the following layers (from top to bottom):

- 1-ft vegetative soil; and
- 2-ft compacted clay layer ($\leq 10^{-5}$ cm/sec).

The uppermost 1-ft soil layer would need to sustain vegetative growth. It would typically be composed of a soil with sufficient organic content and permeability to allow vegetative growth. USCS soil types such as OH and OL are often suitable for this end use. The United States Department of Agriculture (USDA) soil taxonomy system would also be referenced and used to aid in identifying suitable vegetative layer soils.

The 2-ft compacted clay layer would consist of a USCS CL, CH, ML, MH, or SC soil type with characteristics such that a compacted permeability 1×10^{-5} cm/sec or less could be achieved during construction.

5.5.6 Long-Term Operations, Maintenance, and Monitoring and Non-Engineered Components

Long-term OM&M activities and the non-engineered components for the full excavation with off-site disposal alternative would still require post-closure care activities associated with a closed MSW landfill, which would generally be the same as those described in Sections 5.3.1.10 and 5.3.2 for the ROD-selected remedy and described in Section 5.2 of Appendix G for the full excavation with off-site disposal alternative. Given that all RIM containing radionuclides above levels that would allow for unrestricted use would have been removed from Areas 1 and 2 under the full excavation with off-site disposal alternative, some of the long-term OM&M activities and institutional controls included as part of the ROD-selected remedy should not be necessary for Areas 1 and 2, including:

- Long-term OM&M of Areas 1 and 2 may only need to be performed for a 30-year period;

- Institutional controls required solely for the presence of radionuclides in Areas 1 and 2 would no longer be necessary;

- Monitoring of radon occurrences in landfill gas around Areas 1 and 2 should not be necessary; and

- Performance of 5-year reviews may not be necessary for as long a period as would be required for the other alternatives.

Financial assurance would be required to provide for operation, maintenance, and monitoring of the remedy. Because radionuclides above levels that would allow for unrestricted use would be removed under this alternative, 5-year regulatory reviews, as described in Section 5.3.2.2, should not be required for as long a period for the full excavation with off-site disposal alternative.

Groundwater and landfill gas monitoring of Areas 1 and 2 would also be mandated for a period of 30 years, consistent with the post-closure monitoring requirements for solid waste landfills (10 CSR 80-2.030(4)(A)3.E(I)). Maintenance and monitoring of institutional controls would also be necessary, similar to the requirements described above for the ROD-selected remedy.

5.6 Full Excavation and Disposal in an Engineered On-Site Cell

This alternative includes full excavation of all RIM and disposal of the excavated RIM in an on-site disposal cell. The volume of RIM to be excavated would be the same as the volumes included in the full excavation with off-site disposal alternative, but instead of transporting the RIM offsite, the RIM would be disposed of in a new engineered on-site disposal cell. The on-site cell would be constructed to meet UMTRCA standards and possibly also RCRA Subtitle C standards, and would include an UMTRCA engineered cover similar to that described for the UMTRCA cover alternative.

5.6.1 Potential Locations for an On-Site Cell

The on-site cell could be located in one of several locations at the Site including, but not necessarily limited to, the area of the current Bridgeton Landfill soil stockpile, or on top of the Closed Demolition Landfill or the Inactive Sanitary Landfill (Figure 5-12). Alternatively, the existing waste material could be removed from the northern portion of Area 2, and a new cell could be located in the underlying native soil in this area. The location of the existing Bridgeton Landfill soil stockpile area is the same area that was previously evaluated for a new disposal cell during the SFS (EMSI, et al., 2011). It should be noted that during review of the SFS, EPA determined that this location did not comply with location-specific ARARs associated with the solid waste regulations due to proximity to the airport. The other potential areas (on top of the Closed Demolition Landfill or the Inactive Sanitary Landfill, or on the northern portion of Area 2) are being considered because they would be located outside of the 10,000-foot distance from the end of the westernmost runway at Lambert St. Louis International Airport.

For purposes of this FFS, the current location of the Bridgeton Landfill soil stockpile area has been evaluated as the location for a new on-site cell (Figure 5-13). The eastern, southern, and western sides of the borrow area are bounded by the Bridgeton Landfill property boundaries, while the northern side of the borrow area is bounded by a stormwater pond. The existing borrow area is approximately 22 acres in size, and varies from a high elevation of 575 feet amsl to a low elevation of 475 feet. Although for purposes of this FFS, it is assumed that a new disposal cell would be located within the boundary limits of the existing borrow area for the Bridgeton Landfill, if this alternative were to be selected by EPA, additional evaluations of other locations, such as those listed above and described further below, are expected to occur as part of remedial design.

5.6.1.1 Preliminary Evaluation of Potential Locations Over Existing Disposal Areas

A preliminary evaluation of potential placement of a new on-site cell over three areas that were previously used for waste disposal was performed for this FFS. These three areas include (1) on top of the existing inactive Demolition Landfill, (2) on top of the southern portion of the existing Inactive Sanitary Landfill, and (3) on top of the northern portion of the existing Inactive Sanitary Landfill (Figure 5-12). The main goals of this preliminary evaluation were to:

1. Develop preliminary cell layouts within the designated areas to assess whether these locations could provide the necessary capacity for the estimated RIM volume;

2. Assess several key siting criteria considerations on a preliminary basis for these locations; and

3. Assess engineering feasibility of these locations by identifying any special technical considerations that may need to be addressed during remedial design.

Preliminary plans for layout of a potential new on-site disposal cell were developed for the liner grades and final cover grades for each of three locations, with the goal of developing conceptual cell designs that achieve the minimum required disposal capacity of 350,000 CY, if possible. The lateral extent of the cell footprints were selected to provide a minimum 100-ft set-back from the property boundary to the disposal (liner) limits, and also with a set-back from any nearby RIM excavation limits to avoid potential overlaps/conflicts between temporary excavation slopes and on-site cell features.

Additionally, the selection of the lateral extent of the cell footprints took into account the existing topography, with the aim of generally being situated on relatively flat terrain. Sloping terrain was avoided because: (i) this would likely involve placement of more extensive fill quantities to grade the cell floor and the perimeter containment berm; (ii) this would result in a much larger limit of disturbance to tie-in the berm sideslopes to existing ground sloping away from the disposal cell; and (iii) placing a lined cell on a sideslope may very well be geotechnically stable, but represents a configuration that is preferable to avoid if possible until calculations can verify geotechnical stability.

The area on top of the Closed Demolition Landfill would result in 6.2-acre on-site disposal cell. Based on preliminary grading plans, the cell would have a maximum elevation of about 542 feet above mean sea level (ft, amsl) (height of about 72 feet above existing ground), and a total disposal capacity of approximately 163,000 CY.

The area on top of the southern portion of the existing Inactive Sanitary Landfill could accommodate a 9.1-acre on-site disposal cell. The preliminary base grading plan and final cover grading plan for this option indicate that the cell would have a maximum elevation of about 538 ft amsl (height of about 68 feet above existing ground), and a total disposal capacity of approximately 368,000 CY.

The area on top of the northern portion of the existing Inactive Sanitary Landfill could accommodate a 6.6-acre on-site disposal cell. The preliminary base grading plan and final cover grading plan for this option indicate that the cell would have a maximum elevation of about 558 ft amsl (height of about 88 feet above existing ground), and a total disposal capacity of approximately 141,000 CY.

Preliminary evaluation of the potential disposal volume available for each of these three areas indicates that only the area located in the southern portion of the Inactive Sanitary Landfill would provide sufficient disposal capacity to hold all of the estimated RIM from a full excavation alternative after accounting for estimated bulking/shrinkage and the addition of daily cover.

Although the preliminary evaluations suggest that the two other locations would not meet the disposal capacity requirements as they are currently configured, it is possible that the concepts could be further refined to increase their disposal capacity. Some possible refinements that could be considered to assess whether they result in enough increased disposal capacity are presented below.

- Increase height and exterior slope steepness of containment berm. The current berm configuration is at a 5H:1V to be consistent with the final cover slopes, and based on UMTRCA guidelines conservatively applied to the berm (because the berm is an integral part of the UMTRCA cell and thus may potentially be subject to the same slope requirements and associated long-term performance objectives). If the exterior slopes can be steepened, this would allow the berm height to be increased without increasing the limit of disturbance – thereby allowing for a corresponding increase in the final cover grades and thus the disposal capacity.

- Increase steepness of final cover system slopes. The 5H:1V final cover slopes were selected based on UMTRCA cell design criteria (10 CFR 40, Appendix A, Criterion 4). This regulatory criterion does not appear to be an absolute slope limitation, and it may be possible to demonstrate that steeper slopes are adequately stable and would meet the other applicable long-term performance objectives, allowing a waiver of this UMTRCA design criterion. If so, a cell designed with steeper final cover slopes (e.g., on the order of 4H:1V or possibly as steep as 3H:1V) would allow for increased disposal capacity.

- Increase the cell footprint laterally. Locations 1 and 3 may have additional room laterally to increase the cell footprint, without interfering with Site features and constraints such as RIM excavation limits, property buffers, sloping existing terrain, surface water management features, and other site access and infrastructure. A larger lateral footprint would allow for increased disposal capacity.

Further design iterations of the on-site disposal cell concepts for these locations, through use of alternative design criteria, combined with enlargement of the lateral footprint to the extent practicable, may result in these locations providing sufficient capacity. Because the feasibility of using the Closed Demolition Landfill area or the northern portion of the Inactive Sanitary Landfill cannot be ascertained without conducting additional evaluations, these locations are not evaluated further in this FFS. Furthermore, because the preliminary evaluations indicated that a cell location on the Closed Demolition Landfill or the northern portion of the Inactive Sanitary Landfill would each only provide less than half the volume needed, it may not be possible to adjust the design to achieve the minimum required capacity. In addition, the area of the Closed Demolition Landfill is also being considered as a location for stockpiling of incoming construction material need to construct the on-site cell (e.g., clay, sand and gravel for cell liner and leachate collection system construction), to perform the waste excavation (e.g., daily cover material), and for construction of the final cover (e.g., clay and rock material).

5.6.1.2 Technical Considerations for Locating a New Cell on Existing Waste Disposal Areas

The three on-site disposal cell options discussed above would entail a new cell being located on top of areas of existing landfilled waste. The landfill industry has numerous successful examples of new lined landfill areas that overlay existing waste (often referred to as “piggy-back” landfills, and referred to herein as “overlay landfills”). This situation presents a few additional design considerations including:

- Overlay landfills have the potential for relatively large total and/or differential settlements since the underlying waste can be more compressible than natural foundations;

- Overlay landfills place an additional load on existing waste, making it important to evaluate foundation slope stability as well as the potential for increased leachate generation due to squeezing of the existing waste; and

- Overlay landfills create an impermeable barrier over the existing ground surface, which may influence landfill gas migration patterns if the underlying waste is generating gas and necessitate subsurface venting layers and/or gas migration control features.

These issues would be "special" technical considerations that would apply to the remedial design of an on-site disposal cell if it were to be located over existing wastes. The manner in which these issues have been typically addressed in conjunction with vertical expansions of existing landfills are discussed below; a detailed evaluation of these technical considerations would take place in connection with the remedial design.

- Settlement. Settlement of underlying waste has the potential to cause grade reversals that may impair function of the overlaying liner and leachate collection system and/or could induce excessive tensile strains or other impacts in the liner and/or cover system components. Fortunately, this issue was recognized in the late 1980s when modern landfill regulations were under development, and engineering methodologies have been advanced and implemented since that time. There is a body of literature on typical settlement properties of solid wastes, and design procedures are available to calculate predicted settlements. Depending on the magnitude of predicted total and/or differential settlements, typical design solutions include the use of steeper leachate collection slopes to compensate for future settlement (which may involve placing a "mounded" contouring/buffer layer of structural fill beneath the overlay liner), conducting subgrade proof-rolling during liner subgrade preparation to identify and fix any soft spots, or potentially using a geogrid reinforcement if there is reason to believe there are soft foundation areas needing to be bridged.

- Pore Pressures and Leachate. Placing additional load on existing waste is a particularly important consideration if the existing waste is saturated or in direct contact with the groundwater table. If so, the added load can induce pore water pressures in the leachate/groundwater, which would require a thorough slope stability analysis to check short-term, undrained loading conditions. Further, as these pore pressures dissipate over time through consolidation of the underlying waste, the resulting liquid squeezed out of the waste mass would be leachate that could migrate downward into the subsurface and/or groundwater. If the existing waste is above the water table and not saturated, this issue is negligible since the unsaturated waste would likely compress its open void space (air voids) and thus not produce pore water pressures or expel leachate. These issues are typically evaluated during design, with cell configuration adjustments made as needed to provide adequate foundation stability. If warranted, a field pre-loading program (which may include monitoring of subsurface pore pressures) can be included. Finally, with respect to potential generation of leachate due to squeezing of existing waste, this is a site-specific consideration dependent on the makeup of the existing waste and quality of groundwater (i.e., whether there are any impacts). It should also be recognized that the short-term effect of potentially squeezing out leachate is offset by a long-term benefit due to the overlying cell, because the cell liner provides a substantial barrier against future infiltration into the waste (preventing subsequent generation of new leachate).

- Landfill Gas Control. Placing a barrier (lined cell) over an existing landfill that may be producing landfill gas could produce uplift on the new cell liner system. While the magnitude of uplift forces is often not enough to cause instability once material is placed in the new cell, the presence of the liner system may also cause the landfill gas to migrate laterally in the subsurface since its previous pathway of venting to the atmosphere has been cut off. This issue can be evaluated during design and, depending on the nature of the existing waste, a gas venting layer (or venting trenches) can be included beneath the liner system to relieve landfill gas uplift pressures and allow for controlled migration pathways for any accumulated gas to vent to the atmosphere around the exterior of the new cell.

In short, the three issues identified above can be addressed and resolved during remedial design. While the design of a lined cell over existing waste presents a few special technical considerations, this approach has gained widespread acceptance in the landfill industry by engineers, operators, and regulators. Overlay landfills came into prominence in the early 1990s, as RCRA Subtitle D went into effect for municipal solid waste landfills. In advance of these regulations, several key technical papers addressing the technical considerations and providing design recommendations for overlay landfills were published in the 1990 ASTM Special Technical Publication (STP) 1070 titled "Geotechnics of Waste Fills – Theory and Practice". As the industry evolved and overlay landfills became more numerous, the industry has gained experience and the body of technical literature has grown. There are numerous technical publications that address design and implementation of new landfill units over the top of prior landfill units (e.g., Giroud, et al., 1990, and Hauser, 1994, among others).

In summary, the landfill overlay approach is considered readily implementable if the design is prepared to properly address the standard and special technical considerations described herein.

5.6.2 On-Site Cell Design

The on-site cell will be constructed in accordance with the following considerations and modifications (as appropriate), as set forth in EPA's November 28, 2017 request for additional work under the AOC:

- NRC Low Level Waste facility regulations (10 C.F.R. 61);

- NRC Criteria relating to the operation of uranium mills and the disposition of tailings or wastes (10 C.F.R. 40 Appendix A);

- UMTRCA Subpart D standards for management of uranium byproduct materials (40 C.F.R. 192.32); and

- RCRA Subtitle C regulations.

Based upon guidance provided by the EPA during a November 30, 2017 meeting, for feasibility-level considerations, the following design assumptions were utilized to estimate available disposal volumes, potential costs, and anticipated construction schedule for a new disposal cell:

- Assume a UMTRCA cover similar to that described for the UMTRCA cover alternative and as shown on Figure 5-6:

- Assume a liner thickness of 5 feet consisting of 3 feet of recompacted clay, with 2 geomembranes, a geosynthetic clay liner, and two leachate collection zones; and

- Assume that the lowest elevation of the bottom of constructed liner would be 1 foot above the water table elevation.

The conceptual design of the liner system for a new engineered on-site disposal cell is anticipated to include the following layers/materials (from top to bottom):

- protective cover and/or drainage/filter layer (1 foot thick);
- leachate collection drainage gravel layer (1 foot thick);
- geocomposite drainage layer or geotextile cushion;
- primary geomembrane liner;
- leak detection layer geocomposite;
- secondary geomembrane liner; and
- compacted clay liner (3 feet thick @ $k \leq 1x10^{-7}$ cm/s).

Also, it was determined that any waste material placed within such a cell would need to be located at least 100 feet from any property boundary that adjoins property not owned by Bridgeton Landfill.

5.6.2.1 On-Site Cell Liner Components

Based upon the information provided above, the liner design for the on-site cell (Figure 5-14) would consist of the following components from the bottom layer up:

- Foundation layer or subgrade;
- 3-ft-thick low-permeability earthen liner ("clay" layer);
- Geosynthetic Clay Liner (GCL)
- 80 mil high-density polyethylene (HDPE) textured geomembrane;
- A geocomposite secondary drainage layer consisting of two 12 oz/yd^2 geotextiles thermally bonded to a geonet webbing layer;

- 80 mil high-density polyethylene (HDPE) textured geomembrane;
- A 16 oz/yd^2 cushioning geotextile;
- 1-ft-thick drainage layer consisting of non-carbonate gravel serving as the primary leachate drainage system; and
- 1-ft-thick filtration layer consisting on two different gradation of gravels / coarse sands to filter the waste materials from the underlying leachate drainage layer.

5.6.2.2 Liner Construction – On-site Cell

A preliminary liner design was developed based on discussions with EPA and the USACE during a November 30, 2017 design guidance meeting. The maximum excavation and corresponding liner slope was 5H:1V.

The base of the landfill liner system was established using third-quarter 2017 groundwater elevations from the only monitoring wells in this area, which are on the northwestern side of the borrow area: PZ-202-SS, -209-SS/SD, -211-SS/SD, and -212-SS/SD. These wells are screened in two zones (both bedrock, the St. Louis / Upper Salem formation, and the Deep Salem formation). Based upon a review of this data, it was determined that the groundwater the potentiometric elevations for the two zones were:

- St. Louis / Upper Salem (Bedrock): 467.00 – 469.42 ft amsl
- Deep Salem (Bedrock): 465.07 – 467.74 ft amsl

Based upon this review, groundwater generally occurs in the 465-470 ft amsl on the northwest side of this area. However, there is no groundwater level data in the glacial till/loess deposits located in the southern portion of the soil borrow/stockpile area. While a hydrogeological study of the borrow area (or other area as appropriate) would have to be conducted during the remedial design phase, a conservative bottom of liner elevation of 475 ft amsl was selected to be the lowest liner elevation. Therefore, the lowest top of liner elevation was 480 ft amsl.

Along the northern limit of the on-site cell baseliner, a structural fill berm would be constructed to an elevation of 485 ft amsl, which would support the liner northern sideslope of the same elevation to create a containment cell. This northern limit would be the side where the leachate drains and pumping sumps would be installed.

The on-site cell base would be designed in a herringbone pattern with the cross slopes (draining to the leachate pipes) at a minimum 3% slope, and the pipes themselves draining longitudinally at 1% minimum. These leachate pipes would drain into sumps, which would have individual pumps that would pump the leachate using a sideslope riser pipe (typically 18” min) to a pumping wet well outside the on-site cell boundary.

For preliminary evaluation purposes only, in order to prepare a cost estimate for this FFS for the full excavation with on-site disposal alternative, it is assumed that the leachate would be pumped out of the on-site cell into a holding/equalization tank and transferred via a force main to the Bridgeton Landfill leachate pretreatment plant, where it would be treated and then discharged to MSD. Evaluation of handling and treatment, including evaluation of necessary approvals and limitations, would be conducting during remedial design. The holding/equalization tank would be located adjacent to the on-site cell.

The initial activity for construction of the on-site disposal cell would be excavating approximately 280,000 cubic yards of stockpiled soil and relocating the soil material to the closed demolition area landfill and/or on portions of OU-2 stockpile area. After the stockpiled soil has been removed, the liner components would be constructed in accordance with the Missouri Solid Waste Program Regulations, as amended to address the requirements of the UMTRCA regulations, the applicable NRC regulations, and RCRA Subtitle C (as applicable).

5.6.2.3 Subgrade and Structural Fill Foundation

If required after relocation of the stockpiled soil, a compacted earth subgrade (foundation) and perimeter berms would be constructed using on-site soils. Roots, cobbles, debris, and other deleterious material would be removed from the soil prior to compaction and the soil would not be used for construction when frozen or placed on frozen ground. Each soil layer would be worked sufficiently to break down oversized clods, obtain uniform moisture content and ensure uniform density. The foundation would be graded in a manner to parallel the top of liner/leachate collection grades.

5.6.2.4 Low Permeability Earthen Liner

After removal of the stockpiled soil (or after construction of a subgrade foundation), a low permeability earthen liner would be constructed by compacting cohesive soils delivered to the site in loose lifts utilizing moisture correction techniques. This earthen cohesive liner would consist of a 3 feet thick low permeability soil material. The selected soil material would be classified under the USCS as CL, CH, or SC (ASTM Test D2487-85); allow more than thirty percent (30%) passage through a No. 200 sieve (ASTM Test D1140); have a liquid limit equal to or greater than 20 (ASTM Test D4318- 84); have a plasticity index equal to or greater than ten (ASTM Test D4318-84); and have a coefficient of permeability equal to or less than 1×10^{-7} cm/sec when compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, when tested by using (ASTM D-5084) a flexible-wall permeameter.

During construction of the low permeability earthen liner, testing of each lift for field density and field moisture would be conducted in accordance with the requirements of the Construction Quality Assurance (CQA) Plan. During liner construction, continuous visual classification of borrow soil would be performed by a qualified QC inspector or certifying professional engineer. Soil materials for subgrade (foundation) preparation, if required, and liner construction would be hauled by scrapers or trucks to areas requiring these materials. Scrapers or haul trucks would place the loads in an effort to produce approximate 8-inch loose lifts. Dozers would be used to spread any soils that had been placed in thicker lifts. Compaction of the subgrade and liner materials would be achieved by self-propelled sheepsfoot rollers (compactors) to compact the loose lift to approximately 6-inches. Fine grading of materials to design grades would be performed with graders and bulldozers.

5.6.2.5 Geosynthetic Clay Liner

After completion and certification of the compacted earthen liner by the CQA engineer, a reinforced GCL would be installed over the earthen liner, with intimate contact to the underlying surface. The surface of the earthen liner would be graded and rolled smooth prior to the installation of the reinforced GCL and would be free rocks, stones, roots, sharp objects or debris. The surface of the earthen liner would provide a structurally competent foundation for the reinforced GCL. The reinforced GCL would consist of a layer of sodium bentonite between two 6-ounce per square yard non-woven geotextiles which are needle punched together. The reinforced GCL would have a hydraulic conductivity of less than 5×10^{-9} cm/sec. During installation, the reinforced GCL panels would be installed with a six-inch overlap longitudinally and a twelve-inch overlap on panel end seams. Powered bentonite (or alterative such as a CETCO “supergrove) would be used on all reinforced GCL panel intersections. All seams would be shingled in the direction of drainage where possible. The reinforced GCL would not be placed during precipitation events or in the presence of excess moisture or ponded water. No vehicles or equipment would be allowed to drive directly on the reinforced GCL during construction. The reinforced GCL would be covered each day with the overlying geomembrane.

5.6.2.6 Geomembrane

There are two separate geomembranes proposed for the on-site cell design. The lower geomembrane liner would be placed over the reinforced GCL and the primary geomembrane liner would be placed over the secondary leachate collection system geocomposite drainage layer.

The geosynthetic membrane liners would be constructed of 80 mil thick textured HDPE and installed by welding contiguous panels of membranes together to form a monolithic low permeability layer. During liner installation, all seams would be nondestructively tested and random destructive testing of selected seams of the geomembrane liner would occur. Most welds would be accomplished by using a hot wedge welder, which fuses the two sheets together, creating an air channel that can be tested. Secondary welds would be accomplished using an extrusion welder, which uses molten HDPE extrudate to weld two HDPE pieces together. The HDPE material is chemically compatible with any leachate expected to be generated. All selected geomembrane materials would have properties that conform with the Geosynthetic Research institute's GRI-GM13 specifications ("Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"), while the installation testing would comply with GRI-GM19 specifications ("Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes").

5.6.2.7 Geocomposite Drainage Layer

After installation of the first layer of geosynthetic membrane liner and subsequent approval by the CQA engineer, a double-sided geocomposite (geocomposite) would be installed with intimate contact to the underlying surface. The geocomposite would consist of a layer of three dimensional bi-planar Geonet (250 mil) which would be laminated on both sides with non-woven geotextiles (12 ounces per square yard). During installation, the geocomposite panels would be overlapped in the direction of flow to facilitate drainage. Panels would be oriented in the direction of the slope to minimize seams on the slope. Adjacent rolls would be overlapped a minimum of four-inches longitudinally and a twelve-inch overlap on panel end seams. Plastic fasteners would be used to tie the geonet component to adjacent panels at a maximum frequency of five-feet longitudinally and six-inches on butt seams. After joining of the geonet layer, the upper geotextile portion of the geocomposite would be continuously sewn using a contrasting colored thread for easy inspection.

5.6.2.8 Cushioning Geotextile

After the primary geomembrane was installed, tested, and certified by the CQA engineer, a cushioning geotextile would be installed over the geomembrane. This geotextile would be used to protect the geomembrane from the placement of the leachate drainage layer. The geotextile would be non-woven and have a mass per unit area of 16 ounce per square yard. This geotextile layer would be installed by unrolling rolls of geotextile and sewing the individual panels together.

5.6.2.9 Leachate Drainage and Collection Layer

After the cushioning geotextile was installed, a granular leachate drainage layer would be placed. Any leachate generated from the relocated RIM would be collected via a leachate collection system installed within the granular drainage media. The leachate collection system would consist of a 1-ft thick granular drainage media layer that would convey leachate to a perforated HDPE collection pipe, that in turn would lead to a sump at the low end of the cell containing a pump to remove leachate.

The leachate collection system would be designed and operated to maintain a leachate liquid layer head of one (1) foot or less on the liner. A layer of ½ inch river gravel or similar stone material would be used for the drainage layer media, with a minimum permeability of $1x10^{-2}$ cm/sec. The slope of the leachate collection system would be designed such that the longitudinal and cross slopes would allow for gravity drainage into collection areas from which accumulated leachate can be removed. One or more riser pipes would extend from the leachate collection system sump at the end of the cell, up the side- slope of the cell to the ground surface at the perimeter of the cell. Submersible pumps positioned at the bottom of the riser pipes would remove accumulated leachate in the sump.

5.6.2.10 Filtration Grading Layer

Due to the concern of long term biological clogging of a geotextile, the filtration and separation from the relocated RIM wastes and the leachate drainage collection layer would be accomplished using a 1-ft thick granular filtration layer that would meet acceptable filtration criteria determined in the remedial design. It is envisioned that this layer would be non-carbonate pea gravel or course sand. This layer could consist of two 6-in thick layers of increasingly smaller diameter materials from bottom to top to meet the gradation criteria. This layer(s) would also have a minimum permeability of $1x10^{-2}$ cm/sec.

5.6.2.11 Leachate Volume Estimates

As a part of the SFS evaluation, preliminary, feasibility-level leachate generation calculations were performed using the HELP Model (Schroeder, et. al., 1994). Results of this modeling were used to predict the quantity of leachate that would be generated from the volume of RIM in the on-site cell. This modeling indicated that the leachate volume would be approximately 4,200,000 gallons per year (approximately 8 gpm) in the first year after construction of the on-site cell is completed and would decline over time as the cell is filled, covered, and closed, to a rate of approximately 140 gallons per year in year 20 and beyond.

5.6.3 Other Aspects of the Full Excavation with On-Site Disposal Alternative

With the exception of the construction and operation of a RIM loadout building and the loading, transportation and offsite disposal of the RIM, all other aspects of the full excavation with on-site disposal are expected to be the same as those previously described for the full excavation with off-site disposal alternative (see Section 5.5). In particular, the volume of RIM to be excavated would be the same as that described for the full excavation with offsite disposal alternative (see Section 5.5.1).

Activities associated with the full excavation with on-site disposal alternative would include the following components:

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of material from the OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use relative to the presence of radionuclides;
- Survey and identification of the presence and extent of soil on the Buffer Zone and Lot 2A2 property that contains radionuclides at levels above those that would allow for unrestricted use;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading and transport of any RIM and impacted soil from the Buffer Zone and Lot 2A2 property and disposal of these materials in a new on-site engineered disposal cell;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls for Areas 1 and 2 and the on-site disposal cell;
- Groundwater monitoring consistent with the requirements for sanitary landfills for Areas 1 and 2 and consistent with UMTRCA requirements for the on-site disposal cell;
- Landfill gas monitoring and control, as necessary for Areas 1 and 2 and the new on-site disposal cell;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site for Areas 1 and 2 and an UMTRCA disposal cell for the new on-site disposal cell; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2 and UMTRCA cover over the on-site disposal cell.

Several components of this alternative have been addressed above in the full excavation with off-site disposal alternative (Section 5.5) and will not be repeated here; however, there are some differences. Because the RIM would be placed in an on-site disposal cell under this alternative, the engineered cover for the on-site disposal cell would require the biointrusion layer and the GCL or other geosynthetic included for the UMTRCA cover alternatives (also included in the partial excavation alternatives). In addition, although no radon flux testing would be required in Areas 1 and 2 upon completion of construction of the new landfill cover in those areas, radon flux testing would be required upon completion of installation of the engineered cover over the new on-site cell. Although Areas 1 and 2 would not require institutional controls specifically associated with the presence of radionuclides, such controls would be required for the on-site cell. Operations, maintenance and monitoring (OM&M) in Areas 1 and 2 may only be needed for a shorter time period, that is, until the landfill does not present a threat to human health or the environment at the point of exposure for humans or environmental receptors (i.e., achieves functional stability), OM&M would be required in perpetuity for the on-site disposal cell.

5.7 Partial Excavation – Removal of RIM Greater than 52.9 pCi/g within 16-foot Depth

This section describes the partial excavation alternative that includes removal of RIM containing combined radium or combined thorium activities greater than 52.9 pCi/g that is located within 16 feet of the topographic elevation of the 2005 ground surface of Areas 1 and 2.

The SOW (EPA, 2015b) provides that the Respondents have the ability to propose in the Work Plan for the RI Addendum and Final FS a different depth to be used for this alternative. Respondents reviewed the data to determine if an alternative depth value should be considered. With the incorporation of the additional data obtained during the Comprehensive Phase 1 Investigation (EMSI et al., 2016a), the results of the additional characterization work (EMSI, 2015b), and the subsequent geostatistical (indicator kriging) evaluation of the RIM occurrences and extent (SSP&A, 2017), no obvious depth interval bounding the majority of the RIM appears to exist. (see the cross-sections and horizontal slices contained in Appendix B).

This alternative consists of many of the same components that were previously discussed for the full excavation with off-site disposal alternative, including:

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from the OU-1 Areas 1 and 2 that contains combined radium or combined thorium activities greater than 52.9 pCi/g that is located within 16 feet of the 2005 topographic surface;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2;

- Excavation of any soil from the Buffer Zone and/or Lot 2A2 that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading and transport of the RIM and impacted soil and disposal of these materials at an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting UMTRCA design, performance, and longevity standards over Areas 1 and 2;
- Design, installation, and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for UMTRCA and sanitary landfills;
- Landfill gas and radon monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radiological materials; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

The primary differences between the 52.9 pCi/g partial excavation alternative and the full excavation with off-site disposal alternative are the higher criteria for excavation of RIM under the 52.9 pCi/g partial excavation alternative (52.9 pCi/g of combined radium or combined thorium as compared to 7.9 pCi/g for the full excavation alternative) and the imposition of a maximum depth of 16 feet for the RIM excavation under the 52.9 pCi/g partial excavation alternative. These differences result in significantly lower volumes of RIM and overburden material to be excavated under the 52.9 pCi/g partial excavation alternative as compared to the full excavation alternative, and accordingly, a remedy that (comparatively speaking) may be implemented more readily.

The designs of the engineered covers for the two alternatives are also different. For the full excavation with off-site disposal alternative, all of the RIM would be removed and thus, the UMTRCA design, performance, and longevity standards would not be applicable. Therefore, only a RCRA Subtitle D landfill cover would be installed over Areas 1 and 2 as part of the full excavation alternative. Because RIM would be left in place in Areas 1 and 2 with the 52.9 pCi/g partial excavation alternative, the enhanced cover that would meet the UMTRCA design, performance and longevity standards would be installed in conjunction with that alternative.

5.7.1 RIM Volumes for the 52.9 pCi/g Partial Excavation Alternative

The total volumes of RIM containing combined radium or combined thorium activities greater than 52.9 pCi/g in Areas 1 and 2 that were located within 16 feet of the 2005 topographic surface were estimated based on geostatistical evaluations as described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017). The values used in the FFS were based on the 50% probability estimates developed by the geostatistical analysis and are as follows:

Area 1 RIM (52.9 pCi/g criteria)	10,200 bcy
Area 2 RIM (52.9 pCi/g criteria)	73,700 bcy
Total RIM (52.9 pCi/g criteria)	83,900 bcy

Figures 5-15 and 5-16 illustrate the extent of RIM that would be excavated from Areas 1 and 2 under the 52.9 pCi/g partial excavation alternative.

The volumes of non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM above the 52.9 pCi/g criteria were estimated to be as follows:

Area 1 overburden (52.9 pCi/g criteria)	50,000 bcy
Area 2 overburden (52.9 pCi/g critiera)	140,000 bcy
Total overburden (52.9 pCi/g criteria)	190,000 bcy

These values are based on the more detailed engineering evaluations performed in conjunction with the development of preliminary design plans (Appendix M) and therefore represent a refinement of the estimated overburden volumes developed from the geostatistical evaluations (SSP&A, 2017).

In contrast to the full excavation with off-site disposal alternative, removal of all of the RIM containing combined radium or combined thorium levels greater than 52.9 pCi/g down to a depth of 16 feet below the 2005 topographic elevations would not require removal of the above-grade mass of the North Quarry portion of the Bridgeton Landfill, because RIM within the portion of Area 1 that is located beneath the above-grade portion of the North Quarry is located deeper than 16 feet below the 2005 topographic surface. However, removal of RIM greater than 52.9 pCi/g likely would require relocation of the Bridgeton solid waste transfer station building to allow for removal of RIM located near the transfer station (*e.g.*, GCPT 1-2, GCPT 1C-2R, and GCPT 1C-6, GCPT 1C-6T, GCPT 1C-6T1, and boring 1C-6), as that excavation would affect the stability of the transfer station (Figure 5-15). As previously discussed in Section 5.5.1 in connection with the full excavation with off-site disposal alternative, the only usable space for relocation of the transfer station is the area currently occupied by Simpson Asphalt pursuant to a 99-year lease, which would require buyout of the Simpson lease (if possible). Use of shoring techniques adjacent to the transfer station in order to minimize the potential for impacts to the structural integrity of the transfer station will be evaluated during RD but would result in any RIM located between the shoring system and the transfer station foundation being left in place (Appendix D-1).

The methods and supporting calculations used to estimate the extent and volumes of RIM containing combined radium or combined thorium activities greater than 52.9 pCi/g in Areas 1 and 2 that were located within 16 feet of the 2005 topographic surface, as well as the non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM, are further described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017).

As previously discussed in Section 5.5.1 relative to the full excavation with off-site disposal alternative, the estimates of the RIM and overburden volume associated with the 52.9 pCi/g alternative were developed to a feasibility study level of accuracy. Therefore, a high degree of uncertainty exists relative to the above-listed estimates for the same reasons cited in Section 5.5.1 relative to the full excavation alternative. Specifically, "best" estimates of the volume of RIM were prepared based on a 50% probability of RIM occurrence at any given location, and the sensitivity of these volume estimates was then evaluated through comparison to estimates based on a 25% and a 75% probability of RIM occurrence. Although from a purely statistical standpoint, the 50% estimate represents a "likely" value, for the reasons detailed in the geostatistics report and as previously discussed in Section 5.5.1, the results obtained based on the 50% values likely underestimate the actual amount of RIM and the volumes of material that would need to be excavated and disposed of to remove the RIM. For purposes of this FFS, the volume based on the 50% probability has been used to develop cost and schedule estimates and evaluated the potential risks to workers. The following table presents a comparison of the estimated volumes of RIM based on the 25%, 50% and 75% probabilities of RIM occurrence:

Area/Volume (cy)	25% Probability	50% Probability	75% Probability
Area 1	2,720	10,200	25,600
Area 2	30,700	73,700	153,000

In addition, uncertainty exists as to whether any RIM containing combined radium and/or combined thorium levels less than 52.9 pCi/g but greater than 7.9 pCi/g that is removed in conjunction with removal of overburden material can ultimately be placed back on site. It is possible that EPA could decide in the future that such material would need to also be shipped off site, which would affect the cost, schedule and potential short-term impacts associated with this alternative. For purposes of this FFS evaluation, the estimated volume of RIM is the single largest uncertainty affecting the estimated costs for all of the excavation alternatives.

5.7.2 Other Aspects of the 52.9 Partial Excavation Alternative

All other aspects of the 52.9 pCi/g partial excavation alternative would generally be the same as those previously described for the full excavation with off-site disposal alternative, except that because RIM would be left on site, the enhanced cap included under the UMTRCA cover alternative would also be included as part of 52.9 pCi/g alternative. Because the excavated area could be backfilled with RIM, or a combination of RIM and non-RIM, an evaluation will need to be made during remedial design of the potential impacts and risks if RIM is to be placed in the upper portion of the backfilled material. Because all RIM greater than 52.9 pCi/g would be removed to a depth of 15 ft below the 2005 topographic surface, which is the same or in areas where inert fill was subsequently placed lower than the current topographic surface), only RIM below 52.9 pCi/g would be left in the upper 16 feet. Because the UMTRCA cover design was based on the entirety of the RIM remaining on site (i.e., the UMTRCA cover alternative assumes no RIM is removed), using the 95% UCL values for all of the RIM (which are greater than 52.9 pCi/g), the 52.9 pCi/g partial excavation alternative should not pose an unacceptable level of gamma radiation, radon emissions or long-term risks. Nevertheless, additional evaluations of the engineered cover design may be performed during remedial design to verify the proposed cap design would be protective. Such evaluations could include additional evaluations (e.g., estimation of gamma radiation and radon flux levels) of the engineered cover design based on the estimated radioactivity levels of the backfilled material or a simple comparison of the 95% UCL of the backfilled material, or the uppermost backfilled material, to the 95% UCL used as the basis of design for the final engineered cover. Alternatively, the design specifications could require that any RIM that is to be replaced in the excavated areas be placed in the lowermost portion of the excavated areas to provide additional shielding and radon attenuation and/or be mixed with non-RIM material such that the radioactivity of the backfilled material is below the levels used as the basis of design of the engineered cover. The specific nature of these evaluations will be determined during remedial design.

The 52.9 pCi/g alternative would require less soil material (1,250,000 loose cubic yards) to be purchased and delivered to the Site for construction as compared to the full excavation with off-site disposal alternative. In addition, because radionuclides above the unrestricted use criteria would still remain at the Site, 5-year review evaluations, groundwater monitoring for radionuclides, and radon gas monitoring would be required for the 52.9 pCi/g partial excavation alternative. Baseline monitoring for measurement of radon gas in landfill gas wells for the partial excavation alternatives is described in Section 4.1.2 of Appendix G, and includes measurement of radon gas in landfill gas wells installed along the boundaries of Areas 1 and 2.

5.8 Partial Excavation – Removal of RIM Greater than 1,000 pCi/g

This section provides a description of the partial excavation alternative that includes removal of RIM containing combined radium or combined thorium activities greater than 1,000 pCi/g. As with the 52.9 pCi/g partial excavation alternative, this alternative consists of many of the same components that were previously discussed for the full excavation with off-site disposal alternative including:

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from the OU-1 Areas 1 and 2 that contains combined radium or combined thorium activities greater than 1,000 pCi/g;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Crossroad Lot 2A2 property;
- Excavation of any soil from the Buffer Zone and/or Crossroad Lot 2A2 property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading and transport of the RIM and impacted soil and disposal of these materials at an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of an engineered cover meeting the UMTRCA design, performance, and longevity standards over Areas 1 and 2;
- Design, installation, and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for UMTRCA and sanitary landfills;
- Landfill and radon gas monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radionuclides; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

The primary difference between the 1,000 pCi/g partial excavation alternative and the 52.9 pCi/g partial excavation and full excavation alternatives is the higher criteria for excavation of RIM associated with this partial excavation alternative (1,000 pCi/g of combined radium or combined thorium as compared to 7.9 pCi/g for the full excavation alternatives and 52.9 pCi/g for the other partial excavation alternative). The higher criteria associated with the 1,000 pCi/g partial excavation alternative results in a lower volume of RIM to be excavated. However, in contrast to the 52.9 pCi/g partial excavation alternative, which includes a maximum depth of excavation limited to 16 feet below the 2005 ground surface, the 1,000 pCi/g partial excavation alternative does not include any depth limitation. Therefore, even though the RIM volume associated with this alternative is smaller, the volume of overburden that would need to be removed to allow for removal of RIM greater than 1,000 pCi/g is significantly greater than the volume of overburden associated with the 52.9 pCi/g partial excavation alternative.

In addition, while a RCRA Subtitle D landfill cover would be installed over Areas 1 and 2 as part of the full excavation with off-site disposal alternative, the UMTRCA cover would be installed in conjunction with the partial excavation alternatives.

5.8.1 RIM Volumes for the 1,000 pCi/g Partial Excavation Alternative

The total volumes of RIM containing combined radium or combined thorium activities greater than 1,000 pCi/g in Areas 1 and 2 were estimated based on geostatistical evaluations as described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017). The values used for the FFS evaluations were based on the 505 probability estimates from the geostatistical evaluation and are as follows:

Area 1 RIM (1,000 pCi/g criteria)	7,700 bcy
Area 2 RIM (1,000 pCi/g criteria)	31,000 bcy
Total RIM (1,000 pCi/g criteria)	38,700 bcy

Figures 5-17 and 5-18 illustrate the extent of RIM that would be excavated from Areas 1 and 2 under the 1,000 pCi/g partial excavation alternative.

The volumes of non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM above the 1,000 pCi/g criteria were estimated to be as follows:

Area 1 overburden (1,000 pCi/g criteria)	500,000 bcy
Area 2 overburden (1,000 pCi/g critiera)	145,000 bcy
Total overburden (1,000 pCi/g criteria)	645,000 bcy

These values are based on the more detailed engineering evaluations performed in conjunction with the development of preliminary design plans (Appendix M) and therefore represent a refinement of the estimated overburden volumes developed from the geostatistical evaluations (SSP&A, 2017).

Similar to the full excavation with off-site disposal alternative, removal of all of the RIM containing combined radium or combined thorium levels greater than 1,000 pCi/g would require removal, stockpiling, and ultimately replacement of a large part of the above-grade mass of the North Quarry portion of the Bridgeton Landfill. However, removal of RIM greater than 1,000 pCi/g is not expected to require relocation of the Bridgeton solid waste transfer station building.

The methods and supporting calculations used to estimate the extent and volumes of RIM above the 1,000 pCi/g criteria, as well as the non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM, are further described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017).

Similar to the discussion in Section 5.5.1 in connection with the full excavation with off-site disposal alternative, the estimates of the RIM and overburden volume associated with the 1,000 pCi/g alternative were developed to a feasibility study level of accuracy. Therefore, a high degree of uncertainty exists relative to the above-listed quantities for the same reasons cited in Section 5.5.1 relative to the full excavation alternative. Specifically, "best" estimates of the volume of RIM were prepared based on a 50% probability of RIM occurrence at any given location and were used to develop cost and schedule estimates and evaluate the potential risks to workers for this FFS. The sensitivity of these volume estimates was then evaluated through comparison to estimates based on a 25% and a 75% probability of RIM occurrence. The following table presents a comparison of the estimated volumes of RIM based on the 25%, 50% and 75% probabilities of RIM occurrence:

Area/Volume (cy)	25% Probability	50% Probability	75% Probability
Area 1	1,460	7,690	23,300
Area 2	7,900	31,000	77,400

In addition, uncertainty exists as to whether any RIM containing combined radium and/or combined thorium levels less than 1,000 pCi/g that is removed in conjunction with removal of overburden material can ultimately be placed back on-site. It is possible that EPA could decide in the future that such material would also need to be shipped off-site which would greatly impact the cost, schedule and potential short-term impacts associated with this alternative. For purposes of this FFS evaluation, the estimated volume of RIM is the single largest uncertainty affecting the estimated costs for all of the excavation alternatives.

5.8.2 Other Aspects of the 1,000 Partial Excavation Alternative

All other aspects of the 1,000 pCi/g partial excavation alternative would generally be the same as those previously described for the 52.9 pCi/g partial excavation alternatives. Because RIM would be left on site, the enhanced cap included under the UMTRCA cover alternative would also be included as part of 1,000 pCi/g alternative. Because the excavated area could be backfilled with RIM, or a combination of RIM and non-RIM, an evaluation will need to be made during remedial design of the potential impacts and risks if RIM is to be placed in the upper portion of the backfilled material. Additional evaluations of the engineered cover design may need to be performed during remedial design to verify the proposed cap design would be protective. Such evaluations could include additional evaluations (e.g., estimation of gamma radiation and radon flux levels) of the engineered cover design based on the estimated radioactivity levels of the backfilled material or a simple comparison of the 95% UCL of the backfilled material, or the uppermost backfilled material, to the 95% UCL used as the basis of design for the final engineered cover. Alternatively, the design specifications could require that any RIM that is to be replaced in the excavated areas be placed in the lowermost portion of the excavated areas to provide additional shielding and radon attenuation and/or be mixed with non-RIM material such that the radioactivity of the backfilled material is below the levels used as the basis of design of the engineered cover. The specific nature of these evaluations will be determined during remedial design.

Because the 1,000 pCi/g alternative is not subject to any depth restrictions, the 1,000 pCi/g alternative would require more soil material (1,420,000 loose cubic yards) to be purchased and delivered to the Site for construction as compared to the 52.9 pCi/g partial excavation alternative (which is limited to the first 16 ft below the 2005 surface). Ongoing monitoring for radionuclide occurrences in groundwater and potentially measurement of radon gas in landfill gas wells installed along the boundaries of Areas 1 and 2 could be required as part of this alternative. Because this alternative only entails removal of radionuclides above 1,000 pCi/g, radionuclides would still remain at the Site at levels above the unrestricted use criteria. Therefore, 5-year review evaluations and radon gas monitoring would be required for the 1,000 pCi/g partial excavation alternative.

5.9 Risk-Based Partial Excavation Alternative

This section provides a description of the risk-based partial excavation alternative. This alternative includes removal of RIM with radionuclide levels greater than those that would be protective of future industrial land uses (*i.e.,* outdoor storage yard worker) in Areas 1 and 2. Because this alternative would remove RIM as needed to meet industrial land use risk-based levels, it has been termed the risk-based partial excavation alternative. The final elements of the design of this remedial alternative are still under development, and details regarding the approach will be further evaluating following discussions with EPA.

Under this partial excavation alternative, RIM containing combined radium or combined thorium activities greater than levels that would be protective of future industrial uses (*i.e.,* outdoor storage yard worker in 1,000 years) in Areas 1 and 2 would be removed. This alternative is based on examination of potential risks that may remain after completion of regrading to a 5% (or possibly a 2%) surface slope, but, in accordance with direction from EPA, before installation of a new landfill cover. Notably, the installation of an engineered cover, as will be required by the applicable ARARs, would eliminate any unacceptable risk to future industrial users. The purpose of this alternative, however, is to assess the scope of excavation needed to mitigate unacceptable risks to a future industrial user, even without capping.[41]

The basis for this alternative is described in Appendix L. Specifically, this remedy would be designed to achieve reduction of radon emissions at the surface of Areas 1 and 2 to meet risk-based criteria for industrial land use and ARARs, ensure that gamma radiation is below acceptable levels for industrial use, and ensure that the potential risks to any industrial work are below 1×10^{-4}. To achieve these goals, any RIM (i.e., any material containing combined radium or combined thorium greater than 7.9 pCi/g, or combined uranium greater than 54.5 pCi/g) located within 2.2 feet of the projected final grade of the waste materials (i.e., base of the engineered cover) would be removed. The excavated areas would be backfilled with inert fill material (e.g., clean soil from an offsite source) resulting in at least two feet of non-RIM waste or soil between any RIM and the bottom of the engineered cover. As a result, this alternative would result in 7.2 feet of non-RIM material between RIM remaining after the partial excavation and the ground surface (2.2 feet of non-RIM waste or imported fill plus the 5-foot-thick UMTRCA cover).

Similar to the 52.9 pCi/g and 1,000 pCi/g partial excavation alternatives, this alternative would likely include many of the same components that were previously described for the full excavation with off-site disposal alternative, including, as needed:

- Excavation and stockpiling of overburden in OU-1 Areas 1 and 2 in order to access the RIM;

- Excavation of RIM from the OU-1 Areas 1 and 2 that results in a radon flux exceeding the allowable level[42];

- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2;

- Excavation of any soil from the Buffer Zone and/or Lot 2A2 that contains radionuclides at levels greater than those that would allow for unrestricted use;

- Loading and transport of the RIM and impacted soil and disposal of these materials at an off-site disposal facility;

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[41] As discussed in the Baseline Risk Assessment, current Site conditions are already protective of an industrial worker, so this evaluation looks solely at the increased risk resulting from ingrowth of radium after 1,000 years.

- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (2% or 5%) and maximum (25%) slope criteria;
- Installation of an engineered cover meeting the UMTRCA design, performance, and longevity standards over Areas 1 and 2;
- Design, installation, and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for UMTRCA and sanitary landfills;
- Landfill and radon gas monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radionuclides; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

5.9.1 RIM Volumes for the Risk-Based Partial Excavation Alternative

The total volumes of RIM containing combined radium or combined thorium activities greater than 7.9 pCi/g in Areas 1 and 2 present within two feet of a projected 5% final grade were estimated based on geostatistical evaluations (SSP&A, 2017), and are as follows:

Area 1 RIM (risk-based criteria)	2,190 bcy
Area 2 RIM (risk-based criteria)	13,380 bcy
Total RIM (risk-based criteria)	15,570 bcy

Figures 5-19 and 5-20 illustrate the extent of RIM that would be excavated from Areas 1 and 2 under the risk-based partial excavation alternative.

The volumes of non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM above the risk-based criteria were estimated to be as follows:

Area 1 overburden (risk-based criteria)	1,380 bcy
Area 2 overburden (risk-based critiera)	3,830 bcy
Total overburden (risk-based criteria)	5,210 bcy

Additional material would need to be relocated in conjunction with regrading of the landfill surface and slopes and to create space for a stormwater impoundment in Area 1. The total volume of non-RIM waste that is excepted to be relocated under this alternative is

Area 1 total non-RIM waste (risk-based criteria)	31,000 bcy
Area 2 total non-RIM waste (risk-based critiera)	57,000 bcy
Total non-RIM waste (risk-based criteria)	88,000 bcy

These values are based on the more detailed engineering evaluations performed in conjunction with the development of preliminary design plans (Appendix M) and therefore represent a refinement of the estimated overburden volumes developed from the geostatistical evaluations (SSP&A, 2017).

In contrast to the full excavation with off-site disposal and the 1,000 pCi/g partial excavation alternatives, the risk-based partial excavation alternative would not require removal of any of the above-grade mass of the North Quarry portion of the Bridgeton Landfill. Furthermore, the risk-based partial excavation alternative is also not expected to require relocation of the Bridgeton solid waste transfer station building.

The methods and supporting calculations used to estimate the extent and volumes of RIM above the 1,000 pCi/g criteria, as well as the non-radiological overburden soil and waste materials that would have to be removed to allow for excavation of the RIM, are further described in the "*Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill, Operable Unit 1, Bridgeton, Missouri: With Additional Calculations to Support Potential Excavation Remedy Alternatives*" (SSP&A, 2017).

Similar to the discussion in Section 5.5.1 in connection with the full excavation with off-site disposal alternative, the estimates of the RIM and overburden volume associated with the risk-based partial excavation alternative were developed to a feasibility study level of accuracy. Therefore, a high degree of uncertainty exists relative to the above-listed quantities for the same reasons cited in Section 5.5.1 in connection with the full excavation with off-site disposal alternative. Specifically, "best" estimates of the volume of RIM were prepared based on a 50% probability of RIM occurrence at any given location, and were used to develop cost and schedule estimates and evaluate the potential risks to workers for this FFS. The sensitivity of these volume estimates was then evaluated through comparison to estimates based on a 25% and a 75% probability of RIM occurrence. The following table presents a comparison of the estimated volumes of RIM based on the 25%, 50% and 75% probabilities of RIM occurrence:

Area/Volume (cy)	25% Probability	50% Probability	75% Probability
Area 1	610	2,190	6,710
Area 2	7,610	13,380	25,140

For purposes of this FFS evaluation, the estimated volume of RIM is the single largest uncertainty affecting the estimated costs for all of the excavation alternatives.

5.9.2 Other Aspects of the Risk-Based Partial Excavation Alternative

The primary difference between the industrial land use risk-based partial excavation alternative and the other excavation alternatives are (i) the consideration of the presence of overburden materials between the RIM and the graded surface that would limit projected risk and the resultant maximum depth of RIM excavation for this alternative, and (ii) the potential use of a variable cleanup level as a function of depth for this alternative. In addition, unlike the 52.9 pCi/g partial excavation alternative, which included a depth limit based on a set (2005) topographic surface, the depths limits for the risk-based partial excavation alternative are based on depths from the anticipated final surface grades (*i.e.*, base of final cover) in Areas 1 and 2 after completion of landfill regrading.

All other aspects of the risk-based partial excavation alternative would generally be the same as those previously described for the 52.9 pCi/g and 1,000 pCi/g partial excavation alternatives. In contrast to the full excavation with off-site disposal and the 1,000 pCi/g partial excavation alternative, the risk-based partial excavation would not require removal of the above-grade waste in the North Quarry portion of the Bridgeton Landfill. Because RIM would be left on site, the enhanced cap included under the UMTRCA cover alternative would also be included as part of this risk-based alternative. Ongoing monitoring for radionuclide occurrences in groundwater and, potentially, measurement of radon gas in landfill gas wells installed along the boundaries of Areas 1 and 2, could be required as part of this alternative. Because this alternative only entails removal of radionuclides above levels protective of industrial land use, radionuclides would still remain at the Site at levels above the unrestricted use criteria. Therefore, 5-year review evaluations and radon gas monitoring would be required for the industrial land use risk-based partial excavation alternative.

6 DETAILED ANALYSIS OF ALTERNATIVES

This section provides a detailed analysis of the remedial alternatives evaluated in this FFS: the No Action alternative, the ROD-selected remedy, the UMTCRA cover alternative, the full excavation with off-site disposal of RIM alternative, the full excavation with on-site disposal of RIM alternative, and the three partial excavation alternatives described in Section 5. The purpose of this detailed analysis is to provide sufficient information to allow for comparisons among the alternatives based on the nine evaluation criteria specified in the NCP.

The detailed evaluation of final alternatives for a remedial action is a two-stage process. This section presents the first stage of evaluation, in which each of the alternatives is assessed against the nine evaluation criteria prescribed by the NCP. This evaluation is based on the conceptual descriptions of the alternatives provided in Sections 5.2 through 5.9.

Section 7 will set out the second stage of the evaluation process, in which the alternatives are compared against each other to identify relative advantages, disadvantages and trade-offs using the nine NCP evaluation criteria. The purpose of the comparative analysis is to provide information for a balanced remedy selection.

The NCP categorizes these nine evaluation criteria into three groups: threshold criteria, primary balancing criteria, and modifying criteria. The evaluation criteria consist of:

Threshold Criteria:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria:

- State Acceptance
- Community Acceptance

Each criterion has its own weight when it is evaluated.

- Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).[43]

- Primary balancing criteria are used to weigh effectiveness and tradeoffs among alternatives. The primary balancing criteria include: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the evaluation of alternatives is based.

- Modifying criteria include State acceptance and community acceptance. These criteria are evaluated and applied by EPA as part of any decision process that may be undertaken by EPA after completion of the FFS. Accordingly, only the seven threshold and primary balancing criteria are applied in the detailed analysis phase of this section.

6.1 Description of Evaluation Criteria

Specific elements to be considered in the evaluation of the nine NCP criteria are discussed below.

6.1.1 Overall Protection of Human Health and the Environment

This criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by contaminants present at the Site, in both the short and long term. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through implementation of the remedial activities. Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

6.1.2 Compliance with ARARs

This criterion is used to evaluate whether each alternative would comply with federal and State ARARs, or, if not, whether invoking waivers to one or more specific ARARs is justified. Other source of information—such as advisories, criteria, or guidance—are considered during the ARARs analysis as “to be considered” elements (TBCs). The considerations evaluated during

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[43] Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived. An ARARs waivers analysis is outside the scope of this FFS.

the analysis of the ARARs applicable to each alternative are presented below. Potential chemical-, location-, and action-specific ARARs for West Lake Landfill OU-1 are discussed in detail in Section 3.1.

Chemical-Specific ARARs:

- Likelihood that the alternative will achieve compliance with chemical-specific ARARs within a reasonable period of time.
- Evaluation of whether a waiver is appropriate it the chemical-specific ARAR cannot be met.

Location-Specific ARARs:

- Determination of whether any location-specific ARARs apply to the alternative.
- Likelihood that the alternative will achieve compliance with the location-specific ARAR.
- Evaluation of whether a waiver is appropriate if the location-specific ARAR cannot be met.

Action-Specific ARARs:

- Likelihood that the alternative will achieve compliance with action-specific ARARs.
- Evaluation of whether a waiver is appropriate if the action-specific ARAR cannot be met.

Other criteria and guidance:

- Likelihood that the alternative will achieve compliance with other criteria, such as risk-based criteria.

6.1.3 Long-Term Effectiveness and Permanence

Alternatives are to be assessed for the long-term effectiveness and permanence that they afford, along with the degree of certainty that the alternative will prove successful. The primary components of this criterion are the magnitude of residual risk remaining at the Site after remedial objectives have been met, and the adequacy and reliability of controls (such as containment systems or institutional controls) that may be required to manage that risk. The analysis of each alternative for long-term effectiveness and permanence is presented below.

Magnitude of residual risks:

- Identify remaining risks from treatment residuals and untreated contamination.

- Magnitude of the remaining risks.

The magnitude of residual risk at the completion of remedial activities is evaluated against numerical standards (e.g., cleanup levels or chemical-specific ARARs), or the volume or concentration of contaminants remaining. The characteristics of the residuals remaining are also evaluated, considering their volume, toxicity, mobility, and propensity to bioaccumulate.

<u>Adequacy and reliability of controls</u>:

This criterion requires evaluation of the adequacy and reliability of controls that are used to manage either treatment residuals or untreated materials that remain after attaining remediation goals. This evaluation includes an assessment of containment systems and institutional controls to assess the degree of confidence that they will adequately handle potential problems and provide sufficient protection. Factors to be considered are:

- Likelihood that the technologies will meet required process efficiencies or performance specifications.
- Type and degree of long-term management required.
- Long-term monitoring requirements.
- Operations, Maintenance, and Monitoring (OM&M) functions that must be performed.
- Difficulties and uncertainties associated with long-term OM&M functions.
- Potential need to replace technical components of the remedial action.
- Magnitude of threats or risks should the remedial action need replacement.
- Degree of confidence that controls can adequately handle potential problems.
- Uncertainties associated with land disposal of residuals and untreated wastes.

At EPA's direction (EPA, 2015b), the evaluation of long-term effectiveness for the West Lake Landfill Superfund Site also includes evaluation of potential impacts to the alternatives if a tornado were to occur at the Site, the potential effects of climate change, and potential impacts if a subsurface reaction (SSR) were to occur within Area 1 or 2. EPA also directed that the potential impacts of severe weather on the short-term effectiveness of the partial and full excavation alternatives be evaluated.

6.1.4 Reduction of Toxicity, Mobility or Volume through Treatment

This criterion addresses the anticipated performance of the treatment technologies employed by each alternative in permanently and significantly reducing toxicity, mobility, or volume of hazardous substances. The NCP expresses a preference for remedial actions in which treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for reduction of toxicity, mobility, or volume of contaminants are presented below:

(1) Treatment process and remedy:

- Likelihood that the treatment processes address the principal threat, including the materials to be treated.
- Special requirements for the treatment processes.

(2) Amount of hazardous material destroyed or treated:

- Portion (mass) of constituents of potential concern (COPC) that is destroyed.
- Portion (mass) of COPC that is treated.

(3) Reduction in toxicity, mobility, or volume through treatment:

- Degree of expected reduction in the total mass, mobility, volume, or toxicity of contaminants (measured as a percentage of reduction or order of magnitude).

(4) Irreversibility of treatment:

- Degree to which the effects of the treatment are irreversible.

(5) Type and quantity of residuals remaining following treatment:

- Residuals that will remain.
- Quantities and characteristics of the residuals, including persistence, toxicity, mobility, and propensity to bioaccumulate.
- Risk posed by the treatment residuals.

(6) Statutory preference for treatment as a principal element:

- Extent to which treatment addresses the principal threats.
- Extent to which treatment reduces the inherent hazards posed by the principal threats at the site, including the extent to which toxicity, mobility, or volume are reduced either alone or in combination.

6.1.5 Short-Term Effectiveness

Short-term effectiveness considers the ability of each remedial alternative to protect human health and the environment during the construction and implementation phase. The short-term effectiveness evaluation addresses protection prior to meeting the RAOs. The considerations evaluated during the analysis are presented below.

(1) Protection of the community during any remedial action:

- Short-term risks that might be posed to the community during the implementation of an alternative.
- How these risks will be addressed and mitigated.
- Remaining risks, if any, that cannot be readily controlled.

(2) Protection of workers during remedial actions:

- Potential risks to the workers that must be addressed.
- How these risks will be addressed and mitigated, and the effectiveness and reliability of measures to be taken.
- Remaining risks, if any, that cannot be readily controlled.

(3) Environmental impacts of any remedial action:

- Potential environmental impacts that are expected as a result of the construction and implementation of the alternative.
- Available mitigation measures, as well as their effectiveness and reliability in minimizing potential impacts.
- Impacts that cannot be avoided, should the alternative be implemented.

(4) Time until RAOs are achieved:

- Time to achieve protection against the threats being addressed.
- Time until any remaining threats are addressed.
- Time until RAOs are achieved.

At EPA's direction (EPA, 2015b), the evaluation of short-term impacts also includes an evaluation of environmental justice considerations.

6.1.6 Implementability

Implementability evaluates the technical and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative, as well as the availability of required services and materials during remedy implementation. The following considerations are evaluated for implementability:

Technical Feasibility

(1) Ability to construct and operate the technology:

- Difficulties associated with the construction.
- Uncertainties associated with the construction.

(2) Reliability of the technology:

- Likelihood that technical problems will lead to schedule delays.

(3) Ease of undertaking additional remedial actions:

- Likely future remedial actions that may be anticipated.
- Difficulty implementing additional remedial actions.

(4) Monitoring considerations with respect to effectiveness of the remedy:

- Migration or exposure pathways that cannot be monitored adequately.
- Risks of exposure, should the monitoring be insufficient to detect failure.

Administrative Feasibility

Coordination with other agencies:

- Steps required to coordinate with regulatory agencies other than EPA to implement the remedy.
- Steps required to establish long-term or future coordination among agencies.
- Ease of obtaining permits for off-site activities, if required.

Availability of Services and Materials

(1) Availability of adequate treatment, storage capacity, and disposal services:

- Availability of adequate off-site treatment, storage capacity, and disposal services.
- Additional capacity that is necessary.
- Whether lack of capacity prevents implementation.
- Additional provisions required to ensure that additional capacity is available.

(2) Availability of necessary and adequate equipment and specialists:

- Availability of necessary equipment and specialists.
- Additional equipment or specialists required.

- Whether there is a lack of equipment or specialists that would prevent implementation.
- Additional provisions required to ensure that equipment and specialists are available.

(3) Availability of prospective technologies:

- Whether technologies under consideration are generally available and sufficiently demonstrated.
- Further field applications needed to demonstrate that the technologies may be used for full-scale treatment of contaminants.
- When the technology would be available for full-scale use.
- Whether more than one vendor would be available to provide a competitive bid.

6.1.7 Cost

In accordance with the NCP, as well as the "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA, 1988a) and "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000c), estimated capital costs, annual OM&M costs, periodic costs, and present worth costs have been prepared for the ROD-selected remedy, the UMTCRA cover alternative, the two full excavation of RIM alternatives, and the three partial excavation alternatives. As specified in the RI/FS guidance (EPA, 1988a), the estimated costs were developed to provide a level of accuracy of +50/-30 percent. That is, the actual costs may be up to 50% higher or 30% lower than the estimated costs.

6.1.7.1 Capital and Operation, Maintenance, and Monitoring Costs

Capital costs include (1) direct costs for labor, equipment, materials, subcontractors, contractor markups such as overhead and profit, and professional/technical services that are necessary to support construction of the remedial action; and (2) indirect capital costs that are not part of the actual construction but are necessary to implement the remedial action (e.g., engineering, legal, construction management, and other technical and professional services). OM&M costs include annual post-construction costs for labor, equipment, materials, subcontractors, and contractor markups such as overhead and profit associated with activities such as monitoring and maintaining the components of the remedial action. Annual OM&M costs also include expenditures for professional/technical services necessary to support OM&M activities. Periodic costs are those that might occur only once every few years (e.g., 5-year reviews, cap/cover repair, and equipment replacement), or expenditures that would occur only once during the entire OM&M period or remedial timeframe (e.g., well abandonment, update of the Institutional Controls (ICs) Plan, and site closeout).

In preparing the cost estimates used in this FFS, quantities for labor, equipment, and materials were developed as discussed in Sections 2 and 5 of this report. Cost data were obtained from a variety of sources including cost estimating guides and references such as unit prices in the latest RS Means Heavy Construction and Sitework & Landscaping Cost Data, RS Means Data Online Second Quarter 2017 digital cost data, site-specific vendor and contractor quotes and discussions, experience with actual costs from similar projects, other historical project costs updated to 2017 costs using the Engineering News Record Construction Cost Index (ENR CCI), and engineering judgment.

As discussed in Section 4.3.5.4, only four disposal facilities (US Ecology's facility in Grandview, Idaho; US Ecology's facility in Wayne, Michigan; the Energy*Solutions* facility in Clive, Utah; and Clean Harbors' Deer Trail facility in Last Chance, Colorado) have been identified that could accept RIM from the West Lake Landfill for off-site disposal.

All of the disposal companies considered in Section 4.3.5.4 of the FFS have experience performing the type of services that would be necessary for implementation of a full excavation of RIM or partial excavation alternative, although their prior experience has been with soil containing radionuclides, not radionuclides within soil mixed with municipal solid waste (MSW). US Ecology's Idaho facility has experience relative to excavation, transport and off-site disposal of radiologically-impacted soils from the St. Louis Airport Site (SLAPS), which is geographically close to the West Lake Landfill. More recently, US Ecology acquired a facility in Michigan (the former EQ Wayne disposal facility in Wayne, MI, referenced above); this facility is located closest to the Site, although it is uncertain at this time whether the levels of radionuclides that would be present in any waste excavated under the full and partial excavation alternatives would be below the waste acceptance criteria at this facility (maximum radium level of 50 pCi/g). The latter two disposal facilities have performed similar services for Formally Utilized Sites Remedial Action Program (FUSRAP) sites, as well as for remedial actions at other Superfund sites that contained radioactively-impacted materials.

Because these turnkey disposal firms performed removal, transportation, and off-site disposal services for SLAPS and other sites, estimates of the expected costs for transport and disposal of the West Lake Landfill RIM are considered appropriate for preparation of FS-level cost estimates.

Unlike the soil removed from SLAPS and other sites, the radionuclides in Areas 1 and 2 are located within a matrix of soil and MSW. Although it may be possible to segregate some or possibly all of the soil containing radionuclides from the MSW materials, for the reasons discussed in Sections 4.3.5.2 and 4.4.1.2, the potential effectiveness, implementability, and cost of physical segregation/separation and radiological segregation/separation cannot be determined at this time. Therefore, for purposes of this FFS, it has been assumed that RIM that would be transported and disposed of offsite would consist of soil containing radionuclides, other soil, decomposed organic matter, and some MSW debris. In contrast to soil alone, such material would likely be classified as debris which would require additional treatment (stabilization) at the receiving disposal site. In addition, the anticipated densities of MSW/soil mixture in OU-1 are expected to be less than the typical densities associated with soil. Therefore, different methods of transportation may be appropriate for the West Lake Landfill RIM compared to those used for transport of impacted soil from SLAPs or sites (*e.g.*, use of intermodal containers as opposed to direct loading of gondola cars; see prior discussion in Section 5.5.3). All of these factors were discussed with US Ecology as part of the development of estimated costs for transportation and disposal of RIM from West Lake Landfill OU-1.

Each of the identified contractors could provide all coordination involved with leasing a nearby rail spur, waste profiling and acceptance testing, loading and manifesting each truck that leaves the Site, and scheduling railcar transportation with the respective railroads who own the track along the rail routes between the West Lake Landfill and the disposal facility location. Solely for purposes of preparing the cost estimates for the FFS, the unit costs for the complete "turnkey" services provided by US Ecology for transportation and disposal of RIM from the Site were used. For the full and partial excavation alternatives, this FFS considered unit costs for complete ("turnkey") services for waste classification, transportation, and disposal provided by US Ecology for its Grandview, Idaho facility. Contacting trucking and rail companies to obtain independent estimates of the potential costs of transportation separate from the potential costs for disposal is beyond the scope and level of detail required to prepare FS-level cost estimates. Furthermore, it would be difficult to ascertain the degree of qualifications, capabilities and understanding such transportation firms might have regarding the licensing, permitting, applicable fees, manifesting, placarding, health and safety monitoring, and other aspects of interstate transportation of radioactive wastes. US Ecology provided unit costs for complete turnkey services for waste profiling and acceptance testing, waste transportation (including all related fees and taxes), and waste disposal services (including all related fees and taxes). The information provided by US Ecology is considered appropriate for an FS-level evaluation of potential alternatives. The possible cost impacts of using the Energy*Solutions* facility were previously evaluated as part of the sensitivity evaluation of the cost estimates performed for the SFS (EMSI et al., 2011), and it was determined that use of the Energy*Solutions* facility would result in significantly greater costs.

Estimates for professional/technical services cost elements (project management, remedial design (RD), construction management, and technical support) were based on the example percentages provided in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000c) for construction of remedies greater than $10 million. These percentages of total construction cost are 5%, 6%, and 6%, respectively, for project management, RD, and construction management. Costs for regulatory oversight were estimated at 5% of the capital costs (exclusive of off-site transportation and disposal costs and contingency costs), and 5% of the long-term OM&M costs.

The factors (*e.g.*, total number of acres to be regraded under the ROD-selected remedy, the volume of RIM to be excavated under the full partial excavation alternatives, the total length of fencing, etc.) and the assumptions (e.g., material densities and swell factors, volume of leachate encountered or stormwater generated during construction, excavation efficiency factors, etc.) used to prepare the cost estimates are presented in Appendix K-9.

6.1.7.2 Contingency Costs

A contingency was added as a percentage of the total capital, annual OM&M, and periodic costs to cover unknowns, unforeseen circumstances, or unanticipated conditions that are not possible to evaluate from the data on hand at the time the FS-level cost estimates were prepared. Contingency is composed of two elements: scope and bid.

Scope contingency covers unknown costs due to scope changes that may occur during RD and represents project risks associated with an incomplete design, because design concepts are not typically developed enough during preparation of an FS to identify all project components or quantities. This type of contingency represents costs unforeseeable at the time of the preparation of the FS, as well as conceptual design cost estimate preparation, both of which are likely to become better known as the RD phase progresses. For this reason, scope contingency is sometimes referred to as "design" contingency. In general, scope contingency should decrease as RD progresses and should be near 0% at the 100% design stage. At the early stages of RD (*e.g.*, during the FS stage, which represents 0% to 10% design completion), concepts are not typically developed enough to identify all project components or quantities. Higher scope contingency values may be justified for alternatives with greater levels of cost growth potential. A low percentage for scope contingency indicates an opinion that the project scope would undergo minimal change during design. A high percentage indicates an opinion that the project scope may change considerably between the FS and final design. In accordance with EPA guidance (EPA, 2000c), engineering judgment was used whenever selecting a scope contingency percentage, and the value used was clearly identified in the cost estimate.

For this FFS, scope contingency factors ranged from 10% to 55%, depending upon the degree of certainty or uncertainty associated with each alternative and the remedial technologies that comprise each alternative, and taking into consideration the ranges in FS-level scope contingency percentages listed in Exhibit 5-6 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000c). Exhibit 5-6 of that guidance provides a range of scope contingencies to consider for various remedial technologies. As examples, the following ranges from Exhibit 5-6 were considered and selected for this FFS.

Remedial Technology	Scope Contingency Range from Exhibit 5-6 (%)	Selected Scope Contingency for FFS (%)
Soil excavation	15 – 55	55
Off-site disposal	5 – 15	15
Synthetic cap	10 – 20	20
Clay cap	5 – 10	10

The uppermost values for these remedial technologies were selected for use in this FFS due to the high level of uncertainty associated with the scope of each of the remedial alternatives. Factors contributing to the high level of uncertainty for the ROD-selected remedy, UMTRCA cover alternative, the two full excavation alternatives, and the three partial excavation alternatives include the following:

- The estimated volume of RIM to be removed under the full excavation of RIM and partial excavation alternatives. The results of the geostatistical evaluation (SSP&A, 2017) of the RI data were used to delineate the lateral and vertical extent of RIM and estimate the volume of waste material that might need to be removed for each alternative. The resulting estimated RIM volumes (see prior discussions in Section 5) associated with each remedial alternative served as the basis for the cost estimates presented in this FFS (Appendix K). Costs for excavation and off-site transportation and disposal are directly proportional to the estimated volume of RIM to be excavated, removed, or disposed off-site.

- The assumed unit weight of the existing in-place filled material in Areas 1 and 2 and the assumed waste volume expansion or “swell” factor for the filled material after excavation: Based on experience from other sites and engineering judgment, a unit weight of 1,500 pounds per cubic foot (lbs/cf) and a swell factor of 1.5 were used in this FFS. Swell factors reported for the CERCLA landfill excavation remedial action for OU-1 at the Mound (Miamisburg, OH) site varied from 1.2 to 1.6 (Lee, 2010), while a swell factor of 2 was experienced during excavation of the Tulalip Landfill CERCLA site near Marysville, WA (Richtel, 2010). Assuming a swell factor of 1.3 instead of the 1.5 used in this FFS would result in 13% less volume of RIM that would be disposed off-site under the full or partial excavation alternatives, while a swell factor of 2.0 would result in 33% more RIM volume than the amount estimated using the 1.5 swell factor.

- The uncertain level of effort for radiation surveying and confirmatory laboratory sample turnaround time and analysis required to guide the excavation of RIM, and the effect of such uncertainties on excavation progress.

- The ability and level of effort required to excavate deeper occurrences of RIM in Areas 1 and 2.

- The methods assumed to handle overburden materials so as to minimize “double handling” of the materials during excavation and subsequent replacement have not been fully developed or designed.

- The actual equipment production rates for regrading or excavation of the landfilled wastes in Areas 1 and 2 are uncertain at this time.

- It was not possible to estimate precise volumes of precipitation and resultant contact stormwater that might be generated when precipitation is exposed to waste during regrading activities under the ROD-selected remedy or to waste and RIM during excavation of overburden and to RIM from Areas 1 and 2 under the full and partial excavation alternatives. Detailed design would be conducted during RD to address management of the types and quantities of stormwater that might be generated during construction of the selected remedy. For purposes of preparing cost estimates for the alternatives evaluated in this FFS, it is assumed that precipitation that contacts wastes and/or RIM during regrading, excavation, or waste re-placement and then accumulates in the low point of an excavation or fill would be pumped to a series of storage tanks. Stormwater would be pumped from the tanks to a treatment building, subjected to filtration and liquid phase granular activated carbon (LPGAC) treatment processes, and discharged to the Metropolitan Sewer District (MSD) in accordance with MSD procedures and discharge limitations. Capital and OM&M costs for stormwater collection and on-site treatment are included for each of the alternatives assuming a maximum historical 24-hour rainfall over an anticipated maximum area of exposed waste at any one time of four acres, resulting in an estimated stormwater volume of 608,000 gallons. This value is based on an assumption that the majority of the work area would be covered with tarps or other means to reduce the amount of precipitation which comes into contact with the overburden, waste or RIM. Although the same storm event and exposed area were assumed for all of the alternatives, the estimated OM&M costs vary among the alternatives as a result of differences in the estimated construction schedules (*i.e.*, the estimated duration that areas being excavated might be exposed to precipitation) for each alternative.

- Uncertainties regarding the rates at which cover construction materials could be delivered from off-site sources.

- Uncertainties regarding the actual type of materials to be used for cover construction (*e.g.*, the use of "shot rock" from a nearby quarry was assumed for the materials for the biointrusion layer rather than more uniformly sized large rip-rap).

- For the full and partial excavation alternatives, uncertainties exist regarding: (1) the methods and effectiveness of physically separating the radiological and non-radiological materials during excavation activities; (2) transport relative to the availability and location of a truck/rail transloading facility; (3) the amount of handling of material at a truck/rail transloading facility; (4) which off-site disposal facilities would be able to accept the RIM relative to the available waste capacities and waste acceptance criteria of such facilities at the time of remedy implementation[44]; (5) and the overall validity, duration, and reliability of the verbal quotes received from disposal facility representatives.

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[44] Potential disposal facilities were contacted during preparation of the prior SFS and US Ecology was contacted again during preparation of this FFS with regard to available capacity for municipal solid waste mixed with soil containing radionuclides and their specific Waste Acceptance Criteria (WAC). Every indication is that sufficient capacity currently exists for disposal of the material and that the material should be able to meet the WAC. However, there is no way to ensure that these facilities would still have sufficient capacity for such material or that such materials would meet the WAC that may be in effect in the future when a remedy for OU-1 is implemented.

Bid contingency represents costs, unforeseeable at the time of estimate preparation, which are likely to become known as the remedial action construction or OM&M proceeds. Bid contingency accounts for changes that occur after a construction or OM&M contract is awarded and represents a reserve for quantity overruns, modifications, change orders, or claims during construction or OM&M. Examples include changes due to adverse weather, fuel price fluctuations, material or supply shortages, or new regulations. A bid contingency of 20% was included for all of the alternatives in this FFS, in accordance with the range of bid contingency factors from "A Guide to Developing and Documenting Cost Estimates during the Feasibility Study" (EPA, 2000c).

6.1.7.3 Present Worth and Non-Discounted Constant Dollar Costs

A present worth analysis has been prepared to allow comparison of the estimated costs of each alternative on the basis of a single figure – i.e., a single dollar amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. In accordance with EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988a), a 30-year period of performance was used in the development of the present worth analysis. The use of a 30-year period for the present worth analysis is not intended to imply or otherwise provide a basis to limit future site maintenance and monitoring activities to 30 years. The need for, and scope of, continued monitoring and maintenance both within and beyond 30 years would be subject to ongoing evaluation as part of the 5-year review process for the Site. For some of the alternatives, radioactively-impacted materials would remain on-site and active beyond 30 years, and monitoring and maintenance activities would likely be required beyond the 30-year period used in the cost estimates. Therefore, for the alternatives in which radioactively-impacted materials would remain on-site, OM&M cost estimates and present worth estimates were prepared for 30-year, 200-year, and 1,000-year periods in accordance with the criteria set forth under the NCP and the UMTRCA regulations.

While the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988a) recommends the general use of a 30-year period of analysis for estimating present worth costs during a FS, more recent EPA guidance ("A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000c) (FS Costing Guidance)), recommends that for projects with durations exceeding 30 years, the FS should prepare both a present worth analysis using the project duration and a non-discounted constant dollar cash flow over time scenario. In this FFS, both present worth and non-discounted constant dollar cash flow analyses have been developed for all of the alternatives. It should be noted that the 2000 guidance states that "non-discounted constant dollar costs are presented for comparison purposes only and should not be used in place of present value costs in the Superfund remedy selection process."

EPA policy on the use of discount rates for RI/FS present worth cost analyses is stated in the preamble to the NCP (55 Fed. Reg. 8722) and in the Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-20 entitled “Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis” (EPA, 1993a). Based on the NCP and the OSWER directive, a discount rate of 7% should be used in developing present value cost estimates for remedial action alternatives during the FS (EPA, 2000c). According to the FS Costing Guidance: “This specified rate of 7% represents a ‘real’ discount rate in that it approximates the marginal pretax rate of return on an average investment in the private sector in recent years and has been adjusted to eliminate the effect of expected inflation.” It should be noted that the “recent years” cited in EPA’s 2000 guidance appear to refer to pre-NCP timeframe, which would place this period in the 1970s, or, alternatively, prior to issuance of OSWER Directive 9355.3-20 in 1993. Although OMB Circular A-94 is updated on an annual basis, the 7% discount rate contained in the main portion of the circular is not updated on an annual basis (EPA, 2000c). The 7% discount rate has been in use since the initial Superfund legislation was passed in 1980 and likely does not reflect current pre-tax return on an average private sector investment. Regardless, the 7% discount rate has been used in the calculation of present worth costs for the remedial alternatives for purposes of this FFS.

The FS Costing Guidance states that there may be circumstances in which it would be appropriate to consider the use of a lower or higher discount rate than 7% for the FS present value analysis if an explanation for use of the different rate is provided. The U.S. Securities and Exchange Commission (SEC) has determined that the appropriate discount rate to be applied to an environmental remediation liability should be the rate that would produce an amount at which the environmental liability could be settled in an arms-length transaction with a third party (SEC Codification of Staff Accounting Bulletins Topic 5 Miscellaneous Accounting – Y. Accounting and Disclosures Relating to Loss Contingencies Question 1). The SEC further states that the discount rate used to discount cash payments should not exceed the interest rate on monetary assets that are essentially risk-free and have maturities comparable to that of the environmental liability (SEC Codification of Staff Accounting Bulletins Topic 5 Miscellaneous Accounting – Y. Accounting and Disclosures Relating to Loss Contingencies Question 1). Treasury bills are a primary investment tool that is essentially risk-free. According to the latest (November 2016) Office of Management and Budget (OMB) Circular A-94 Appendix C 30-year, the Real Interest Rates on Treasury Notes and Bonds for a 30-year period is 0.7 percent. This rate has also been applied to the present worth analyses.

6.1.8 State Acceptance

This criterion involves technical and administrative concerns that the state may communicate in its comments concerning the alternatives addressed in an FS. State acceptance will initially be evaluated based on comments provided by MDNR on this FFS. A final evaluation of state acceptance will be performed by EPA as part of any decision process that may be undertaken by EPA after completion of the FFS.

6.1.9 Community Acceptance

Community acceptance will be evaluated by EPA as part of any decision process that may be undertaken by EPA after completion of the FFS.

6.2 Detailed Analysis of Alternatives

This section provides a detailed analysis of the eight potential alternative remedies for the Site: (1) No Action alternative; (2) the ROD-selected remedy (regrading and enhanced capping); (3) an UMTRCA cover alternative; (4) full excavation of RIM with off-site disposal; (5) full excavation of RIM with on-site disposal; (6) partial excavation of RIM with activity levels above 52.9 pCi/g located within 16 feet of the 2005 topographic surface; (7) partial excavation of RIM with activity levels greater than 1,000 pCi/g; and (8) partial excavation of RIM to risk-based levels associated with industrial land use. Each of these alternatives is assessed against the nine NCP evaluation criteria described above.

6.2.1 No Action Alternative

This section presents the description and detailed analysis of the No Action alternative. Under the No Action alternative, no additional engineering measures would be implemented to reduce potential exposures or control potential migration of COPCs from Areas 1 and 2, and no maintenance would be performed to ensure the integrity of the existing measures[45]. However, the Site will continue to be an active industrial facility to which access to the overall landfill property is controlled (including fencing and 24-hour security). Therefore, it is anticipated that the industrial uses currently ongoing at the Site would continue into the future, and that the existing Site perimeter fencing and access controls would remain in effect for the No Action alternative. However, under the No Action Alternative, the existing fencing around Areas 1 and 2 may not be maintained and no additional fencing would be implemented to control land use, access, or potential future exposures to potential receptors at or near Areas 1 and 2.

No additional institutional controls would be imposed under the No Action Alternative beyond those already in place at the Site. Because the existing institutional controls cannot be removed or modified without the approval of the land owner(s), EPA and MDNR, the existing institutional controls are assumed to remain in effect as part of the No Action alternative.

It is also assumed that monitoring would not be conducted under the No Action alternative to identify or evaluate any potential changes that may occur to conditions at Areas 1 and 2 or to contaminant levels or occurrences. As RIM and other wastes would remain on-site, a 5-year review would be performed by EPA as part of the implementation of the No Action alternative.

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[45] Prior actions include installation of the non-combustible cover, fencing and signage on Areas 1 and 2.

Because the No Action alternative does not include any active engineering measures, this alternative is not consistent with the NCP expectation that engineering controls, such as containment, should be used for waste that poses a relatively low long-term threat or where treatment is impracticable. The No Action alternative serves as the baseline for comparison of the effectiveness of the other alternatives and is therefore evaluated in this FFS, as required by the NCP, EPA's SOW for the RI Addendum and FFS (EPA, 2015b), and EPA's RI/FS guidance documents (EPA, 1988a and 1993b).

6.2.1.1 Overall Protection of Human Health and the Environment

Based on the results of the BRA evaluations (Auxier, 2000 and 2017), conditions associated with OU-1 do not currently pose an unacceptable risk to on-site workers or the off-site community. Potential incremental cancer risks to an on-property building user adjacent to Areas 1 and 2 were 8.7×10^{-6} and 1.9×10^{-5}, respectively, and potential risks to an on-property groundskeeper working outside of Areas 1 and 2 were 1.7×10^{-6}. These risks are within EPA's acceptable risk range of 10_{-4} to 10^{-6}. Potential risks to a building user on Lot 2A2, offsite commercial building users, and offsite residents were all less than 1×10^{-6}. Because no receptors other than remediation workers have access to Areas 1 and 2, there are no noncarcinogenic risks to any receptors.

Potential future risks (calculated at 1,000 years but that could occur prior to that timeframe) for a future outdoor storage yard worker or groundskeeper working in Area 1 or 2 or the Buffer Zone, a future off-Site farmer to the north or west of the Site, and a future commercial building user located on Lot 2A2 or located off-site to the north or west exceed EPA's acceptable risk range. The BRA analyses indicated that the potential risks posed to a future (1,000 year) outdoor storage yard worker[46] working in Areas 1 and 2 were 2×10^{-2} and 2.2×10^{-2}, respectively (see BRA Table 57), which are above the generally accepted risk range of 10^{-4} to 10^{-6} used by EPA. The BRA evaluations were dependent on the assumed frequency and duration that potential future on-site workers would be present in Areas 1 and 2 at some point in the future. Potential future risks to groundskeepers working in Areas 1 and 2 or the Buffer Zone were estimated to be 2.3×10^{-3}, 2.5×10^{-3}, and 2.8×10^{-4}, respectively (see BRA Table 57), which are also above EPA's accepted risk range. Potential future (1000 year) risks to a hypothetical farmer located to the north or west of the Site were 4.1×10^{-4} and 2.3×10^{-4}, respectively (see BRA Table 57), which slightly exceeded EPA's accepted risk range. Potential future (1000 year) risks to an off-site commercial building user located to the north, west or on Lot 2A2 were estimated to be 2.0×10^{-4}, 1.1×10^{-4}, and 1.3×10^{-4}, respectively (see BRA Table 57), which are also slightly above EPA's accepted risk range.

[46] The updated Baseline Risk Assessment (Auxier, 2017) concluded that a future outdoor storage yard worker working in Area 1 or Area 2 was the potential receptor with the reasonably-maximum exposure.

Because the surface of Areas 1 and 2 is not currently covered by a landfill cover meeting the requirements of the MDNR solid waste regulations, infiltration into and erosion of these areas poses a potential risk to human health and the environment in the future.

The No Action alternative does not provide for monitoring and enforcement of institutional controls, which are necessary to ensure overall protection. Additionally, this alternative does not provide for monitoring and maintenance of Areas 1 and 2, which would also be necessary to ensure overall protection. Lastly, this alternative does not address all the pathways identified by the RAOs. Therefore, the No Action alternative is not considered to be protective of human health and, absent appropriate response actions, the Site poses an unacceptable risk over the long term.

6.2.1.2 Compliance with ARARs

Chemical-specific ARARs that may potentially be applicable or relevant and appropriate to OU-1 are the UMTRCA radon emission and groundwater protection standards; the radon NESHAP; the NRC standards for protection against radiation; and the Missouri MCLs for radionuclides, VOCs, inorganic chemicals, and other parameters (Tables 3-1 through 3-3). The No Action alternative is expected to meet some, but not all, of these potential chemical-specific ARARs. Overall radon emissions for Areas 1 and 2 were measured and currently are below the UMTRCA standard and radon NESHAP of 20 pCi/m^{2}s (see RI Addendum Section 7.1.1.1). Potential future (1,000 year) radon flux emissions were estimated to be 20 pCi/m^2/sec for Area 1 and 38 pCi/m^2/sec for Area 2 due to projected future increases in radium-226 levels from decay of thorium-230 (see BRA Attachment A). Therefore, it is expected that at some point in the future the radon flux from Areas 1 and 2 will exceed the UMTRCA and NESHAP standard of 20 pCi/m^2/sec. Current air monitoring (Auxier and EMSI, 2015a, 2016b and 2016c and 2017a, 2017b, 2017c, and 2017d) indicate that radon emissions from Areas 1 and 2 currently meet the UMTRCA radon standard that restricts radon at the boundary of a disposal site to 0.5 pCi/L above background. This same air monitoring and health and safety monitoring performed during the Phase 1 and additional characterization investigations conducted in 2013, 2014, and 2015 indicate that the conditions in and around Areas 1 and 2 meet the NRC standards for protection against gamma radiation. Based on the groundwater testing conducted to date, individual groundwater wells have shown some isolated occurrences of chemical or radiological constituents (*e.g.,* benzene and radium) at levels slightly above the UMTRCA groundwater protection standards and the Missouri MCLs. The USGS (2014) concluded that that there are four general hypotheses for the origin of radium in groundwater, and that the available data are not adequate to provide definitive conclusions regarding the validity of any hypotheses. The USGS could not rule out RIM as the origin for radium identified in seven groundwater monitoring wells; however, the USGS did conclude that there is not a strong spatial association of monitoring wells surrounding or downgradient of RIM areas with elevated radium concentrations, as might be expected if RIM areas were releasing substantial quantities of radium to the groundwater. EPA has indicated that additional evaluations of groundwater will be conducted in the future as part of the OU-3 RI/FS. Although conditions associated with Areas 1 and 2 currently meet most of these chemical-specific ARARs (with the exception of a few isolated occurrences of chemical constituents and radium in groundwater), without installation and maintenance of additional engineering controls, continued compliance with these standards cannot be ensured (e.g., future radon fluxes from Areas 1 and 2 are projected to exceed the UMTRCA/NESHAP standard).

The No Action alternative is expected to currently meet all of the location-specific ARARs identified in Section 3.1.2 of this FFS. In the event that the Earth City levee and other flood control measures are not maintained in the future, flooding by the Missouri River could inundate the Earth City Industrial Park and Crossroads Industrial Park, including Lot 2A2. In such event, floodwater could reach the toe of Area 2 and erosion of the materials at the toe of the landfill could potentially occur. Under the No Action alternative, no maintenance or repairs would be performed in the event of erosion of the toe of the landfill.

Because there are no active engineering measures or waste handling, treatment, or disposal activities associated with the No Action alternative, there are no action-specific ARARs for this alternative.

6.2.1.3 Long-Term Effectiveness and Permanence

Without monitoring and maintenance of Areas 1 and 2, the No Action alternative would not be effective in meeting the RAOs. All potential future risks identified in the updated BRA would remain under the No Action alternative. As indicated above, future activities such as outdoor storage activities that may be performed in Areas 1 and 2 could result in potential risk levels to on-site workers above the generally accepted risk range used by EPA for CERCLA actions when taking in to account future increased concentrations of radium-226 from decay of thorium-230. Because the surfaces of Areas 1 and 2 do not currently meet the MDNR cover requirements for inactive solid waste landfills, infiltration into and erosion off of these areas pose an overall potential risk to human health and the environment in the future.

The existing institutional controls cannot be changed without the agreement of EPA and MDNR; however, by their nature, institutional controls are not considered to be permanent. The No Action alternative does not provide the same degree of long-term effectiveness as would be achieved by active engineered measures. The No Action alternative contains no provisions to stabilize or maintain the physical integrity of the disposal units in Areas 1 and 2, and there are no provisions to monitor and maintain existing institutional or access controls. Therefore, the No Action alternative may not be effective over the long-term at reducing risks to potential future receptors.

6.2.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

The No Action alternative does not include any treatment measures and therefore there would be no reduction in contaminant toxicity, mobility, or volume through treatment associated with this alternative. Similarly, no treatment residuals would be generated by this alternative.

6.2.1.5 Short-Term Effectiveness

Because there are no active remediation measures included in the No Action alternative, it does not pose any unacceptable short-term risks or other adverse impacts. Because no remedial action would be taken under the No Action alternative, no short-term risks to the community or to workers from implementation of this action would occur. Similarly, no environmental impact from construction activities would occur.

The RAOs of (1) preventing direct contact with contaminated media (2) preventing exposure by inhalation and external radiation; (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; (5) controlling radon and landfill gas emissions from Areas 1 and 2; and (6) remediating soils on Lot 2A2 to the extent necessary to ensure no unacceptable residential exposures would not be met by the No Action alternative.

6.2.1.6 Implementability

Because no active or passive remedial technologies would be implemented under the No Action alternative, there are no technical implementability concerns or issues associated with the No Action alternative. There are no engineering or administrative impediments to implementation of the No Action alternative for Areas 1 and 2.

6.2.1.7 Costs

Because no active or passive engineering measures or monitoring would be performed, the only costs anticipated to be associated with the No Action alternative are costs associated with performance of 5-year reviews. A periodic (every five years) cost of $36,000 is estimated to perform the activities that would be associated with a 5-year review. The estimated present worth costs under the 7% discount rate scenario for performance of 5-year reviews over periods of 30 years, 200 years, and 1,000 years are estimated to be $83,000, $95,000, and $95,000, respectively. Under the 0.7% discount rate scenario, the 30-, 200-, and 1,000-year present worth costs are estimated to be $193,000, $767,000, and $1,011,000, respectively. The total non-discounted costs for the No Action alternative are estimated to be $216,000 for 30 years,

$1,440,000 for 200 years, and $7,200,000 for 1,000 years. Present worth calculations for the No Action alternative are provided in Appendix K-1.

6.2.2 Regrading and Capping (Modified ROD-Selected Remedy)

As discussed in Section 5.3, the ROD-selected remedy (as modified) consists of the following components:

- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills, including enhancements consistent with the standards for uranium mill tailing sites (*i.e.*, armoring layer and radon barrier), and inclusion of flood protection measures along the toe of Area 2.

- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2.

- Excavation of any soil containing radionuclides above levels that would allow for unrestricted use from the Buffer Zone and/or Lot 2A2 and consolidation of the excavated soil within Areas 1 or 2.

- Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills.

- Design, installation and maintenance of surface water runoff controls.

- Gas monitoring and control, including for radon and decomposition gas, as necessary.

- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides.

- Long-term surveillance and maintenance of the remedy.

The ROD-selected remedy consists of regrading (cutting and filling) the existing landfill materials along with placement of additional soil or clean fill material (as defined in the Missouri solid waste regulations [10 CSR 80-2.010(11)]) over Areas 1 and 2 to adjust the final grades to achieve minimum slope angles of 2% and maximum angles of 25%. Per the ROD, "Prior to construction of the landfill cover, the areas will be brought up to grade using placement of inert fill and regrading of existing material as determined in the RD. Final grades will achieve a minimum slope of two percent. The landfill berm around Area 2 will be regraded through placement of additional clean fill prior to placement of the landfill cover resulting in an estimated 100 lateral feet of additional material between the current landfill toe and the toe at completion of the RA." As indicated in the ROD, Areas 1 and 2 will be brought up to grade using placement of inert fill and regrading of existing material as determined in the RD. However, the ROD also states that the landfill berm around Area 2 will be regraded through placement of additional clean fill prior to placement of the landfill cover resulting in an estimated 100 lateral feet of additional material between the current landfill toe and the toe at completion of the RA.

Placement of additional fill alone to regrade the landfill berm is not feasible. Portions of the landfill berm along the northeast side of Area 2 exceed 25%. Placement of additional fill in this area would require placement of fill up to or very close to the edge of St. Charles Rock Road, which would eliminate the perimeter drainage channel which also serves to provide drainage of runoff from St. Charles Rock Road. Extending the toe of the Area 2 berm to the north 100 feet would also impact use of developed portions of offsite properties in the Crossroads Industrial Park. Therefore, for purposes of this FFS, it has been assumed that a modified ROD remedy would be implemented such that the portions of Areas 1 and 2 that contain slopes greater than 25% would be regraded through relocation of waste material or other measures as determined appropriate during remedial design. Portions of the landfill berm that contain slopes greater than 25% would be regraded through construction of a perimeter "starter" berm, regrading the existing landfill materials, and/or placing additional material to reduce the slope angles to 25% or less. The method used to regrade the perimeter portions of Areas 1 and 2 would be subject to physical constraints associated with the location of the toe of the landfill relative to the property boundary or adjacent Site features (*e.g.*, the solid waste transfer station access road).

Upon completion of the landfill regrading, a new RCRA Subtitle D-equivalent landfill cover would be constructed over Areas 1 and 2 consistent with the MDNR final cover requirements for operating sanitary landfills without composite liners. The final cover system would encompass approximately 24 acres for Area 1 and 51 acres for Area 2. Although not required for a Subtitle D cover, a layer of well-graded rock or concrete/asphaltic-concrete rubble would be installed immediately beneath the clay layer to minimize the potential for biointrusion and erosion, increase the longevity of the landfill cover, and enhance the radon attenuation capability of the cover system. Installation of a rock layer would require the rock to be well-graded and/or to include a filter layer or geotextile between the rock and overlying materials (*e.g.*, clay layer) to prevent loss of fine-grained material from the overlying layer into void spaces in the rock layer. Loss of fines could affect the performance of an overlying clay layer and/or result in voids that could extend through the cap to the ground surface if not otherwise addressed during design and construction. For purposes of this FFS, it is assumed that the biointrusion layer would be constructed using rock material containing a sufficient quantity of finer-grained material to avoid a potential loss of fines and the other effects discussed above. Design of the biointrusion layer and selection of the materials to be used to construct this layer would be performed as part of RD. Surface drainage diversions, controls, and structures would also be designed and constructed on the surface of or adjacent to the landfill cover as necessary to route non-impacted, uncontaminated stormwater (stormwater that has not contacted the underlying waste materials) off of Areas 1 and 2 and onto the adjacent areas of the Site or into off-site storm water drainage systems.

The cover system under the ROD-selected remedy would consist of the following layers (from top to bottom):

- A 1-foot thick layer of soil capable of sustaining vegetative growth;
- A 2-foot thick infiltration layer of compacted, low-permeability clay or silt soil with a permeability coefficient of 1×10^{-5} cm/sec or less; and
- A 2-foot thick biointrusion/marker layer consisting of well-graded rock or concrete/asphaltic concrete rubble consisting of pieces up to 4 inches in size with sufficient gradation to eliminate voids or, alternatively, a geotextile on top to prevent loss of fine particles from the overlying layer.

Sampling would be performed to evaluate the presence and extent of radiologically-impacted soil that may still be present on the Buffer Zone/Crossroads Property. To the extent that soil containing radionuclides at levels greater than those which would allow for unrestricted use are present on these areas, this soil would be removed and placed into Area 1 or 2. Based on sampling performed during the RI prior to subsequent regrading and placement of gravel cover by the adjacent property occupant in these areas, it was estimated that radionuclides may be present on approximately 1.78 acres to a depth of one foot, resulting in approximately 2,900 bank cubic yards (bcy) of potentially impacted soil.

The existing institutional controls on Areas 1 and 2 and the Buffer Zone would be maintained, and any modifications or additions to these that EPA determines are necessary would be implemented as needed as part of the ROD-selected remedy. The institutional controls are necessary to ensure that residential uses do not occur at the Site, and that commercial and industrial uses or ancillary uses that could result in unacceptable risks do not occur on Areas 1 and 2 or the Buffer Zone. In addition to prohibiting land uses that could result in potential exposure to waste materials or contaminants in the Site, institutional controls would also limit or prohibit land uses or activities that could disrupt the integrity, performance or longevity of the new landfill cover or other components of the remedy. Landfill gas and groundwater monitoring, as described in Sections 5.3.1.7 and 5.3.1.10, respectively, are also included as part of the ROD-selected remedy. Finally, the ROD-selected remedy calls for long-term inspections and maintenance activities of the engineered components (Section 5.3.1.10) and enforcement of the institutional controls (Section 5.3.2.1).

6.2.2.1 Overall Protection of Human Health and the Environment

The ROD-selected remedy would protect human health and the environment through the use of engineered containment, long-term surveillance and maintenance, and institutional controls on land and resource use. The landfill cover would reduce potential risks from exposure to external gamma radiation or radon gas emissions, and eliminate potential risks associated with inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, and wind dispersal of fugitive dust.

The cover would prevent users of the Site from exposure to external gamma radiation, primarily through shielding and increasing the distance to the radiation source (*i.e.*, the cover materials would be of sufficient thickness and design to attenuate gamma radiation). For the types of clay soils used for infiltration protection in the construction of final covers, the depth of cover required for gamma radiation shielding is on the order of two feet (60 cm). The total thickness of the final cover required by the ROD-selected remedy would be a minimum of 5 feet (2 feet of biointrusion rock/rubble, 2 feet of clay soil, and 1 foot of vegetative soil). A minimum thickness of 1 foot of clay is necessary to meet the UMTRCA and NESHAP radon flux standard (see Appendix F).

The biointrusion/marker layer would consist of well-graded rock or concrete/asphaltic concrete rubble consisting of pieces up to 4 inches in size with sufficient gradation to eliminate voids or, alternatively, a geotextile on top to prevent loss of fine particles from the overlying layer.

The cover materials would also be of sufficient thickness and design to retard or divert the vertical upward migration of radon. The landfill cover would act as a diffusion barrier, allowing time for the decay of the relatively short-lived radon-222 gas (the half-life for radon-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon needs only to be detained in the cover materials for a few days in order to decay to its non-radiological progeny, thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a gas control system. Calculations presented in Appendix F indicate that the cover system's design, a clay layer thickness of 2 feet, combined with a 2-foot-thick rock/rubble layer and a 1-foot-thick vegetative layer, would provide sufficient radon attenuation to meet the radon emissions ARAR of 20 picocuries per square meter per second (pCi/m^2s). As discussed in Appendix F, these calculations were based on the increased levels of radium expected to be present at the Site after 1,000 years of radium ingrowth from the decay of thorium. A minimum thickness of 1 foot of clay is necessary to meet the UMTRCA and NESHAP radon flux standard after 1,000 years of radium in-growth and will also meet this standard after 9,000 years when peak radium and therefore radon values are projected to occur (see Appendix F).

The potential for direct contact with waste materials would be eliminated by placing a barrier (multi-layer landfill cover including biointrusion layer) between the waste materials and any potential receptors. Likewise, there would be no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place.

The multi-layer cover would also be designed to minimize infiltration of surface water through the wastes, thereby reducing the potential for leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier (e.g., a compacted clay layer meeting the specified permeability requirements). These are all conventional functions for landfill cover technologies and are widely used by government and industry to address similar circumstances where contaminated materials must be encapsulated to protect against future potential contact. Long-term maintenance of the cover and monitoring of the groundwater would ensure that the ROD-selected remedy functions as intended.

The ROD-selected remedy also requires monitoring of groundwater quality to ensure that groundwater quality meets ARARs (see Tables 3-1 through 3-3).[47] Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2 would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls (as described above) would ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions reflect the presence of radionuclides at the Site.

6.2.2.2 Compliance with ARARs

The ROD-selected remedy would comply with all ARARs, as explained below.

6.2.2.2.1 Missouri Solid Waste Rules for Sanitary Landfills

Under RCRA Subtitle D, a state may promulgate more stringent regulations for landfills, provided that EPA approves them. Missouri is an approved state for regulating landfills. Missouri's solid waste regulations became effective July 1, 1997 (see 22 Mo. Reg. 1008, June 2, 1997) (the Solid Waste Rules). The Solid Waste Rules establish closure and post-closure requirements for existing sanitary landfills that are closed after October 9, 1991. Although not applicable to the closure of Areas 1 and 2, the Missouri Solid Waste Rules described below are considered relevant and appropriate. The ROD-selected remedy meets these ARARs.

The Solid Waste Rules require cover to be applied to minimize fire hazards, precipitation infiltration, and odors and blowing litter, as well as to control gas venting and vectors, discourage scavenging, and provide a pleasing appearance (10 CSR 80-3.010(17)(A)). Final cover is to consist of at least two feet of compacted clay with a coefficient of permeability of 1×10^{-5} cm/sec or less, overlaid by at least one foot of soil capable of sustaining vegetative growth (10 CSR 80-3.010(17)(C)(4)). Placement of soil cover addresses the requirements for minimization of fire hazards, odors, blowing litter, control of gas venting, and scavenging. Placement of clay meeting the permeability requirement addresses the requirement for minimizing precipitation infiltration. Placement of soil and establishment of a vegetative cover meet the requirement of providing a pleasing appearance. The final cover would prevent Site users from coming into contact with the waste material.

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[47] After issuance of the ROD in 2008, EPA announced its intention to address groundwater at the Site as part of a separate operable unit (OU-3).

The Solid Waste Rules also contain minimum and maximum slope requirements. Specifically, these regulations require the final slope of the top of the sanitary landfill to have a minimum slope of 5% (10 CSR 80-3.010(17)(B)(7)). MDNR regulations also require that the maximum slopes be less than 25%, unless it has been demonstrated in a detailed slope stability analysis that steeper slopes can be constructed and maintained throughout the entire operational life and post-closure period of the landfill. Even with such a demonstration, no active, intermediate, or final slope may exceed 33.33%.

The objective of these requirements is to promote maximum runoff without excessive erosion and to account for potential differential settlement. Because landfilling of Areas 1 and 2 was completed approximately 30 years ago, most compaction of the refuse has taken place and differential settlement is no longer a significant concern. The 5% minimum sloping requirement is greater than necessary and may not be optimal in this case. Therefore, the 5% minimum sloping requirement is not considered appropriate. Sloping specifications would be designed to promote drainage and reduce infiltration of precipitation while minimizing the potential for erosion. It is anticipated that a 2% slope would be sufficient to meet drainage requirements while resulting in a lower potential for erosion. This approach should increase the life of the cover and overall longevity of the remedy compared to a steeper slope, which would be subject to increased erosion potential. The maximum sloping requirements would be met.

The requirements for decomposition gas monitoring and control in 10 CSR 80-3.010(14) are considered relevant and appropriate (Section 3.1.3.4) and would be met by the ROD-selected remedy. The number and locations of gas monitoring points and the frequency of measurement would be established in RD submittals to be approved by EPA and MDNR. In the event landfill gas is detected at the Site boundaries above the regulatory thresholds, appropriate gas controls would be implemented.

The requirements for a groundwater monitoring program in 10 CSR 80-3.010(11) are considered relevant and appropriate (Section 3.1.3.4). The monitoring program must be capable of monitoring any potential impact of the Site on underlying groundwater. The monitoring program would enable the regulatory agencies to evaluate the need for any additional requirements.

The substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate. These provisions provide a useful framework for OM&M and corrective action plans. They require post-closure plans describing the necessary maintenance and monitoring activities and schedules. These requirements would be used in addition to EPA CERCLA policy and guidance on developing robust OM&M and long-term monitoring plans.

6.2.2.2.2 Environmental Protection Standards for Uranium and Thorium Mill Tailings

The Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subpart A) provide standards for control of residual radioactive materials from inactive uranium processing sites. The standards were developed pursuant to the Uranium Mill Tailings

Radiation Control Act of 1978 (UMTRCA) (42 U.S.C. § 2022 et. seq.,). Although not applicable, some of the regulations that provide for closure performance standards are considered potentially relevant and appropriate to the ROD-selected remedy for OU-1. Specifically, the UMTRCA Standards presented in 40 CFR 192.02 (discussed in Section 3.1.3.1 of this FFS) require that:

> Control of residual radioactive materials and their listed constituents shall be designed[48] to:
>
> (a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,
>
> (b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
>
> > (1) Exceed an average[49] release rate of 20 picocuries per square meter per second, or
> >
> > (2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.
>
> (c) Provide reasonable assurance of conformance with the following groundwater protection provisions […]

40 CFR § 192.02(d) requires that each disposal site "be designed and stabilized in a manner that minimizes the need for future maintenance." For UMTRCA tailings piles, the longevity consideration was initially addressed through placement of a rock armoring layer over the upper surface of the tailings pile capping system (Waugh, 2004, Smith, 1999, Lommler, et al., 1999, Caldwell and Reith, 1994, Caldwell and Shepherd, 1990, Reith and Caldwell, 1990, DOE, 1989, and Caldwell and Truitt, 1987). Later designs have included vegetative layers or rock mulch vegetated layers to control erosion to address the longevity standard (Waugh, 2004, Smith, 1999, Lommler, et al., 1999, Caldwell and Reith, 1994, Caldwell and Shepherd, 1990, Reith and Caldwell, 1990, DOE, 1989, and Caldwell and Truitt, 1987). To address longevity considerations for OU-1 and long-term hazards relating to disruption of the disposal site by natural phenomena within the context of a Subtitle D solid waste landfill cover, the ROD-selected remedy includes a hybridized cover system that incorporates a rock or concrete rubble

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[48] As expressly noted in 40 CFR 192.02, "Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) and (b)."

[49] This average shall apply over the entire surface of the disposal site and over a least a one-year period. Radon will be emitted from both the residual radioactive materials and from the materials covering them. Radon emissions from the covering materials should be estimated as part of the development of a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

layer under the clay soil layer to restrict biointrusion and erosion into the underlying landfilled materials.

Three chemical-specific standards of the UMTRCA regulations are considered potentially relevant and appropriate (although not applicable) to OU-1. Specifically, the radon emission and groundwater protection standards for closed uranium tailing units are potentially relevant and appropriate standards for Areas 1 and 2. The unrestricted use standards for soil on vicinity properties are potentially relevant and appropriate for the evaluation and remediation of any remaining radionuclide occurrences on the Buffer Zone or Crossroads Property. The applicability of these chemical-specific standards to the ROD-selected remedy is discussed further below.

First, Subpart A of the UMTRCA standards provides that control of residual radioactive materials (defined to mean waste in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents) and their listed constituents shall be designed to provide reasonable assurance that the release of radon-222 from residual radioactive materials to the atmosphere will not exceed an average release rate of 20 $pCi/m^2/s$ (40 CFR §192.02 (b)(1)). For inactive sites, this standard can be satisfied by providing reasonable assurance that releases of radon-222 from residual radioactive materials to the atmosphere will not increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half of a picocurie per liter (0.5 pCi/L) (40 CFR § 192.02(b)(2)). As discussed in Section 7.1.1.1 of the RI Addendum (EMSI, 2017a), radon flux measurements performed in 2016, after substantial completion of construction of the non-combustible cover, demonstrate that Areas 1 and 2 currently meet this standard. The ROD-selected remedy would ensure that the radon emission standard promulgated under UMTRCA continues to be met in the future through placement of clean fill material and construction of the landfill cover. The landfill cover system would be designed appropriately to take into consideration future radon generation resulting from increased radium levels due to the decay of thorium over time. Evaluations presented in Appendix F indicate that the landfill cover included in the ROD-selected remedy would provide sufficient radon attenuation to ensure such that future surface emissions from Areas 1 and 2 would meet the UMTRCA radon standard.

Second, the UMTRCA regulations establish concentration limits for groundwater protection (see discussion in Section 3.1.1.1.3). Based on the presence of radioactive materials in OU-1, the groundwater protection standards (40 CFR § 192.02(c)(3) and (4)) and monitoring requirements (40 CFR § 192.03) are relevant and appropriate and would be met. Specifically, regrading of the landfill surface to promote stormwater drainage and installation of an engineered landfill cover under the ROD-selected remedy would greatly reduce the potential for infiltration through, and generation of leachate within, the landfill mass in Areas 1 and 2, thereby reducing the potential for infiltrating precipitation to cause migration of radionuclides from soil to groundwater.

Third, the standards for cleanup of land and buildings contaminated with residual radioactive materials in Subpart B of the UMTRCA regulations are potentially relevant and appropriate requirements for the remediation of any radiologically-impacted soil that may be present outside of Areas 1 and 2 and the Buffer Zone (*e.g.*, on Lot 2A2). UMTRCA defines "land" to mean any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building. These soil standards address the remediation of soil contaminated with radium. Specifically, 40 CFR § 192.12(a) states:

> The concentration of Ra-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than:
>
> 1. 5 pCi/g, averaged over the first 15 centimeters of soil below the surface; and
>
> 2. 15 pCi/g, averaged over 15-centimeter-thick layers of soil more than 15 centimeters below the surface.

The EPA has promulgated guidance on the use of these UMTRCA soil standards for CERCLA site cleanups ("Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites," OSWER Directive 9200.4-25, February 12, 1998 [the UMTRCA Guidance]). This guidance document was discussed in detail in Section 3.1.1.5.1 of this FFS. In brief, the UMTRCA Guidance states that the subsurface concentration criterion (15 pCi/g) is not a health-based standard; rather, it was developed for use in limited circumstances that, for most CERCLA sites, are not considered sufficiently similar to UMTRCA sites to warrant use of the 15 pCi/g standard for subsurface soil (EPA, 1998). EPA also determined that although the UMTRCA soil standards were developed for Ra-226, they are also suitable for Ra-228. EPA further determined that the soil standards should be applied to both the combined level of Ra-226 and Ra-228 and the combined level of Th-230 and Th-232. These UMTRCA soil cleanup standards for vicinity properties, as modified by the UMTRCA Guidance, are considered potentially relevant and appropriate criteria for evaluation and cleanup of radionuclides in soil on the Buffer Zone and Lot 2A2. The ROD-selected remedy would satisfy the UMTRCA soil standards through further investigation of radionuclide occurrences in soil outside of Areas 1 and 2 and through removal of soil that exceeds these standards, including removal of soil on the Buffer Zone and the adjacent Crossroads Lot 2A2 Property and consolidation of such soil in Areas 1 and 2.

6.2.2.2.3 National Emissions Standards for Hazardous Air Pollutants (NESHAPs)

EPA's National Emissions Standards for Hazardous Air Pollutants (NESHAPs) include standards for radon-222 emissions to ambient air from designated uranium mill tailings piles that are no longer operational. As discussed in Section 3.1.1.4.1, the radon-222 NESHAP is considered to be potentially relevant and appropriate. As discussed in Section 7.1.1.1 of the RI Addendum (EMSI, 2017a), radon flux measurements performed in 2016, after substantial completion of construction of the non-combustible cover, demonstrate that Areas 1 and 2 currently meet the NESHAP radon standard. The ROD-selected remedy would ensure the radon emission standard continues to be met, through placement of clean fill material and construction of the landfill cover. Evaluations presented in Appendix F indicate that the landfill cover system included as part of the ROD-selected remedy would provide sufficient radon attenuation to ensure that the radon NESHAP standard is met under both current conditions and in the future (1,000 years), accounting for future radon generation resulting from increased radium levels owing to the decay of thorium over time. As described in Tables 3-1 through 3-3, this ARAR would require performance of radon flux measurement tests upon completion of construction of the engineered cover to demonstrate that the landfill cover achieves the radon emission standard. Such measurements would be performed in accordance with the procedures set forth in 40 CFR Part 61 Appendix B Method 115, or other procedures with prior EPA approval. Additional evaluations to demonstrate the ability of the landfill cover to meet the radon NESHAP may be performed as part of the remedial design.

6.2.2.2.4 Safe Drinking Water Act

40 CFR Part 141 (in particular, sections 141.50-51, 55, 60-62), establishes primary drinking water regulations, including MCLs pursuant to Section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (SDWA), and related regulations applicable to public water systems. These MCLs apply to public drinking water systems. Missouri regulations (10 CSR 60-4.010 et seq.) also establish MCLs for public drinking water systems (Table 3-1). Consistent with the NCP, MCLs and non-zero Maximum Contaminant Level Goals (MCLGs) are considered potentially relevant and appropriate to all potentially usable groundwater. Regardless of whether groundwater beneath the Site is subsequently determined to be usable for drinking water, regrading of the landfill surface to promote stormwater drainage and installation of an engineered landfill cover under the ROD-selected remedy would greatly reduce the potential for infiltration through, and generation of leachate within, the landfill mass in Areas 1 and 2, thereby reducing the potential for infiltrating precipitation to cause the migration of radionuclides to groundwater.

6.2.2.2.5 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against Ionizing Radiation (10 CFR Part 20) contain chemical-specific standards that address radiation protection. These regulations establish dose limits for individual members of the public and for radiation workers and define maximum permissible exposure limits for specific radionuclides in air at levels above background inside and outside of controlled areas. These requirements are considered potentially applicable during implementation of any remedial action. Specifically, to meet these regulations, perimeter air monitoring would be conducted during remedy implementation. Site health and safety plans would address worker protection consistent with these requirements (including perimeter air monitoring); therefore, the ROD-selected remedy would meet this ARAR.

6.2.2.2.6 Missouri Well Construction Code

MDNR has promulgated regulations pertaining to the location and construction of water wells. The Well Construction Code (10 CSR 23-3.010) prohibits the placement of a well within 300 feet of a landfill. These rules should provide protection against the placement of wells on or near the Site. The regulations on monitoring well construction (10 CSR 23-4) would apply to the construction of new or replacement monitoring wells. The ROD-selected remedy would meet this ARAR through enforcement of the existing institutional controls[50] and by adhering to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

6.2.2.2.7 Missouri Storm Water Regulations

The Missouri regulations governing storm water management at construction sites are set out in 10 CSR 20-6.200 (Table 3-3). A disturbance of greater than one acre or the creation of a storm water point source during construction of the remedy would trigger these requirements. The ROD-selected remedy would meet these requirements through implementation of a Stormwater Pollution Prevention Plan (SWPPP), use of Best Management Practices (BMPs) during construction, installation and maintenance of an engineered landfill cover to prevent stormwater from contacting the waste materials, and construction and maintenance of stormwater diversion and control structures to control runon and runoff and reduce erosion potential as part of the design of the engineered landfill cover.

6.2.2.3 Long-Term Effectiveness and Permanence

These criteria refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. The ROD-selected remedy provides engineered containment in conjunction with monitoring, maintenance, and land use controls designed to be effective over the long term. Because RIM would remain on-site under this remedy alternative, potential risks associated with the RIM would remain. Construction of an engineered cover for Areas 1 and 2 would reduce the potential for exposure from the following potential pathways: external gamma exposure; inhalation of radon gas or dust containing radionuclides or other constituents; dermal contact with impacted materials; and incidental ingestion of soil containing radionuclides or other chemicals. Maintaining the integrity of the engineered cover would protect the underlying RIM from erosion and intrusion. An intact cover provides a reliable method to control exposure of the RIM to surface receptors and mitigates potential migration of radionuclides or chemicals from the covered waste materials.

The conceptual design of the engineered cover included in the ROD-selected remedy was a hybrid cap that was developed based on EPA's Presumptive Remedy Guidance for CERCLA Municipal Landfill Sites to meet the Subtitle D landfill cover and closure requirements with additional components to address some aspects of the UMTRCA standards. The cover design will be required to last at least 200 years with minimal maintenance required. Specifically, the engineered cover included in the OU-1 ROD-selected remedy was evaluated for its protectiveness against gamma radiation and radon emissions in terms of both risks to workers

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[50] In addition, the deed restrictions currently in place on Areas 1 and 2 and the Buffer Zone (and which are to be maintained in perpetuity as part of the ROD-selected remedy) prohibit the placement of water wells for drinking water or agricultural purposes.

and the public and compliance with ARARs (*e.g.*, UMTRCA and NESHAP standards). These evaluations were performed based on the 95% UCL for the current levels of radium-226 in Areas 1 and 2 and the projected increase in radium-226 levels that will occur in the future (1,000 years) due to in-growth of radium-226 from decay of thorium-230. The engineered cover included in the OU-1 ROD-selected remedy was determined to be protective and compliant with the ARARs both under existing and future (1,000 year) conditions (Appendix F and Tables 3-1 through 3-3). Peak radium values are projected to occur in 9,000 years and the design of the engineered cover included in the ROD-selected remedy was determined to be protective and compliant with ARARs based on the projected peak radium-226 levels that would occur in approximately 9,000 years (Appendix F).

Due to the long-time frames a containment system would need to remain in place and effective at limiting exposures to and migration of radionuclides, there are uncertainties associated with the long-term permanence of the ROD-selected remedy (or any remedy that entails containment). A potential exists for additional consolidation and settlement of the waste materials over time that could affect the structural integrity of the landfill cover which could require repair, or potentially replacement of all or portions of the landfill cover in the future. Such effects would be easily identified by visual inspection or comparison of successive aerial topographic surveys, such that repairs could be implemented before any waste materials were exposed or any contaminants were released; however, if such repairs are not performed in a timely manner, a potential for release could occur. The area with a 0.2% flood recurrence interval (i.e., the 500-year floodplain) is located adjacent to Area 2 and extends along St. Charles Rock Road to the east side of Area 1. The 500-year floodplain in the vicinity of the Site is protected from flooding through a combination of an engineered levee and stormwater management system operated by the Earth City Flood Control District to protect the commercial real estate in the Earth City Industrial Park. Although largely based on passive physical components (e.g., levee and stormwater collected basins), the Earth City flood control system does require operation of pumps to reduce pore water pressures within the levee system and gates to prevent backflow of flow water from the Missouri River into the Earth City stormwater channels and basins. Consequently, although the Site is not located within the area of the 500-year floodplain protected by levees, the proximity of the Site to the margins of the 500-year floodplain that is protected by levees, the reliance on external controls such as the Earth City levee and flood control system to prevent flooding from reaching the toe of the landfill, and location of the Site within the geomorphic floodplain raise uncertainty regarding the potential for future flooding and related impacts to the integrity of the containment system. This uncertainty would be addressed through design considerations (e.g., use of a thick starter berm to provide isolation of the waste materials from floodwaters, inclusion of rock armoring at the base of the starter berms/landfill toe, etc.) and performance of inspections and monitoring and implementation of any required maintenance, repairs or replacement of containment features.

Robust and durable long-term site management plans and institutional controls would be required to address such uncertainties. Long-term groundwater monitoring under the ROD-selected remedy would require monitoring plans that specify the monitoring locations, sampling frequencies, parameters, sampling and analysis procedures, and evaluation approach. Such plans would be developed and submitted as part of the O&M Plan in the RD/RA process. The monitoring program may be optimized with time based on the monitoring results, e.g., monitoring locations or the list of analytes may be adjusted to increase effectiveness or efficiency. Monitoring plans and groundwater protection standards would need to be consistent with the requirements found in the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subparts A and B) and the Missouri Solid Waste Rules for Sanitary Landfills [10 CSR 80-3.010 (11)]. The groundwater monitoring program is expected to be effective in verifying the remedy is performing as required and groundwater is protected.

Existing institutional controls cannot be removed or modified without the consent of EPA, MDNR, and the property owners. Revision of the institutional controls to be consistent with the Missouri Environmental Covenants Act would further prevent complications that could otherwise arise during future property transfer actions. While not anticipated, even with the loss of institutional controls and long-term management, the landfill cover would still act to passively prevent potential contaminant migration and human exposures for an indefinite period.

By moving the radiologically-impacted soil from the Buffer Zone/Lot 2A2 to the Site (and thereby subjecting it to the remedial measures and controls described above), the ROD-selected remedy also provides long-term effectiveness and permanence relative to the Buffer Zone/Crossroads Lot 2A2 Property.

6.2.2.3.1 Magnitude of Residual Risks

The calculated lifetime risks to the reasonably maximally-exposed individual (an on-site storage yard worker) in Areas 1 and 2 after the ROD-selected remedy has been implemented (Appendix H) are as follows:

- Area 1: 5.1×10^{-7} for year 1, 6.9×10^{-7} for year 1,000, and $1.5 \text{ x } 10^{-6}$ for year 9,000; and
- Area 2: 7.1×10^{-7} for year 1, 1.2×10^{-6} for year 1,000, and $2.9 \text{ x } 10^{-6}$ for year 9,000.

These calculated risks are attributable to gamma radiation and radon emissions from the RIM that would remain at the Site after implementation of the ROD-selected containment remedy. Given that the RIM would be capped and thus rendered inaccessible, along with the use of access restrictions and institutional controls, direct contact with RIM and exposure from ingestion, inhalation, or dermal contact with the waste materials would not be expected to occur. Ingestion, inhalation, or dermal contact are the primary exposure pathways for any non-radiological COPCs that may also be present in Areas 1 and 2. Because no complete exposure pathway would exist for such materials after completion of the cap construction, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks from non-radiological COPCs.

The calculated risk levels are below or within EPA's target risk range of 1×10^{-6} to 1×10^{-4}, and therefore the magnitude of the radiological carcinogenic risk from capped RIM in these two remediated areas is acceptable. These risks do not specifically include potential exposures from non-radiological landfill waste after construction is complete. However, those wastes would also be covered by a cap which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

After soils containing radionuclide concentrations above the cleanup levels are removed from the Buffer Zone/ Lot 2A2, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.2.3.2 Adequacy and Reliability of Controls

The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. The engineered cover included in the OU-1 ROD-selected remedy was determined to be protective and compliant with the ARARs both under existing and future (1,000 year) conditions (Appendix F). Peak radium values are projected to occur in 9,000 years, and the design of the engineered cover included in the ROD-selected remedy was also determined to be protective and compliant with ARARs based on the projected peak radium-226 levels that would occur in approximately 9,000 years (Appendix F).

In addition to being designed to be protective and compliant with ARARs based on the projected in-growth of radium over the next 1,000 years, the cover construction is based on and relies upon the use of natural materials that would be expected to remain in place and meet performance criteria for at least 200 years, as required by the UMTRCA longevity standard in 40 CFR 192.02 (a). Post-closure inspection and maintenance of the cover, as required by the solid waste regulation ARARs and as routinely performed at thousands of landfills across the country, also would ensure long-term reliability of the landfill cover.

Currently the surfaces of Areas 1 and 2 are not graded to promote drainage of stormwater, but instead are generally flat with several surface depressions which act to increase precipitation accumulation and infiltration through the waste mass. In addition, no engineered landfill cover exists over these areas. Although the non-combustible cover installed over portions of Areas 1 and 2 in 2016 was intended to serve as a short-term measure to prevent potential risks from a surface fire, it does serve to reduce the potential for erosion of the waste and soil, reduce radon emissions and gamma radiation, and prevent direct contact with the waste and RIM, even though it was not primarily intended or designed for these purposes. The non-combustible cover was placed on the existing grades, and therefore does not promote stormwater drainage or reduce the potential for infiltration of precipitation. Regrading to promote drainage and installation of the engineered landfill cover included in the ROD-selected remedy would significantly reduce infiltration of precipitation and the potential for leaching, providing further protection against potential impacts to groundwater.

Long-term OM&M would include routine cover and storm water ditch inspection and service, if necessary, to mitigate erosion and, if a landfill gas collection and treatment system is needed, OM&M of such a system. Long-term monitoring would also be implemented to assess compliance with groundwater standards. The performance of these engineering controls would also be re-evaluated during statutory 5-year reviews.

Covenant restrictions (Appendix A) have been recorded by each of the West Lake Landfill property owners against their respective parcels and the entire West Lake Landfill (including Areas 1 and 2, as well as the Buffer Zone) prohibiting residential use (including use as a day care, preschool, or other educational use) and use of groundwater for drinking water. With respect to Areas 1 and 2 and the Buffer Zone, restated and amended restrictive covenants filed in 2016 (Appendix A) also prohibit (1) the installation and use of wells for drinking water; (2) the construction of buildings or other habitable structures for any purpose; (3) the construction of underground pipes/utilities and excavation work (except in conjunction with approved remedial activities); and (4) use of the property for commercial or industrial purposes, including as a storage yard (whether indoor or outdoor).[51] Covenant restrictions cannot be terminated without the written approval of the parcel owners, MDNR, and EPA. It is assumed that the restrictions would be revised as necessary during RD to address the requirements set forth under the Missouri Environmental Covenants Act.

The current covenants and restrictions for Areas 1 and 2 and the Buffer Zone would be adequate to provide protection to human health under the ROD-selected remedy. Permanence of these restrictions is assumed to be adequate for the foreseeable future, as both EPA and MDNR approval are required to remove or modify the restrictions. The adequacy of the restrictions would be continually evaluated during the statutorily-required 5-year reviews.

6.2.2.3.3 Climate Change and Potential Impacts of a Tornado

Per EPA's SOW, the FFS is to include a discussion of climate change and vulnerabilities associated with extreme weather events—such as possible flooding or tornadoes—as part of the evaluation of long-term effectiveness. This evaluation should consider any system vulnerabilities to potential climate change in accordance with EPA's "Climate Change Adaptation Technical Fact Sheet: Landfills and Containment as an Element of Site Remediation" (EPA, 2014a) and the EPA Region 7 Climate Change Adaption Implementation Plan (EPA, 2014b). EPA also required the FFS to include information and results from the "Evaluation of Possible Effects of a Tornado on the Integrity of the ROD-Selected Remedy" (EMSI, 2013f).

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[51] Construction work and commercial and industrial uses were also previously precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc. in January 1998. This Declaration prohibited the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation on the property. The 2016 Declaration of Covenants amends and restates the requirements of the May 1997 and January 1998 covenants, but does not otherwise alter them.

The ROD-selected remedy includes an engineered landfill cover that would be classified as in-situ containment system (EPA, 2014a). Climate change adaptation for a containment system focuses on evaluating the vulnerability of the system to climate change and implementing adaptation measures, when warranted, to ensure the remedy continues to prevent human or environmental exposure to contaminants of concern (EPA, 2014a).

Evaluation of the vulnerability of a containment system to climate change may involve:

- Identifying climate change hazards of concern;
- Characterizing the system's exposure to those hazards of concern;
- Characterizing the system's sensitivity to the hazards of concern; and
- Considering factors that may exacerbate system exposure and sensitivity.

A climate change exposure assessment identifies climate change hazards of concern for a remediation system in light of a range of potential climate and weather scenarios (EPA, 2014a). EPA identified the following potential climate change impacts for landfills and containment remedies:

- Increased occurrence of extreme temperatures;
- Sustained changes in average temperatures;
- Decreased precipitation and increasing drought;
- Increased heavy precipitation events;
- Increased flood risk; and
- Increased intensity of tornadoes.

EPA indicated that precipitation changes that could degrade cover systems is a specific climate change hazard relative to landfills and containment systems.

A climate change sensitivity assessment evaluates the likelihood for the climate change hazards of concern to reduce the effectiveness of a landfill/containment system. Damage to cover materials and a potential washout of contaminated contents, as well as unexpected and additional costs for repairing or replacing a cover system, are particular concerns for a landfill containment system. Specific containment system components included in the ROD-selected remedy that could be affected by climate change include:

- Physical and water damage to the vegetative layer overlying the low-permeability cover layer;
- Physical or water damage and reduced access to surface water drainage systems and structures; and
- Physical damage or reduced access to groundwater and landfill gas monitoring wells.

In particular, the vegetative layer could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and increases in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potentially increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence.

The low-permeability cover layer could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low permeability material (CCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Such impacts are not considered to be significant because the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. In addition, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards and are projected to remain below these standards in the future (see prior discussion in Section 2.3.1 and also in RI Addendum Section 7.1.1.1). Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality or radon emissions are not expected to be significant. More importantly, the vegetative layer would show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL. Therefore, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities such as temporary irrigation to maintain the grass cover, overseeding with grasses that required less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Further, such impacts are not expected to result in release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying low-permeability layer. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot thick rock layer in the base of the cover system, stormwater erosion—even under the most severe storm event—is not anticipated to result in erosion down through the entire landfill cover. Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in the implementation of repairs (if needed). Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. However, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair, and replacement of cover material in response to any damage that may occur.

The ROD-selected remedy is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, based on FEMA's flood insurance rate map (FIRM) the extent of the 500-year flood does not include areas where waste materials are present in Areas 1 and 2. The Buffer Zone and Lot 2A2 portions of the Site and off-site areas to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River are protected by the engineered levee and the stormwater and flood control systems installed to protect the Earth City Industrial Park. In the event of a failure of the Earth City levee and flood control system, floodwaters associated with a 500-year recurrence interval flood could extend to the toe of Area 2. The conceptual design for the modified ROD-selected remedy evaluated in this FFS includes the construction of a perimeter (starter) berm along the toe of the entire northern boundary of Area 2 that would result in placement of approximately 26 feet of rock and soil between any possible floodwaters and the landfilled waste. This perimeter berm may be further protected from flooding by placement of rip-rap along the base of the berm. Therefore, although increased occurrences of flooding in the area of the Site may be a potential impact of climate change, the ROD-selected remedy is not expected to be vulnerable to flooding.

An evaluation of the potential impacts of a tornado on the ROD-selected remedy was previously performed and submitted to EPA (EMSI, 2013f). This evaluation concluded that the ROD-selected remedy was not vulnerable to impacts from a tornado. Specifically, based on review of the impacts of tornados at other sites, a tornado is not expected to damage the vegetative layer. No published information regarding the potential impact of a tornado on grass or other vegetative cover was identified in conjunction with the review of published literature for this assessment. Review of published assessments and photographs of impacts associated with other tornadoes (EMSI, 2013e), such as the 2011 Joplin Missouri tornado, the April 22, 2011 "Good Friday" tornado in St. Louis, the April 2011 tornadoes in the southeastern U.S., (FEMA, 2012, 2010, 2007a, and 1999; FOXNews, 2012; Glass, undated; McCarthy, Ruthi and Hutton, 2007; Marshall et al., 2008; NOAA-NWS, 2013, 2012, 2011a, 2011c and 2003; The Weather Channel, 2012d; and UPI, undated) and the St. Charles and Calvert Counties, MD 2003 tornado (Gailey, 2002) did not identify any damage or identifiable impacts to grassy areas. Even if a tornado were to impact the vegetative cover, such an impact is not considered to be significant because it could be easily identified and repaired. Furthermore, due to the design and thickness of the engineered cover, any impacts from a tornado are not expected to result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy above-ground infrastructure such as signage, fencing or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the ROD-selected remedy is not considered to be vulnerable to impacts from a tornado.

Although the ROD-selected remedy is not considered to be vulnerable to climate change, implementation of adaptation measures could nevertheless be considered during remedial design.

Several aspects of the conceptual design of the ROD-selected remedy already provide a degree of adaptation for climate change. For example, the ROD-selected remedy includes regrading of the surface of Areas 1 and 2 to a 2% slope, which would reduce the velocity of runoff across these areas as compared to a 5% slope. Installation of runoff collection and diversion systems along the base of the above-grade portion of the North Quarry portion of the Bridgeton Landfill adjacent to Area 1, as well as along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2, would divert runoff from these areas around Areas 1 and 2 to reduce the potential for impacts from heavy precipitation events. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls in order to increase the overall resilience of these features to heavy precipitation events. For example, use of grass-seed mixtures that are more tolerant of long-term changes in precipitation or temperature, and/or additional soil to increase water storage capacity, could be evaluated as part of the design. Similarly, inclusion of geotextile at the base of the vegetative layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low-permeability layer of the cap. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures can be included as part of the ongoing inspection and maintenance program.

6.2.2.3.4 Potential Impacts of a Subsurface Heating Event

Per EPA's SOW, this section presents a discussion of the potential impacts if a subsurface heating event were to migrate to or occur within OU-1.

In December 2010, Bridgeton Landfill, LLC detected elevated temperatures and carbon monoxide levels in the landfill gas extraction system (Bridgeton Landfill, LLC, 2013). Further investigation indicated that the South Quarry portion of the Bridgeton Landfill (which is located within OU-2) was experiencing an exothermic (heat-generating) subsurface reaction or event (Bridgeton Landfill, LLC, 2013). A discussion of this subsurface reaction (SSR)[52] is included in Section 5.7 of the RI Addendum (EMSI, 2017a). An overview of the current state of the reaction (e.g., temperature values and settlement amounts) is presented in Appendix N-1. An overview of the state of technical understanding of elevated temperature landfills is presented in Appendix N-2.

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[52] This reaction has previously been called a "subsurface smoldering event" (SSE) or, by some, a fire but more recently has been identified as a "subsurface reaction" or SSR. Accordingly, current references are to a "subsurface reaction," or SSR, rather than using the prior SSE terminology. An SSR is defined as a subsurface, exothermic, self-sustaining chemical reaction. Unlike a fire, the SSR has not produced visible smoke or flames. Where an underlying document referenced in this FFS uses the term SSE, the term SSE is used (rather than SSR) for consistency with the referenced document.

The discussions in this subsection describe the various evaluations that have been performed to assess the potential impacts in the event that a subsurface heating event were to occur in Areas 1 and 2. These evaluations have primarily focused on the potential for release or increased migration of radionuclides in response to elevated temperatures. An overall summary of the potential effects, including those related to radionuclide migration, along with a discussion of the mitigative measures that have been implemented to control the existing reaction in the South Quarry portion of the Bridgeton Landfill or that could be used to respond to elevated temperatures if such were to occur within the North Quarry portion of the Bridgeton Landfill, is presented at the end of this section.

As described further below, due to the physical conditions of the Site and Areas 1 and 2, and the implementation of measures to control the effects and migration of the existing reaction in the South Quarry, the potential for a reaction to occur within or extend into Areas 1 and 2 is considered to be quite low. Furthermore, if elevated temperatures were to occur in the area between the South Quarry and Area 1 (i.e., within the North Quarry), timely response actions would be taken pursuant to existing regulatory orders and approved work plans that would mitigate any effects of such occurrences.

<u>2014 Qualitative Evaluation of Potential Impacts from an SSE</u>

A qualitative assessment of the potential impacts of a subsurface heating event on the occurrences of RIM in Areas 1 and 2 and potential impacts on the ROD-selected remedy was previously prepared, submitted to EPA, and revised in response to EPA comments (EMSI, 2014e) (the SSE Impact Study). In a March 28, 2014 memorandum to EPA Region 7 (EPA, 2014), EPA's Office of Research and Development (ORD) provided comments on that evaluation.

Based on consideration of the conditions and processes known to be associated with subsurface heating events at landfills and the remedy selected by EPA in the 2008 ROD, several conclusions were reached in the SSE Impact Study[53] as part of the initial qualitative evaluation (EMSI, 2014e). Those conclusions, and EPA's observations and comments on those conclusions, are as follows:

- The RIM disposed of in West Lake Areas 1 and 2 would not become more or less radioactive in the presence of heat. Likewise, the RIM is not explosive and would not become explosive in the presence of heat. EPA agreed with these conclusions (EPA, 2014).

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[53] As noted in the SSE Impact Study, subsurface heating events are described in the literature using many terms, including subsurface fire, smoldering fire, slow pyrolysis, glowing combustion, subsurface oxidation, and subsurface reaction. For purposes of the SSE Impact Study, a "subsurface heating event" was considered to include any and all of these differing heating events.

- An SSE does not create conditions that could carry RIM particles or dust off-site. The heat of an SSE is not high enough to ignite non-RIM wastes or chemical compounds or to cause them to explode. EPA (EPA, 2014) agreed with the second part of this conclusion, but indicated that heating could affect the structural integrity of the cap, resulting in permeation of the cap and possibly in the creation of fissures that could extend down into the waste materials and could possibly allow for escape of fine particulates.

- An increase in subsurface temperatures may allow radon gas to more easily rise through the ground and reach the surface of the landfill than would otherwise occur, because heat reduces the amount of moisture in the buried solid waste (trash), thereby increasing the amount of air between the soil particles and thus limiting the ability of the buried solid waste to retain radon below-ground. Any radon gas that does make it to the surface would dissipate quickly in open air. This potential increase in the rate of release of radon gas at the surface of the landfill would be limited to the area of the SSE and would cease when the SSE ends. EPA also identified the potential for increased radon gas emissions as a possible effect of increased temperature.

- The SSE Impact Study concluded that, in the unlikely event that increased subsurface temperatures were to occur in West Lake Area 1 or 2, such an event would create no long-term additional risks to people or the environment. EPA (EPA, 2014) disagreed with this conclusion, based on the potential for increased radon emissions and potential for increased leachate production. Any short-term risks would be associated with the temporary increase in radon gas coming from the surface of Areas 1 and 2 if no cap is installed, or if the cap called for by the 2008 ROD was not properly maintained. EPA (EPA, 2014) also identified the potential for increased radon emissions and potential for increased leachate production as possible short-term impacts.

- These short-term risks can be addressed by designing, building, and maintaining the landfill cap called for by the 2008 ROD, and by maintaining the land use restrictions already in place on the entire Site, which prevent certain land uses. EPA (EPA, 2014) concluded that short-term risks may be present even with proper cap design.

- The SSE Impact Study concluded that there are no additional ARARs associated with an SSE. EPA concurred with this conclusion. (EPA, 2014)

<u>Evaluations Performed in Conjunction with the 2015 Isolation Barrier Alternatives Assessment</u>

The potential for increased release of radionuclides—including via radon and fugitive dust—were further considered as part of the Isolation Barrier Alternatives Analysis (IBAA) (EMSI, et al., 2014) and as part of the responses to EPA and MDNR comments on this analysis (EMSI, 2015a), both of which were prepared for Bridgeton Landfill, LLC. EPA has not provided final comments on or approval of the IBAA or the associated responses to EPA and MDNR comments. Finally, quantitative calculations and modeling of potential radon and fugitive dust emissions performed on behalf of Bridgeton Landfill, LLC were completed in 2016 as part of additional evaluations of a potential isolation barrier (Auxier and EMSI, 2016d and 2016e). EPA has not yet provided comments on or approval of these evaluations.

As part of the IBAA, the projected increase in radon emissions if a heating event were to enter Area 1, or in the unlikely event that an independent heating event were to otherwise occur in Area 1, were estimated based on examination of three potential conditions associated with radon emissions under elevated temperatures and occurrence of a subsurface heating event in Area 1:

- Initial thermal expansion of landfill gas due to increased temperature as a hypothetical heating event approaches and enters into Area 1, resulting in exhalation (emission at the ground surface) of the incremental increase in the volume of landfill/soil gas due to expansion of the gas volume in response to an increase in subsurface temperature;

- Subsequent increase in radon emissions due to increased soil gas permeability resulting from vaporization of soil moisture in response to increased temperature; and

- Subsequent destruction (pyrolysis) of a portion of the waste mass and associated loss of pore space, resulting in further displacement and resultant emission of an additional portion of the landfill/soil gas.

Results of these calculations indicated that even if these conditions were to occur without any enhancement to existing soil cover over Area 1, the radon emission rate from Area 1 would still be less than the standard established by the radon NESHAP, and if such a release were to occur, risks at or beyond the fenceline would be below the acceptable risk levels established by EPA. As noted above, EPA has not yet provided comments on or approval of these evaluations.

<u>2016 Supplemental Evaluation of Radon Flux</u>

Additional evaluations performed in 2016 on behalf of Bridgeton Landfill, LLC and Rock Road Industries, Inc. further examined potential increases in radon emissions in the event that a heating event were to occur in the southern portion of Area 1, outside of a potential isolation barrier (Auxier and EMSI, 2016d) (the Supplemental Radon Flux Analysis). The Supplemental Radon Flux Analysis evaluated potential radionuclide emissions—primarily radon—if an SSR were to reach isolated RIM deposits on the south side of a hypothetical isolation barrier in the southern portion of Area 1. Specifically, evaluations were performed on potential radon-222 emissions from three sources: (1) Area 1 during a hypothetical, progressive SSR crossing the study area; (2) a postulated release of radon-222 gas by way of a hypothetical event, such as a cover surface crack that exposes a portion of deep RIM after the occurrence of an SSR; and (3) a hypothetical release of RIM-derived soil gas to the landfill gas collection and flare system. In each of these hypothetical situations, the performed calculations estimated the expected surface radon flux generated by diffusion from the RIM combined with advective flux produced by thermal and physical changes associated with the passage of the postulated SSR.

The Supplemental Radon Flux Analysis concluded that largest single contributor to radon emissions under the conditions assumed in the assessment is the area source[54] used to represent Area 1 during a theoretical SSR passing through the area (without enhancements to the cover), followed by radon emitted from the flare stack. The calculated flux emissions were compared to permissible radon flux levels for radium storage and disposal facilities set forth at 40 CFR § 61.192. The Supplemental Radon Flux Analysis concluded that the area weighted average radon flux in Area 1 is less than the radon flux standard of 20 pCi/m^2s.

The Supplemental Radon Flux Analysis also assessed potential risks to receptors beyond the Site fenceline under modeled conditions.[55] In particular, concentrations of radon-222 gas and its progeny were projected in air at four locations: the closest occupied structure, the closest boundary fence (along St. Charles Rock Road), and at the two closest communities (Spanish Village and the Terrisan Reste mobile home community). The highest combined radon concentration at the Area 1 fenceline from all sources—0.013 pCi/L—was projected to occur at the fenceline next to the Bridgeton Landfill office. This is less than the limit of no more than 0.5 pCi/L increase in radon air concentration above background established in 40 CFR § 192.02(b)(2).

Potential risks to one of three different receptor types were evaluated at each of these locations of interest: indoor workers at the Bridgeton Landfill office building, outdoor workers at the closest boundary fence, and residential receptors at the two closest communities. The highest theoretical risk identified in the Supplemental Radon Flux Analysis—2×10^{-6}—was calculated to occur to EPA's default indoor worker inside the closest occupied structure. This theoretical risk is well within EPA's acceptable risk range of 1×10^{-4} to 1×10^{-6} for CERCLA sites. Risks to off-site residential communities were all projected to be below 1×10^{-7}, which is below EPA's acceptable risk range. EPA has not yet provided comments on or approval of these evaluations.

2016 Supplemental Evaluation of Potential Particulate Emissions

The potential for release of particulate matter containing radionuclides was also evaluated in a second report submitted on behalf of Bridgeton Landfill, LLC and Rock Road Industries, Inc. in 2016 (Auxier and EMSI, 2016e) (the Final Particulate Emission Analysis). The purpose of the Final Particulate Emission Analysis was to estimate hypothetical risks to potential receptors if particulates from deeply buried RIM on the south side of an assumed isolation barrier in Area 1 were to somehow be brought to the surface and become airborne. Few viable mechanisms could actually cause such an occurrence on a large scale; however, a review of non-routine practices or events was conducted to determine whether any could actually produce an event where particulates from deep RIM could be released. Based on this review, the Final Particulate

[54] The Supplemental Radon Flux Analysis defined the term "area source" as the size of the area affected by a heating event at any given point in time.

[55] Potential risks were calculated by entering calculated concentrations of radon progeny into EPA's Preliminary Remediation Goals for Radionuclides (PRG) calculator, which is a web-based tool developed by EPA pursuant to the Risk Assessment Guidance (RAGS) guidance.

Emission Analysis postulated that a theoretical subsurface drilling event in Area 1 south of a proposed isolation barrier brought a mixture of landfill waste and subsurface soil to the surface, where it was then deposited on the ground surface around the drilled hole. If this material were to be left unattended, dry particulates within it could become suspended via wind erosion and carried to off-site locations.[56]

Based on the calculated results, the Final Particulate Emission Analysis concluded that even with conservative (worst-case) assumptions, the highest risk identified in the study—2×10^{-6}—was calculated to occur to EPA's default indoor worker inside the closest occupied structure. This calculated risk is within EPA's acceptable risk range of 1×10^{-4} to 1×10^{-6} for CERCLA sites. Further, risks to off-site receptors at the closest boundary fence and at the two closest communities produced risks below 1×10^{-7}, far below EPA's acceptable risk range of 10^{-4} to 10^{-6}. EPA has not yet provided comments on or approval of these evaluations.

<u>2017 FFS Evaluations (Appendix E)</u>

Additional evaluations of the potential radon emissions in the event that an SSR were to extend into or otherwise occur in Area 1 or 2 were performed in support of this FFS (Appendix E). The results of these evaluations concluded that the potential risks from such an increase in radon would be within or below EPA's accepted risk range of 10^{-4} to 10^{-6} (Appendix E).

In the event that a subsurface heating event were to occur in Area 1 or Area 2, such an event is not expected to impact the long-term effectiveness of this alternative. As discussed above, there would be a temporary potential increase in radon emissions. Evaluations performed as part of this FFS indicated that such a temporary increase in radon emissions is not expected to pose unacceptable risks to workers or the community (Appendix E). Destruction or modification of the waste material by increased temperatures could result in a reduction in volume which could cause subsidence and/or differential settlement of the waste mass. In turn, subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time, could result in displacement or disruption of an engineered cover system, thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

- Installation and operation of a heat extraction barrier or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

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[56] The conclusion that dry particulates could become airborne was based in part on several conservative assumptions about drilling procedures and soil/waste conditions. Specifically: the mixture was assumed to remain uncovered on the ground surface; it was assumed to be dry and friable, with the consistency of coal dust; all precipitation events were ignored; and all particulates produced were assumed to be respirable.

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system, followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions, after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2 (as discussed further below), the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills, such as those located in the deeper quarry landfill; that thicker waste provides a significant insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

Summary Evaluation Regarding Potential Impacts from a Subsurface Heating Event

A subsurface exothermic (heat-generating) reaction has been and is continuing to occur in the South Quarry portion of the Bridgeton Landfill. The SSR has resulted in landfill gas temperatures greater than those typically experienced at solid waste landfills, and also has resulted in generation of carbon monoxide and hydrogen gas (in contrast to generation of carbon dioxide and methane at most municipal solid waste landfills). The SSR has also decomposed waste mass in the South Quarry, resulting in subsidence of the ground surface. The locations and rate of the subsidence of the ground surface have been measured and mapped, demonstrating that the highest level of reaction activity currently is located in the southwestern corner. The current location of the SSR in southwestern portion of the South Quarry is the greatest possible distance away from Areas 1 and 2, which should lessen the likelihood that the SSR would migrate toward or into Area 1 (Appendix N-1). In addition, as demonstrated in Appendix N-1, the overall rate of SSR occurring in the South Quarry has diminished, as demonstrated by the significantly decreased rate of settlement (a proxy for the thermal degradation of the organic material).

The nature of the reaction in the South Quarry is not known with complete certainty. Research on elevated temperature landfills has been performed by a consortium of industry academics and industry experts under the umbrella of the Environmental Research & Education Foundation (EREF). This research concludes that these reactions are not smoldering or combustion, but rather are pyrolytic reactions involving biomass containing cellulose, hemicellulose, and related organic materials (see Appendix N-2).

Waste disposal in the South Quarry occurred over the period from approximately 1985 through 2005, and thus the waste material in this unit ranges from 12 to 32 years old. In contrast, waste disposal in Areas 1 and 2 occurred between approximately the mid- to late-1960s and ended by 1974, or potentially in some small portions of Area 1 and 2 by 1976. Therefore, the waste materials in Areas 1 and 2 are approximately 40 to 60 years old. Landfill gas production from decomposition of MSW typically occurs for 20-30 years (EPA, 2017) or 20-50 years (Robertson and Dunbar, 2005, EPA-600/R-05/123a) after completion of waste disposal. Based on expected landfill gas generation rates and timeline indicating that decomposition of MSW (as indicated by landfill gas generation) is nearly complete within 30 to 50 years, essentially complete biodegradation of organics (cellulose and hemicellulose) has already occurred in Areas 1 and 2. Since this decomposition of organics is so mature in Areas 1 and 2, there is little, if any, material remaining of the type needed to support or sustain a reaction (as described by EREF in Appendix N-2), or a smoldering event as hypothesized by others. Therefore, there is very little potential for a subsurface heating event to occur or extend into these areas.

The South Quarry portion of the Bridgeton Landfill is a deep quarry fill landfill with total waste thickness on the order of approximately 250 feet. The presence of such a thick column of waste provides significant insulating effect such that the elevated temperatures associated with the reaction can be maintained. In addition, as the EREF investigation demonstrates, higher ambient pressure and liquid pressures may play an important role in such reactions (see Appendix N-2). West Lake Landfill Areas 1 and 2 are area fill landfills, that is, landfills that were constructed on the existing ground surface, and contain average waste thicknesses of 43.4 ft in Area 1 (including the thickness of the above-grade waste in the North Quarry portion of the Bridgeton Landfill that overlies the southern portion of Area 1) and 31.6 feet in Area 2. Therefore, the waste thicknesses in these areas would not provide significant insulating effects and excess heat should dissipate through transfer to the ground surface or to the underlying alluvium and bedrock deposits. In addition, the thin, largely unsaturated nature of the waste means that the exacerbating pressure conditions that are hypothesized by EREF are not present. These effects should also lessen the potential for a subsurface heating event to occur or extend into these areas.

The area between the South Quarry and North Quarry portions of the Bridgeton Landfill is very narrow and has been identified as the “neck” area, due to the close proximity of the walls of the former quarry in this area. The topographic features of this “neck” area and the associated bedrock walls creates a large potential heat sink that should act to naturally reduce temperatures and thereby limit migration of the South Quarry SSR from extending into the North Quarry portion of the Bridgeton Landfill. This condition should also lessen the potential for the SSR to migrate toward or into Area 1.

Bridgeton Landfill has implemented several actions to control the SSR in the South Quarry including installation of an ethyl vinyl alcohol (EVOH) cover over the South Quarry and large portions of the North Quarry of the Bridgeton Landfill to reduce oxygen intrusion into these areas and control odors from the reaction. Bridgeton Landfill has also implemented a heat extraction barrier in the “neck” area between the South Quarry and the North Quarry portions of the Bridgeton Landfill. This heat extraction barrier consists of enclosed wells or tubes in which fluid is circulated to extract heat from the waste mass. Additional description of this heat extraction barrier installation, operation and effectiveness is summarized in Appendix N-3. Bridgeton Landfill also measures landfill gas temperatures within the North and South Quarry portions of the Bridgeton Landfill, and has also installed a network of temperature monitoring probes within the North Quarry in order to provide early detection of any occurrences of elevated temperatures above those typically associated with MSW landfills. A list of the various technical reports, data transmittals and other documentation that have been submitted to EPA and MDNR on behalf of Bridgeton Landfill that describe the various actions that have been taken by Bridgeton Landfill to address the SSR in the South Quarry is presented in Appendix N-4.

Hypothetically, if, despite these natural and engineered measures that limit migration of the SSR, an SSR were to occur in Area 1 or 2, the projected impacts are not expected to result in unacceptable risks to on-site workers or the surrounding community. As discussed in the above-referenced studies and in Appendix E, the primary impact would be a temporary, localized increase in radon emissions at the ground surface of Area 1 or 2. Potential risks associated with such emissions are evaluated in Appendix E and are expected to be below EPA's acceptable risk range. Additional impacts that may occur could include potential destruction of the waste mass resulting in impacts to the integrity of the engineered cover that could require additional maintenance and repair. Other potential impacts include possible additional leachate generation; however, unlike the South Quarry portion of the Bridgeton Landfill where the majority of the waste mass is located below the regional groundwater level and thus is largely saturated, the majority of the waste mass in Areas 1 and 2 is located above the original ground surface and above the regional groundwater level and thus is largely unsaturated, which should reduce the potential for additional leachate generation from Area 1 or 2.

In the event that a reaction was to generate additional leachate within the waste mass, the existing Bridgeton Landfill's Leachate Pre-Treatment Plant would be immediately available to mitigate any leachate impacts. The plant has been designed and operates to effectively pre-treat reaction impacted leachate from the South Quarry, allowing final discharge to the Metropolitan Sanitary District of St. Louis. The plant was constructed with a capacity of 300,000 gallons per day, and is currently operating at less than half of that capacity. The additional capacity could be utilized immediately to treat any increase in leachate volumes.

In the event that an SSR were to occur in the North Quarry, response actions would be promptly initiated. Per the North Quarry Administrative Settlement Agreement and Order on Consent for Removal Action [NQ ASAOC] (EPA, 2016e) Bridgeton Landfill is required to immediately notify EPA of any event that either constitutes an emergency situation or that may present an immediate threat to public health or welfare or the environment. The North Quarry Temperature Monitoring Probes (TMPs) Work Plan (Feezor Engineering, Inc., 2017) prepared pursuant to the NQ ASAOC requires weekly reporting of temperature data to EPA and MDNR. This plan also requires that EPA and MDNR be notified within 24 hours of an exceedance of elevated temperatures in any TMPs in the "Neck" area or North Quarry portion of the Bridgeton Landfill. The TMP Work Plan also requires that actions be taken to immediately modify landfill gas extraction operations to mitigate the effects of any elevated temperature conditions, and an investigation of the extent of elevated temperature conditions must be performed within two weeks (Feezor Engineering, Inc., 2017). The NQ ASAOC (EPA, 2016e) also requires use of "Inert Gas Injection as a 'hot spot' treatment option to isolate, contain, suppress, inhibit or extinguish any independent surface or subsurface smoldering event/fire that may occur in the 'Neck' area or in the North Quarry of the Bridgeton Landfill." The NQ ASAOC (EPA, 2016e) and the associated Inert Gas Injection Work Plan (SCS, 2016) require such actions to be taken within seven days.

EPA would also implement, or require additional response actions to be implemented, to control or contain such a reaction and to mitigate any effects. Responses actions could include, but are not necessarily limited to, repair of landfill cover or other engineered systems affected by a reaction, installation of additional landfill cover materials such as EVOH, implementation of heat extraction systems or physical barriers, implementation of or expansion of landfill gas extraction, implementation of or expansion of leachate collection, or other measures as appropriate. Such response actions would limit the timeframe for any emissions or other potential releases, thereby reducing the potential exposure durations for on-site workers or the community. These measures, as implemented in the South Quarry, have proven to be effective to mitigate the effects and extent of the reaction.

The low potential for an SSR to occur in Area 1 or 2, the measures Bridgeton Landfill has implemented to control and contain the existing reaction in the South Quarry and to provide early detection of any potential reaction in the North Quarry, and the timeliness of response actions required by EPA and MDNR, all serve to lessen the potential for an SSR to impact radionuclide occurrences, migration or releases from Area 1 or 2 and potential risks to on-site workers or the community.

6.2.2.3.5 Effects of an Isolation Barrier

In 2013, Bridgeton Landfill, LLC began evaluation of potential engineering measures that might be implemented to isolate the RIM in Area 1 from a heating event should such an event either migrate from the South Quarry portion of the Bridgeton Landfill or otherwise originate in the North Quarry portion of the Bridgeton Landfill. Investigations of the subsurface conditions including the extent of RIM (Feezor Engineering, Inc. et al., 2014) were performed as part of this evaluation. Contemporaneously, the USACE, on behalf of EPA, prepared an Isolation Barrier Alignment Alternatives Assessment (USACE, 2014). EPA subsequently requested that Bridgeton Landfill, LLC prepare the IBAA, which was completed in 2014 (EMSI et al., 2014). Agency comments (EPA, 2015d and MDNR, 2014) were received and responded to by Bridgeton Landfill, LLC in 2015 (EMSI, 2015a). Evaluation of potential isolation barrier alignment alternatives was conducted by the USACE in 2015 (USACE, 2015). Additional evaluations were undertaken by Bridgeton Landfill, LLC in 2016 (Auxier and EMSI, 2016d and 2016e). At the time that this draft FFS was being prepared, evaluation of potential alignments and technologies for implementation of an isolation barrier were still ongoing, with no specific alignment or technology (*e.g.*, physical or heat extraction barrier) having been chosen.

In 2015, Bridgeton Landfill, LLC conducted technical evaluations of potential heat extraction technologies to halt any potential movement of the heating event in the South Quarry portion of the Bridgeton Landfill (Feezor Engineering, Inc., 2015 and MDNR, 2015). In April 2016, EPA issued an Administrative Settlement Agreement and Order on Consent (ASAOC) to Bridgeton Landfill, LLC that required, among other items: installation of a heat extraction barrier (HEB) in the "neck" area between the North and South Quarry portions of the Bridgeton Landfill; installation of additional temperature monitoring probes (TMPs); installation of an EVOH cover over the North Quarry portion of the Bridgeton Landfill; and development and implementation of other plans relative to mitigation of a possible migration of the SSR in the South Quarry into the North Quarry portion of the Bridgeton Landfill, or the potential origination of a new SSR or SSE in the North Quarry portion of the Bridgeton Landfill (EPA, 2016c). The HEB was installed in the summer of 2016 and began operating in October 2016 (Feezor Engineering, Inc. and P.J. Carey & Associates, 2016). An EVOH cover design was prepared (Cornerstone, 2016) and approved by EPA, and the EVOH cover is currently (summer 2017) being installed over portions of the North Quarry of the Bridgeton Landfill. The additional TMPs were installed in the fall of 2016 (Feezor Engineering, Inc. 2016), and the additional plans were prepared and submitted to EPA (Feezor Engineering, 2017 and SCS Engineers, 2016).

EPA's SOW for the RI Addendum and FFS (EPA, 2015b) requires an evaluation of the effects of an isolation barrier to be included in the FFS. Installation of a heat extraction barrier consisting of various heat extraction points (regardless of location) would not have a significant impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability, or cost of the ROD-selected remedy. Installation of heat extraction wells could result in bringing RIM to the ground surface which, if not properly managed, could result in a potential for an airborne release. However, most drilling at the Site has to date been performed using Sonic drilling techniques, which generate little to no cutting material, thereby reducing the potential risk. Installation of heat extraction wells after installation of a new cover system would require repair of the cover system around such penetrations which could lead to additional maintenance or further repairs in the future; such activities are routinely performed at solid waste landfills, however, and are not expected to significantly impact the OM&M costs. Installation of a physical barrier, such as a vertical wall of inert material, would require excavation and regrading of the above-grade portion of the North Quarry part of the Bridgeton Landfill located over the southern portion of Area 1. If such a barrier were to be installed prior to implementation of the ROD-selected remedy, the design of the engineered cover included in the ROD-selected remedy would need to account for any changes in the surface grades, stormwater drainage system, and the presence of any above-grade features (*e.g.*, heat extraction points, temperature monitoring probes, or additional gas extraction wells) that may be installed in conjunction with a physical barrier. In contrast, if a physical barrier were installed after construction of the engineered cover included in the ROD-selected remedy, that portion of the engineered landfill cover that extended over the area of an isolation barrier and the associated revised landfill grades would need to be removed as part of construction of an isolation barrier.

Because only Area 1 is located contiguous to the Bridgeton Landfill, an isolation barrier would only be installed near Area 1. Area 2 is physically separated by native material (soil and rock) present beneath the leachate treatment facility and Site access road from the Bridgeton Landfill. Therefore, any potential impacts to or from a potential isolation barrier from or to the ROD-selected remedy would only affect Area 1.

6.2.2.3.6 Environmental Justice Considerations

EPA's SOW (EPA, 2015b) requires the FFS to include an acknowledgement of any environmental justice concerns to be included in both the short-term and long-term effectiveness sections of the alternatives analysis. Executive Order (E.O.) 12898, entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," calls on each covered Federal agency to make achieving environmental justice part of its mission "by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations" (EPA, 2016d). EPA defines environmental justice (EJ) as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. EPA further defines the term *fair treatment* to mean that "no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, governmental, and commercial operations or programs and policies" (EPA, 2011). EPA defines meaningful involvement as, "1) potentially affected populations have an appropriate opportunity to participate in decisions about a proposed activity [i.e., rulemaking] that will affect their environment and/or health; 2) the population's contribution can influence [the EPA's] rulemaking decisions; 3) the concerns of all participants involved will be considered in the decision-making process; and 4) [the EPA will] seek out and facilitate the involvement of population's potentially affected by EPA's rulemaking process" (EPA, 2015e). EPA defines a potential EJ concern as "the actual or potential lack of fair treatment or meaningful involvement of minority populations, low-income populations, tribes, and indigenous peoples in the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA, 2015e).

Executive Order 12898 identifies a number of population groups of concern in considering potential EJ implications of a regulatory action. These include: minority populations, low-income populations, and indigenous peoples. For purposes of E.O. 12898, the term "minority" means "individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic" (CEQ, 1997). A population is identified as minority in an area affected by the policy action if "either (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis" (CEQ, 1997). EPA has indicated that low-income populations may include families whose income is above the poverty threshold but still below the average household income for the United States (EPA, 2016d and 2015e). EPA Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples (EPA, 2014c) defines "indigenous people" to include: state-recognized tribes; indigenous and tribal community-based organizations; individual members of federally recognized tribes, including those living on a different reservation or living outside Indian country; individual members of state-recognized tribes; Native Hawaiians; Native Pacific Islanders; and individual Native Americans.

EPA's "Technical Guidance for Assessing Environmental Justice in Regulatory Analysis" (EPA, 2016d) (referred to as the EJ Technical Guidance) and EPA's Guidance on Considering Environmental Justice During the Development of Regulatory Actions (EPA, 2015e) (referred to as the EJ Process Guidance) were used to evaluate potential environmental justice concerns that may exist in the vicinity of the West Lake Landfill. The EJ Technical Guidance states that the analysis of potential EJ concerns for regulatory actions should address three questions:

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern in the baseline?[57]

- Are there potential EJ concerns associated with environmental stressors affected by the regulatory action for population groups of concern for the regulatory option(s) under consideration?

- For the regulatory option(s) under consideration, are potential EJ concerns created or mitigated compared to the baseline?

Both the EJ Process Guidance and the EJ Technical Guidance recommend the use of a screening-level analysis to identify the extent to which a regulatory action may raise potential EJ concerns that need further evaluation, and what level of analysis is feasible and appropriate for that further evaluation. EPA's EJSCREEN: Environmental Justice Screening and Mapping Tool (EPA, 2015f) was used to perform a screening-level analysis to identify any potential environmental justice concerns that may exist in the vicinity of the Site. The EJ Technical Guidance indicates that when using EJSCREEN, the 80th percentile is a suggested starting point for the purpose of identifying geographic areas in the United States that may warrant further consideration, analysis, or outreach. That is, if any of the EJ Indexes for the areas under consideration are at or above the 80th percentile nationally, then further review may be appropriate (EPA, 2016d).

[57] Per EPA's EJ Technical Guidance, this question asks whether there are discernible differences in impacts or risks to minority populations, low-income populations, or indigenous peoples that exist prior to or that may be created by the proposed regulatory action and that are extensive enough that they may merit Agency action. Differences in impacts or risks may include differential exposures, differential health and environmental outcomes, or other relevant effects. The subsequent analytic questions here are intended to prompt assessment of differences in anticipated impacts across population groups of concern for the baseline and proposed regulatory options, and to prompt the presentation of these results to decision makers to support their determinations regarding potentially actionable disproportionate impacts.

Areas 1 and 2 of the West Lake Landfill were identified on EJSCREEN, and a one-mile buffer around these areas was created (Figure 6-1). EJSCREEN Indexes for the census blocks that intersected this one-mile radius were evaluated. The EJSCREEN Demographic Index, which is a combination of percent low-income and percent minority, was less than 80th percentile for all of the census blocks within the bounds of the one-mile radius (Figure 6-2). The individual EJSCREEN minority population (Figure 6-3), low-income (Figure 6-4), and linguistically isolated (Figure 6-5) indexes were also below the 80th percentile; although the census block immediately to the east of Interstate 270, which is along the margin of the one-mile radius, was identified as a low-income population (Figure 6-4). The only EJSCREEN index that was greater than the 80th percentile for the area within the one-mile radius was the percentage of the population greater than 64 years of age, for which the EJSCREEN index was in the 95th percentile of the national rates (Figure 6-6). This indicates that a significant portion of the population living in the immediate area of the Site is elderly.

The EJSCREEN analyses did not identify any environmental justice concerns in the vicinity of the Site. Discussions with EPA Region 7 personnel on August 1, 2016 indicated that EPA had not identified any environmental justice concerns in the vicinity of the West Lake Landfill. However, EPA did indicate that interviews with the residents of the Terrisan Reste mobile home park suggested that more traditional methods of communication, such as U.S. Postal Service mail, would be more appropriate than electronic methods for providing information to this group of residents.

Region 7 personnel did indicate that a few block groups[58] located within three miles of the Site were identified as being above the 80th percentile for low-income. EPA Region 7 also indicated that it conducted visual inspections and community surveys in the area of the Site, and, based on this work, did identify the Terrisan Reste mobile home park, which is located approximately three-quarters of mile to the southeast of Area 1, as potentially being low-income and potentially having a high proportion of elderly and disabled residents. Based on information obtained from its community survey, EPA indicated that the mobile home park residents faced communication challenges due to limited computer access. Consequently, communication by U.S. Postal Service mail is an important method for communication with these residents in order to ensure meaningful involvement. These actions are addressed as part of the Community Involvement Plan for the Site.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

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[58] A Census Block Group is a geographical unit used by the United States Census Bureau and is generally defined to contain between 600 and 3,000 people. It is the smallest geographical unit for which the Bureau publishes sample data.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Overall, the ROD-selected remedy is a containment remedy and therefore generally would not result in any reduction in the toxicity, mobility, or volume of the waste material through treatment.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be fully neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout portions of the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. The ROD remedy does not include excavation and off-site disposal of RIM, but rather only includes regrading of a relatively small amount of material (currently estimated to be approximately 112,000 yards) in order to reduce the angle of the perimeter landfill slopes, achieve the required minimum surface grade, and create space for stormwater retention basins. A small portion of this material (approximately 15,750 cubic yards) is estimated to be RIM, which would be placed back into Area 1 or 2 beneath the new engineered landfill cover. This alternative is a containment remedy, and does not include excavation of RIM as a component. Therefore, ex-situ treatment techniques are not applicable to the ROD-selected remedy. The heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within portions of the overall solid waste matrix in portions of Areas 1 and 2 suggest that in situ treatment techniques are not applicable. Specifically, the waste heterogeneity would impact the ability to deliver reagents uniformly or to specific materials, resulting in significant uncertainty regarding the potential effectiveness or implementability of such treatment. Additional evaluation of the potential effectiveness and implementability of potential treatment technologies is presented in Section 4 of this FFS. The ROD-selected remedy for the Buffer Zone/Lot 2A2 also would not reduce toxicity, mobility, or volume through treatment because it consists of moving radiologically-impacted soil from the Buffer Zone/Lot 2A2 to Area 1 or 2, where it would be consolidated with the RIM.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. Suspect material would initially be stored on site while test results were obtained to verify the presence, if any, and type of hazardous wastes encountered. Storage would be conducted in accordance with RCRA and State hazardous waste regulation requirements for storage containers or units and limitations on the duration of storage (90 days if the amount of hazardous waste exceeds 2,200 lbs. in a month or 270 days if the amount is less than 2,200 lbs. a month).[59] Procedures to be used for testing, storage, management, treatment and disposal of any hazardous wastes or mixed wastes that could

[59] These storage limitations assume that the off-site facility is located more than 200 miles from the Site. This distance is assumed based on the expectation that any identified hazardous waste would also be rad-contaminated and therefore shipped to one of the four off-site disposal facilities identified in Section 4.3.5.4.

be encountered during implementation of the alternative would be documented as part of the RD activities.

To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's Land Disposal Restrictions (LDR) program and Universal Treatment Standards (UTS)) and in accordance with the permits and standard operating procedures of the receiving facility. Examples of treatment processes include stabilization of soil and micro- or macro-encapsulation of debris. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste or the radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies, but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

As the expected volume of waste material that would be disturbed during landfill regrading is relatively small, the amount of hazardous waste that may be encountered, if any, during implementation of the ROD-selected remedy is also expected to be relatively small. Therefore, it is anticipated that any hazardous waste that may be encountered during implementation of the ROD-selected remedy would be shipped to an off-site disposal facility by truck.

6.2.2.5 Short-Term Effectiveness

During the construction period, the ROD-selected remedy could pose radiation exposure and physical hazards for workers and result in additional local truck traffic. This alternative includes excavation and relocation of waste material from the steeper slopes of Area 1 and 2 in order to meet the minimum and maximum slope angle requirements. The ROD-selected remedy, as modified, would include relocation of approximately 112,000 cubic yards waste materials. Of this amount, approximately 4,000 yards will be cut to achieve the minimum surface slope and promote drainage from the surfaces of Areas 1 and 2, 12,000 yards are expected to be cut to create space for construction of the starter berms, approximately 39,000 yards are expected to be cut to reduce existing perimeter slopes to below 25%, and approximately 23,000 yards are expected to be cut to create space for construction of a surface water detention basin in Area 1. The remaining approximately 35,000 yards reflect regrading of inert fill (*e.g.*, concrete rubble) piles on the surface of Areas 1 and 2. Of the 77,000 cubic yards of MSW that would be regraded (i.e., exclusive of the inert fill), approximately 15,750 cubic yards is anticipated to contain RIM. Therefore, this alternative would entail some excavation, handling, loading and transport of MSW and RIM within the Site associated with re-contouring to achieve slope requirements, and thus could pose some short-term exposure risks to on-site workers. The number of truck trips required to import construction materials to the Site would also result in additional physical risks to the community and/or workers due to the potential for traffic accidents.

The ROD-selected remedy for the Buffer Zone/Lot 2A2 would be effective over the short term and the relatively short duration required to remove any remaining impacted soil should result in no significant adverse impacts.

Evaluation of potential short-term risks to the community and workers that may result from implementation of this alternative are presented in Appendix H and are discussed below. Potential short-term risks to the community and workers would be addressed through monitoring and dust control and other mitigative measures to assess and limit worker and community exposures during construction. Adherence to OSHA practices would be necessary to limit worker exposures and accidents.

6.2.2.5.1 Protectiveness of the Community During Remedial Actions

The projected carcinogenic risks that may be posed to off-site residents by this alternative would be 1.9×10^{-7}, which is below EPA's accepted risk levels (Appendix H). No non-carcinogenic risks are expected to occur.

In order to further ensure that construction activities do not pose unacceptable risks, effective dust control measures would be implemented from the start of the project. An extensive perimeter environmental monitoring system has already been installed at the Site. Results of monitoring along the perimeter of Areas 1 and 2, combined with monitoring performed in the work zone during various investigative activities, have indicated that no significant airborne migration of radionuclides is occurring and that workers and the general public are not being exposed to radionuclides above background levels. Continued monitoring during construction would identify any potential for releases that could impact the area outside the work location.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each alternative. For the ROD-selected remedy, the projected incidence of transportation accidents associated with importing of materials for construction of the multi-layer landfill cover is 0.61, meaning that there would be a 61% probability of at least one transportation-related accident occurring during implementation of the remedy. To address this risk, traffic control for the incoming shipment of the materials would be implemented from the project start. All drivers would be cautioned about the normal congestion existing on St. Charles Rock Road. Routing of trucks, safety briefings, and adherence to traffic laws would reduce but not necessarily eliminate the potential for accidents. To the extent possible, shipments would be scheduled to avoid the highest traffic times.

Vehicle operations during importation of materials used to construct the multi-layer landfill cover and during landfill regrading and cover construction are projected to emit 20,000 tons of carbon dioxide equivalent emissions to the atmosphere (Appendix I, Table I-2).

As Areas 1 and 2 are regraded during cap installation, the nuisance attraction to and congregation by birds at and above the affected areas could be problematic unless effectively controlled. Concerns include odor management, vector control, and the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. Excavation best management practices—including immediate re-deposition of cut material, limiting the area of excavation, and application of daily soil cover—are included in the ROD-selected remedy, and, if necessary, mitigation measures such as tarps, visual and auditory frightening devices, or wire or monofilament grids strung over exposed refuse to prevent bird access, could be implemented to minimize bird attraction to and congregation at and above the disturbed areas.

As Areas 1 and 2 are regraded during cap installation, stormwater controls would be implemented in accordance with Missouri Storm Water regulations 10 CSR 20-6.200.

6.2.2.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6, as part of the evaluation of long-term effectiveness, a screening-level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community.

6.2.2.5.3 Protectiveness of Workers During Remedial Actions

The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the ROD-selected remedy, the projected increased carcinogenic risks are projected to be 2.8×10^{-5}, which is within EPA's accepted risk range; however, projected non-cancer risks to workers are estimated to be 27.0, primarily owing to potential exposures to zirconium[60]. For the ROD-selected remedy, the projected incidence of industrial accidents is 5.17 over the life of the project (Appendix H). The projected radiation dose to a remediation worker is 60.2 millirems/year (mrem/yr) [Appendix H)].

A complete and comprehensive Health and Safety Program would form the core of worker protectiveness measures. The program would direct protective actions of all personnel on the Site. All workers at the Site would be trained to handle both radioactive materials (Rad Worker Training) and hazardous materials (HAZMAT Training). Protective clothing and equipment and constant monitoring for toxic hazards and radioactive emissions would be mandated. All workers on the project would be required to adhere to the project safety requirements, including any sub-contractors or vendors who are at the Site for an extended period of time. Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers including the projected non-carcinogenic risks identified above.

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[60] As discussed in the uncertainty assessment portion of the updated BRA (Auxier, 2017b), zirconium HQs are likely overestimated due to substantial uncertainties in the RfD and due to contributions from naturally-occurring zirconium in background soil.

6.2.2.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from implementation of the ROD-selected remedy. A screening-level ecological assessment was performed as part of the original BRA (Auxier, 2000) and was revised as part of the updated BRA (Auxier, 2017b). The results of that assessment are presented in Section 7 of the BRA (Auxier, 2000) and Appendix B of the updated BRA (Auxier, 2017b). No wetlands are located within the on-site construction footprint of this alternative and no endangered species were identified.

The activities to be conducted during Site regrading and cover construction would affect wildlife and plant life on Areas 1 and 2 and possibly adjacent portions of the Site. This disruption would be temporary and would last for the period of active construction. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Regrading of Areas 1 and 2 and construction of the engineered landfill cover included in the ROD-selected remedy would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.2.5.5 Ability to Monitor Effectiveness

Measurement of gamma radiation and radon flux through the newly constructed landfill cover would be conducted on Areas 1 and 2 after construction is complete. Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2. Measurements of subsurface occurrences of landfill gas and radon levels would be conducted along the property boundaries adjacent to Areas 1 and 2 to verify that off-site gas migration above regulatory thresholds does not occur.

6.2.2.5.6 Time Until Remedial Action Objectives Are Achieved

The RAOs of (1) preventing direct contact with contaminated media (2) preventing exposure by inhalation and external radiation; (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; and (5) controlling radon and landfill gas emissions from Areas 1 and 2 would be met once construction of the new engineered landfill cover over Areas 1 and 2 is completed. The RAO related to the Crossroads Property Lot 2A2 soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from that area.

Construction is estimated to require approximately 1.8 years after approval of the RD. Preparation of the RD should be completed within approximately one year of authorization to proceed with the RD. Therefore, the remedial action objectives should be achieved within approximately 2.8 years of authorization to begin (Appendix J).

6.2.2.6 Implementability

The design and construction of a landfill cover, with subsequent monitoring and maintenance as specified for the ROD-selected remedy, is not expected to pose any significant implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 are readily available and the technologies have been proven through application at other landfills. Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of landfill covers, and are easily implemented.

6.2.2.6.1 Ability to Construct and Operate the Technology

It is technically feasible to regrade existing materials and install a starter berm and/or place additional soil in order to achieve minimum and maximum slopes of 2% and 25% respectively. It is also technically feasible to construct an upgraded landfill cover over Areas 1 and 2. Regrading of existing landfills through placement of additional soil or regrading of existing materials is a common remedial action that has been implemented at many other CERCLA landfill sites as well as at RCRA corrective action sites.

Because of the configuration and location of Areas 1 and 2 within the overall existing larger Site footprint, as well as the existing relatively steep side slopes on portions of the northern and eastern edges of Area 1 and the northern and western edges of Area 2, achieving the required maximum slope grades along the entire margin of Areas 1 and 2 cannot be achieved by placement of additional fill material alone. The toe of the landfill in the northern portion of Area 2 is located near or coincident with the property boundary/fence line, and therefore placement of additional soil or fill material is not an option to reduce the slope angle of the landfill berm in this area. Similar grading constraints exist for portions of the landfill in Area 1 due to the presence of the solid waste transfer station access road located along the northern toe of the landfill berm in Area 1, and the presence of the property/fence line along the eastern toe of the landfill. An existing drainage ditch located along the St. Charles Rock Road immediately outside of the fence line would also pose grading restraints around Area 1. For these areas, re-contouring the waste materials is a viable option to achieve the proper slope for construction of the cover. Re-contouring can be greatly reduced through use of a starter berm, as discussed elsewhere in this FFS report and in more detail in the prior SFS report (EMSI et al., 2011).

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarping of exposed wastes), visual and auditory frightening devices, and use of wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated technologies that can be readily constructed and operated as part of the ROD-selected remedy.

Effective storm water controls can be readily implemented using conventional construction equipment, materials, and best management practices.

6.2.2.6.2 Reliability of the Technology

Landfill cover systems that are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance have been demonstrated to be reliable at: 1) minimizing percolation and infiltration of precipitation; 2) minimizing leachate generation; 3) minimizing impacts to groundwater quality; 4) minimizing impacts to surface water quality and quantity; 5) minimizing erosion of cover material; and 6) minimizing uncontrolled releases of landfill gas. In addition, existing security systems (*e.g.*, gates and fencing, signage, site surveillance, etc.) would be evaluated and enhanced, if necessary. These are reliable mechanisms to prevent unauthorized access to the Site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarps), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated reliable technologies. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. The FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are also well-established technologies that have been implemented and proven reliable at most landfill sites.

6.2.2.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

The only potential additional remedial actions that may need to be taken for the ROD-selected remedy would be maintenance activities to sustain the cover system, repair areas of differential settlement or erosion, or possible implementation of a contingent landfill gas control system. Regrading and contouring the existing waste materials to achieve final grades would require re-compaction of the regraded waste materials in order to minimize the potential for compaction or differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill cover may result in differential compaction of the waste materials, depending upon the nature, age, and amount of prior degradation of the waste materials. Runoff of stormwater can result in formation of erosional rills. Depressions caused by differential settlement of the wastes or erosional features can easily be (and commonly are) addressed at landfill sites through placement of additional soil material to fill such features.

In the event that monitoring of subsurface landfill gas and radon detects the presence of gas levels above regulatory thresholds along the perimeter of the Site, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system, and/or possible use of a carbon adsorption system to remove radon from the extracted gas stream. Installation of a contingent gas system can easily be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund site solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would be straightforward, primarily entailing placement of additional fill, regrading, and re-vegetation of the repaired area.

Storm water management measures other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures are not anticipated.

6.2.2.6.4 Ability to Monitor Effectiveness of Remedy

One purpose of installing a landfill cover would be to prevent direct contact with the waste materials. The integrity of a landfill cover relative to protection from direct contact can easily be monitored through visual inspection to identify the presence of exposed waste or the existence of erosional features that could impact the landfill cover.

Another long-term goal of constructing new landfill covers over the surfaces of Areas 1 and 2 would be to minimize percolation and infiltration of precipitation with subsequent leachate generation and potential impacts to groundwater. Visual inspection of the cover integrity relative to the potential for erosion and infiltration impacts to the landfill cover can be easily performed. Groundwater monitoring to detect the presence of, or verify the absence of, impacts to groundwater is a standard technology that also can easily be performed at the Site.

Demonstrating the effectiveness of the cover systems would be accomplished by implementing the monitoring programs required by the ROD-selected remedy, including programs for the cover surface, landfill gas system, groundwater, and surface water (as previously described in Section 5.3.1.11). These types of monitoring programs are proven at demonstrating cover effectiveness and can be easily implemented.

6.2.2.6.5 Ability to Obtain Approvals from Other Agencies

No approvals by other agencies would be required to implement the ROD-selected remedy. The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the Federal Aviation Administration (FAA) and the

St. Louis Airport Authority (STLAA or Airport Authority). The effectiveness of best management practices and proposed bird nuisance mitigation measures would be of interest to the FAA and the Airport Authority.

6.2.2.6.6 Coordination with Other Agencies

Other than coordination with the STLAA regarding the bird hazard mitigation measures and effectiveness, coordination with other agencies would not be necessary to implement the ROD-selected remedy.

Although they would not be considered "agencies," coordination with the landfill owner and operator, the owners of the various parcels that comprise the West Lake Landfill property, and the asphalt batch plant tenant would be required during regrading and installation of an upgraded landfill cover under the ROD-selected remedy. Coordination would be necessary because:

- Access to operations conducted on other portions the Site would need to be maintained;
- Areas 1 and 2 are within a larger existing Site footprint, and use of areas on the West Lake Landfill property outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction; and
- For the time period during construction when trucks would be delivering rock, clay, and soil materials for cover construction, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the on-site solid waste transfer station and asphalt plant.

The owners of all of the various parcels that comprise the West Lake Landfill (and the Buffer Zone) are participating PRPs and given this, coordination with owners is expected to be feasible.

Coordination with other agencies including the Earth City Flood Control District, MSD, and the Missouri Department of Transportation (MDOT), as well as the adjacent property owners and businesses (*i.e.*, Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities both during and after completion of construction;
- Coordinate with MSD regarding permitting and design of leachate/contact stormwater discharge during construction;
- Coordinate with MDOT for access to areas along St. Charles Rock Road (MO Route 180) and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtaining legal and physical access from Crossroad Properties, LLC and AAA Trailer for testing and, if necessary, remediation of the Crossroads Property and for implementation of remedial actions that may need to be performed along the property boundary (*e.g.* regrading, fencing, etc.).

6.2.2.6.7 Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity

No off-site treatment, storage or disposal services are envisioned as part of the direct implementation of the ROD-selected remedy. Off-site treatment, storage and disposal may be required if hazardous wastes or regulated asbestos-containing materials (RACM) are encountered during re-contouring Areas 1 and 2. Additionally, the four off-site disposal facilities identified for the full excavation of RIM and partial excavation alternatives are permitted to accept liquid, hazardous, and mixed wastes and asbestos, as well as to treat soil and/or debris that contain hazardous or mixed waste.

Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact waste materials during the landfill re-contouring activities could also be required. Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill regrading activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater and initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.2.6.8 Availability of Necessary Equipment and Specialists

Personnel, equipment, and materials are readily available to implement the cover systems, institutional controls, and monitoring components of this alternative. The implementability and potential cost of this alternative would be influenced by the availability and location of clean fill materials and/or off-site soil borrow sources at the time this alternative is implemented. Potential vendors of rock, clay and soil were contacted during the development of the FS (EMSI, 2006), during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI et al., 2008), and during preparation of the SFS (EMSI, et al., 2011). These vendors indicated that rock, clay and clean fill material were readily available from sources located near the Site at the time these inquiries were made. If these local sources of cover materials become exhausted prior to remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site; however, all of the materials are expected to be available.

The necessary materials, equipment, and personnel required for assessment and removal of radiologically-impacted soil that may be present at the Buffer Zone/Lot 2A2 are also readily available.

6.2.2.6.9 Availability of Prospective Technologies

The ROD-selected remedy is based on proven, established, commonly used technologies. Use of prospective technologies is not anticipated to be part of the ROD-selected remedy.

6.2.2.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the ROD-selected remedy are included in Appendix K-2 and summarized on Table 6-1. Conceptual bottom and top of final cover grading plans and stormwater control features used as the basis for the ROD-selected remedy capital cost estimate are provided in Appendix M. The estimated costs to construct the ROD-selected remedy (i.e., design costs, capital costs, and costs for monitoring during the construction period) are $75 million. The estimated annual OM&M costs range from $176,000 to $389,000 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring, years when landfill cover repairs may occur, and years when 5-year reviews are conducted). The cost estimates provided in this FFS are feasibility-level cost estimates; that is, they were developed to a level of accuracy such that the actual costs incurred to implement this alternative are anticipated to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the ROD-selected remedy are projected to be $71 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $79 million. The total non-discounted costs for the ROD-selected remedy over 30 years are projected to be $80 million. Given the long life of the radionuclides present at OU-1, the costs for the ROD-selected remedy were also evaluated for 200- and 1,000-year periods (without consideration of any constraints on annual expenditures). The total non-discounted costs of the ROD-selected remedy are projected to be $113 million over a 200-year period. The total present-worth costs of the ROD-selected remedy are projected to be $71 million based on a 7% discount rate or $95 million based on a 0.7% discount rate, respectively, over a 200-year period. The total non-discounted and present worth costs of the ROD-selected remedy are projected to be $265 million over a 1,000-year period. The present worth costs over a 1,000-year period are projected to be $71 million based on a 7% discount rate or $101 million based on a 0.7% discount rate.

US Ecology was contacted during preparation of this FFS to obtain information regarding the potential costs that would be incurred if some of the RIM were determined to be mixed hazardous and radioactive waste or if hazardous wastes were encountered in the overburden material. For purposes of demonstrating the extent to which shipping of mixed waste could influence costs, it was assumed that mixed waste would represent 0.5% of the total mass of the relocated RIM volume for the ROD-selected remedy (15,750 bcy) resulting in an assumed volume of mixed waste of 130 yards. The added costs for handling, sampling/analysis, and treating of mixed waste are estimated to range from $3,000 to $68,000 (Appendix K-10). If hazardous wastes (as opposed to mixed waste) are encountered in moving the overburden material, additional costs would be incurred for handling, transport and disposal. Assuming that 0.5% of the non-RIM waste material that will be relocated is hazardous waste results in an estimated volume of 793 lcy or 397 tons (Appendix K-10). The additional cost for transport, treatment and disposal of hazardous (non-RIM) waste could range from $164,000 to $614,000 (Appendix K-10) depending upon the nature of the hazardous wastes (*i.e.*, metals or organics) that may be encountered. The range of costs primarily results from variations in the fees charged by the off-site disposal facilities and in uncertainties associated with the nature of such wastes and the required method of treatment. Therefore, the additional costs that may be incurred if mixed and hazardous wastes are encountered during waste regrading for the ROD-selected remedy, as modified, could range from $167,000 to $682,000 (Appendix K-10) the 0.5% of total mass assumption, the added costs would be higher as well.

6.2.3 UMTRCA Cover Alternative

As discussed in Section 5.4, the UMTRCA cover alternative consists of the following components:

- Installation of a landfill cover meeting the UMTRCA performance standards for uranium mill tailing sites and also the Missouri closure and post-closure care requirements for sanitary landfills, and inclusion of flood protection measures along the toe of Area 2.

- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Crossroads Lot 2A2 Property.

- Excavation of any soil containing radionuclides above levels that would allow for unrestricted use from the Buffer Zone and/or Lot 2A2 and consolidation of the excavated soil within Areas 1 or 2.

- Application of groundwater monitoring and protection standards consistent with requirements for uranium mill tailing sites and sanitary landfills.

- Design, installation and maintenance of surface water runoff controls.

- Gas monitoring and control, including radon and decomposition gas as necessary.

- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing long-lived radionuclides.

- Long-term surveillance and maintenance of the remedy.

Similar to the OU-1 ROD-selected remedy as modified, the UMTRCA cover alternative includes regrading (cutting and filling) of the existing landfill materials along with placement of additional soil or clean fill material (as defined in the Missouri solid waste regulations [10 CSR 80-2.010(11)]) over Areas 1 and 2 to adjust the final grades to achieve minimum slope angles of 2% and maximum angles of 25%. Portions of the landfill berm that contain slopes greater than 25% would be regraded through construction of a perimeter "starter" berm, regrading the existing landfill materials, and/or placing additional material to reduce the slope angles to 25% or less. The method used to regrade the perimeter portions of Areas 1 and 2 would be subject to physical constraints associated with the location of the toe of the landfill relative to the property boundary or adjacent Site features (*e.g.*, the solid waste transfer station access road).

Upon completion of the landfill regrading, an engineered landfill cover designed to meet the UMTRCA performance standards and also designed to be consistent with the MDNR final cover requirements for operating sanitary landfills would be constructed over Areas 1 and 2. The final cover system would encompass approximately 24 acres for Area 1 and 51 acres for Area 2. A layer of well-graded rock or concrete/asphaltic-concrete rubble the bottom portion of which would contain approximately 6 inches of finer-grained gravel or sand to serve as a drainage layer, would be installed immediately above the clay layer to minimize the potential for biointrusion and erosion into the clay layer, increase the longevity of the landfill cover, and enhance the radon attenuation capability of the cover system. Installation of a rock layer would require the rock to be well-graded and/or to include a filter layer or geotextile between the rock and overlying materials (*e.g.*, vegetative layer) to prevent loss of fine-grained material from the overlying layer into void spaces in the rock layer. Loss of fines could affect the performance of an overlying layer and/or result in voids that could extend through the cap to the ground surface if not otherwise addressed during design and construction. For purposes of this FFS, it is assumed that the biointrusion layer would be constructed using rock material containing a sufficient quantity of finer-grained material to avoid a potential loss of fines and the other effects discussed above. Design of the biointrusion layer and selection of the materials to be used to construct this layer would be performed as part of RD. Surface drainage diversions, controls, and structures would also be designed and constructed on the surface of or adjacent to the landfill cover as necessary to route non-impacted, uncontaminated stormwater (stormwater that has not contacted the underlying waste materials) off of Areas 1 and 2 and onto the adjacent areas of the Site or into off-site storm water drainage systems.

The cover system included in the UMTRCA cover alternative would consist of the following layers (from top to bottom):

- A 1-foot-thick layer of soil capable of sustaining vegetative growth and potentially including rock mulch in its upper portion;

- An 18-inch-thick biointrusion/erosion protection layer consisting of well-graded rock or concrete/asphaltic concrete rubble consisting of pieces up to 4 inches in size with sufficient grading to eliminate voids;

- A 6-inch-thick drainage material such as a well-graded fine gravel/coarse sand with fine- to medium-grained sand;

- A 2-foot-thick low-permeability layer of compacted, low-permeability clay soil with a permeability coefficient of 1×10^{-7} cm/sec or less; and

- A geosynthetic clay liner (GCL) or other suitable low-permeability material, such as a flexible membrane liner, installed within or on top of the low-permeability clay layer.

If a GCL were used, it would provide a permeability coefficient less than 10^{-7} cm/s (potentially as low as 10^{-9} cm/sec) as compared to the 10^{-7} cm/sec permeability coefficient for the CCL. Because installation of a GCL would require placement of a bedding layer, it is assumed that the GCL would be placed on top of or within the CCL layer. In addition, the drainage layer would be installed immediately above the GCL/CCL to reduce the potential for infiltration and provide a capillary break between the GCL/CCL and the overlying biointrusion and vegetative layers.

Sampling would be performed to evaluate the presence and extent of radiologically-impacted soil that may still be present on the Buffer Zone/ Lot 2A2. To the extent that soil containing radionuclides at levels greater than those which would allow for unrestricted use are present on these areas, this soil would be removed and placed into Area 1 or 2. Based on sampling performed during the RI prior to subsequent regrading and placement of gravel cover by the adjacent property occupant in these areas, it was estimated that radionuclides may be present on approximately 1.78 acres to a depth of 1 foot, resulting in approximately 2,900 bank cubic yards (bcy) of potentially impacted soil.

The existing institutional controls on Areas 1 and 2 and the Buffer Zone would be maintained, and any modifications or additions to these that EPA determines are necessary would be implemented as needed as part of the UMTRCA cover alternative. The institutional controls are necessary to ensure that residential uses do not occur at the Site, and that commercial and industrial uses or ancillary uses that could result in unacceptable risks do not occur on Areas 1 and 2 or the Buffer Zone. In addition to prohibiting land uses that could result in potential exposure to waste materials or contaminants in the Site, institutional controls would also limit or prohibit land uses or activities that could disrupt the integrity, performance, or longevity of the new landfill cover or other components of the remedy. Landfill gas and groundwater monitoring, as described in Sections 5.3.1.7 and 5.3.1.10, respectively, are also included as part of the UMTRCA cover alternative. Finally, similar to the OU-1 ROD-selected remedy, the UMTRCA cover alternative includes long-term inspections and maintenance activities of the engineered components (Section 5.3.1.10) and enforcement of the institutional controls (Section 5.3.2.1).

6.2.3.1 Overall Protection of Human Health and the Environment

The UMTRCA cover alternative would protect human health and the environment through the use of engineered containment, long-term surveillance and maintenance, and institutional controls on land and resource use. The landfill cover would reduce potential risks from exposure to external gamma radiation or radon gas emissions, and eliminate potential risks associated with inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, and wind dispersal of fugitive dust.

The cover would prevent users of the Site from exposure to external gamma radiation, primarily through shielding and increasing the distance to the radiation source (*i.e.*, the cover materials would be of sufficient thickness and design to attenuate gamma radiation). For the types of clay soils used for infiltration protection in the construction of final covers, the depth of cover required for gamma radiation shielding is on the order of 2 feet (60 cm). The total thickness of the final cover envisioned under the UMTRCA cover alternative would be a minimum of 5 feet (2 feet of clay soil, 2 feet of biointrusion rock/rubble with a lower drainage layer, and 1 foot of vegetative soil). A minimum thickness of 1 foot of clay is necessary to meet the UMTRCA and NESHAP radon flux standard (see Appendix F).

The cover materials would also be of sufficient thickness and design to retard or divert the vertical upward migration of radon. The landfill cover would act as a diffusion barrier, allowing time for the decay of the relatively short-lived radon-222 gas (the half-life for radon-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon needs only to be detained in the cover materials for a few days in order to decay to its non-radioactive progeny, thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a gas control system. Calculations presented in Appendix F indicate that the cover design, a clay layer thickness of 2 feet, combined with a 2-foot thick rock/rubble layer and a 1-foot thick vegetative layer, would provide sufficient radon attenuation to meet the radon emissions ARAR of 20 picocuries per square meter per second (pCi/m^2s). As discussed in Appendix F, these calculations were based on the increased levels of radium expected to be present at the Site after 1,000 years of ingrowth of radium from the decay of thorium. A minimum thickness of 1 foot of clay is necessary to meet the UMTRCA and NESHAP radon flux standard after 1,000 years of radium in-growth and will also meet this standard after 9,000 years when peak radium (and therefore radon) values are projected to occur (see Appendix F).

The potential for direct contact with waste materials would be eliminated by placing a barrier (multi-layer landfill cover including biointrusion layer) between the waste materials and any potential receptors. Likewise, there would be no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place.

The multi-layer cover would also be designed to minimize infiltration of surface water through the wastes, thereby reducing the potential for leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier (e.g., a compacted clay layer meeting the specified permeability requirements). These are all conventional functions for landfill cover technologies and are widely used by government and industry to address similar circumstances where contaminated materials must be encapsulated to protect against future potential contact. Long-term maintenance of the cover and monitoring of the groundwater would ensure that the UMTRCA cover alternative functions as intended.

The UMTRCA cover alternative also requires monitoring of groundwater quality to ensure that groundwater quality meets ARARs (see Tables 3-1 through 3-3).[61] Management of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2 would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls (as described above) would ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions reflect the presence of radionuclides at the Site.

6.2.3.2 Compliance with ARARs

The UMTRCA cover alternative would comply with all ARARs, as explained below and as described in Tables 3-1 through 3-3.

6.2.3.2.1 Environmental Protection Standards for Uranium and Thorium Mill Tailings

The Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subpart A) provide standards for control of residual radioactive materials from inactive uranium processing sites. The standards were developed pursuant to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 U.S.C. § 2022 et. seq.). Although not applicable, some of the regulations that provide for closure performance standards are considered potentially relevant and appropriate to the UMTRCA cover alternative for OU-1. Specifically, the UMTRCA Standards presented in 40 CFR 192.02 (discussed in Section 3.1.3.1 of this FFS) require:

> Control of residual radioactive materials and their listed constituents shall be designed[62] to:
>
> (d) Be effective for up to 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

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[61] After issuance of the ROD in 2008, EPA announced its intention to address groundwater at the Site as part of a separate operable unit (OU-3).

[62] Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to § 192.02(a) and (b).

(e) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(3) Exceed an average[63] release rate of 20 picocuries per square meter per second, or

(4) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than 0.5 picocurie per liter.

(f) Provide reasonable assurance of conformance with the following groundwater protection provisions: […]

40 CFR § 192.02(d) requires that each disposal site "be designed and stabilized in a manner that minimizes the need for future maintenance." For UMTRCA tailings piles, the longevity consideration was initially addressed through placement of a rock armoring layer over the upper surface of the tailings pile capping system (Waugh, 2004, Smith, 1999, Lommler, et al., 1999, Caldwell and Reith, 1994, Caldwell and Shepherd, 1990, Reith and Caldwell, 1990, DOE, 1989, and Caldwell and Truitt, 1987). Later designs have included vegetative layers or rock mulch vegetated layers to control erosion to address the longevity standard (Waugh, 2004, Smith, 1999, Lommler, et al., 1999, Caldwell and Reith, 1994, Caldwell and Shepherd, 1990, Reith and Caldwell, 1990, DOE, 1989, and Caldwell and Truitt, 1987). To address longevity considerations for OU-1 and long-term hazards relating to disruption of the disposal site by natural phenomena within the context of a Subtitle D solid waste landfill cover, the UMTRCA cover alternative includes a rock or concrete rubble layer above the clay soil layer to restrict biointrusion and erosion into the underlying low permeability materials.

Three chemical-specific standards of the UMTRCA regulations are considered potentially relevant and appropriate (although not applicable) to OU-1. Specifically, the radon emission and groundwater protection standards for closed uranium tailing units are considered to be potentially relevant and appropriate standards for Areas 1 and 2. The unrestricted use standards for soil on vicinity properties are considered to be potentially relevant and appropriate for the evaluation and remediation of any remaining radionuclide occurrences on Crossroads Lot 2A2 and potentially on the Buffer Zone. The applicability of these chemical-specific standards to the UMTRCA cover alternative is discussed further below.

First, Subpart A of the UMTRCA standards provides that control of residual radioactive materials (defined to mean waste in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents) and their listed constituents shall be designed to provide reasonable assurance that the release of radon-222 from residual radioactive

[63] This average shall apply over the entire surface of the disposal site and over a least a 1-year period. Radon will come from both residual radioactive materials and from the materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

materials to the atmosphere will not exceed an average release rate of 20 pCi/$m^{2/}$s (40 CFR §192.02 (b)(1)). For inactive sites, this standard can be satisfied by providing reasonable assurance that releases of radon-222 from residual radioactive materials to the atmosphere will not increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half of a picocurie per liter (0.5 pCi/L) (40 CFR § 192.02(b)(2)). As discussed in Section 7.1.1.1 of the RI Addendum (EMSI, 2017a), radon flux measurements performed in 2016 (following the substantial completion of the non-combustible cover) demonstrate that Areas 1 and 2 currently meet this standard. The UMTRCA cover alternative would ensure that the radon emission standard promulgated under UMTRCA continues to be met in the future through placement of clean fill material and construction of the landfill cover. The landfill cover system would be designed appropriately to take into consideration future radon generation resulting from increased radium levels owing to the decay of thorium over time. Evaluations presented in Appendix F indicate that the landfill cover included in the ROD-selected remedy (and, by extension, the UMTRCA cover alternative, which provides even greater protections than the ROD-selected remedy) would provide sufficient radon attenuation to ensure that future surface emissions from Areas 1 and 2 would meet the UMTRCA radon standard.

Second, the UMTRCA regulations establish concentration limits for groundwater protection (see discussion in Section 3.1.1.1.3). Based on the presence of radioactive materials in OU-1, the groundwater protection standards (40 CFR § 192.02(c)(3) and (4)) and monitoring requirements (40 CFR § 192.03) are relevant and appropriate and would be met. Specifically, regrading of the landfill surface to promote stormwater drainage and installation of an engineered landfill cover under the UMTRCA cover alternative would greatly reduce the potential for infiltration through and generation of leachate within the landfill mass in Areas 1 and 2, thereby reducing the potential for infiltration of precipitation to cause migration of radionuclides to groundwater.

Third, the standards for cleanup of land and buildings contaminated with residual radioactive materials in Subpart B of the UMTRCA regulations are potentially relevant and appropriate requirements for the remediation of any radiologically-impacted soil that may be present outside of Areas 1 and 2 (*e.g.*, on the Buffer Zone/Crossroads Lot 2A2 Property). UMTRCA defines "land" to mean any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building. These soil standards address the remediation of soil contaminated with radium. Specifically, 40 CFR § 192.12(a) states:

> The concentration of Ra-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than:
>
> 3. 5 pCi/g, averaged over the first 15 centimeters of soil below the surface; and
>
> 4. 15 pCi/g, averaged over 15-centimeter-thick layers of soil more than 15 centimeters below the surface.

The EPA has promulgated guidance on the use of these UMTRCA soil standards for CERCLA site cleanups ("Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites," OSWER Directive 9200.4-25, February 12, 1998 [the UMTRCA Guidance]). This guidance document was discussed in detail in Section 3.1.1.5.1 of this FFS. In brief, the UMTRCA Guidance states that the subsurface concentration criterion (15 pCi/g) is not a health-based standard; rather, it was developed for use in limited circumstances that, for most CERCLA sites, are not considered sufficiently similar to UMTRCA sites to warrant use of the 15 pCi/g standard for subsurface soil (EPA, 1998). EPA also determined that although the UMTRCA soil standards were developed for Ra-226, they are also suitable for Ra-228. EPA further determined that the soil standards should be applied to both the combined level of Ra-226 and Ra-228 and the combined level of Th-230 and Th-232. These UMTRCA soil cleanup standards for vicinity properties, as modified by the UMTRCA Guidance, are considered potentially relevant and appropriate criteria for the evaluation and cleanup of radionuclides in soil on the Buffer Zone and Crossroads Property. The UMTRCA cover alternative would satisfy the UMTRCA soil standards through further investigation of radionuclide occurrences in soil outside of Areas 1 and 2 and through removal of soil that exceeds these standards, including removal of soil on the Buffer Zone and the adjacent Crossroads Property and consolidation of such soil in Areas 1 and 2.

6.2.3.2.2 National Emissions Standards for Hazardous Air Pollutants (NESHAPs)

EPA's National Emissions Standards for Hazardous Air Pollutants (NESHAPs) include standards for radon-222 emissions to ambient air from designated uranium mill tailings piles that are no longer operational. As discussed in Section 3.1.1.4.1, while not applicable, the radon-222 NESHAP is considered to be potentially relevant and appropriate. As discussed in Section 7.1.1.1 of the RI Addendum (EMSI, 2017a), radon flux measurements performed in 2016 (following the substantial completion of the non-combustible cover) demonstrate that Areas 1 and 2 currently meet the NESHAP radon standard. Similar to the OU-1 ROD-selected remedy, the UMTRCA cover alternative would ensure the radon emission standard continues to be met, through placement of clean fill material and construction of the landfill cover. Evaluations presented in Appendix F indicate that the landfill cover system included as part of the OU-1 ROD-selected remedy (and, by extension, the UMTRCA cover alternative) would provide sufficient radon attenuation to ensure that the radon NESHAP standard is met under both current conditions and in the future (1,000 years), accounting for future radon generation resulting from increased radium levels owing to the decay of thorium over time. This ARAR would require performance of radon flux measurement tests upon completion of construction of the engineered cover to demonstrate that the landfill cover achieves the radon emission standard. Such measurements would be performed in accordance with the procedures set forth in 40 CFR Part 61 Appendix B Method 115, or other procedures with prior EPA approval. Additional evaluations to demonstrate the ability of the landfill cover to meet the radon NESHAP may be performed as part of the remedial design.

6.2.3.2.3 Missouri Solid Waste Rules for Sanitary Landfills

Under RCRA Subtitle D, a state may promulgate more stringent regulations for landfills, provided that EPA approves them. Missouri is an approved state for regulating landfills. Missouri's solid waste regulations became effective July 1, 1997 (see 22 Mo. Reg. 1008, June 2, 1997) (the Solid Waste Rules). The Solid Waste Rules establish closure and post-closure requirements for existing sanitary landfills that are closed after October 9, 1991. Although not applicable to the closure of Areas 1 and 2, the Missouri Solid Waste Rules described below are considered relevant and appropriate. The UMTRCA cover alternative meets these ARARs.

The Missouri Solid Waste Rules require cover to be applied to minimize fire hazards, precipitation infiltration, odors and blowing litter, as well as to control gas venting and vectors, discourage scavenging, and provide a pleasing appearance (10 CSR 80-3.010(17)(A)). Final cover will consist of at least 2 feet of compacted clay with a coefficient of permeability of 1×10^{-5} cm/sec or less, overlaid by at least 1 foot of soil capable of sustaining vegetative growth (10 CSR 80-3.010(17)(C)(4)). Placement of soil cover addresses the requirements for minimization of fire hazards, odors, blowing litter, control of gas venting, and scavenging. Placement of clay meeting the permeability requirement addresses the requirement for minimizing precipitation infiltration. Placement of soil and establishment of a vegetative cover meet the requirement of providing a pleasing appearance. The final cover would prevent Site users from coming into contact with the waste material.

The Missouri Solid Waste Rules also contain minimum and maximum side and top slope requirements. Specifically, these regulations require the final slope of the top of the sanitary landfill to have a minimum slope of 5% (10 CSR 80-3.010(17)(B)(7)). MDNR regulations also require that the maximum slopes be less than 25%, unless it has been demonstrated in a detailed slope stability analysis that steeper slopes can be constructed and maintained throughout the entire operational life and post-closure period of the landfill. Even with such a demonstration, no active, intermediate, or final slope may exceed 33.33%.

The objective of these requirements is to promote maximum runoff without excessive erosion and to account for potential differential settlement of the waste and cap. Because landfilling of Areas 1 and 2 was completed approximately 30 years ago, most of the compaction of the refuse has already taken place and differential settlement is no longer a significant concern. The 5% minimum sloping requirement therefore is greater than necessary and may not be optimal (and may be suboptimal) in this case. Therefore, the 5% minimum sloping requirement is not considered appropriate. Sloping specifications would be designed to promote drainage and reduce infiltration of precipitation while minimizing the potential for erosion. It is anticipated that a 2% slope would be sufficient to meet drainage requirements while resulting in a lower potential for erosion. This approach should increase the life of the cover and overall longevity of the remedy compared to a steeper slope, which would be subject to increased erosion potential. Additionally, the maximum sloping requirements would be met.

The requirements for decomposition gas monitoring and control in 10 CSR 80-3.010(14) are considered relevant and appropriate (Section 3.1.3.4) and would be met. The number and locations of gas monitoring points and the frequency of measurement would be established in RD submittals to be approved by EPA and MDNR. In the event landfill gas is detected at the Site boundaries above the regulatory thresholds, appropriate gas controls would be implemented.

The requirements for a groundwater monitoring program in 10 CSR 80-3.010(11) are considered relevant and appropriate (Section 3.1.3.4). The monitoring program must be capable of monitoring any potential impact of the Site on underlying groundwater. The monitoring program would enable the regulatory agencies to evaluate the need for any additional requirements.

The substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate. These provisions provide a useful framework for OM&M and corrective action plans. They require post-closure plans describing the necessary maintenance and monitoring activities and schedules. These requirements would be used in addition to EPA CERCLA policy and guidance on developing robust OM&M and long-term monitoring plans.

6.2.3.2.4 Safe Drinking Water Act

40 CFR Part 141 establishes primary drinking water regulations, including maximum contaminant levels (MCLs) pursuant to Section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (SDWA), and related regulations applicable to public water systems. These MCLs apply to public drinking water systems. Missouri regulations (10 CSR 60-4.010 et seq.) also establish MCLs for public drinking water systems (Tables 3-1 through 3-3). Consistent with the NCP, MCLs and non-zero Maximum Contaminant Level Goals (MCLGs) are considered potentially relevant and appropriate to all potentially usable groundwater. Regardless of whether groundwater beneath the Site is subsequently determined to be usable for drinking water, regrading of the landfill surface to promote stormwater drainage and installation of an engineered landfill cover under the UMTRCA cover alternative would greatly reduce the potential for infiltration through, and generation of leachate within, the landfill mass in Areas 1 and 2, thereby reducing the potential for infiltrated precipitation to cause the migration of radionuclides to groundwater.

6.2.3.2.5 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against Ionizing Radiation (10 CFR Part 20) contain chemical-specific standards that address radiation protection. These regulations establish dose limits for individual members of the public and radiation workers, and define maximum permissible exposure limits for specific radionuclides in air at levels above background inside and outside of controlled areas. These requirements are considered potentially applicable during implementation of any remedial action. Specifically, to meet these regulations, perimeter air monitoring would be conducted during remedy implementation. Site health and safety plans would address worker protection consistent with these requirements (including perimeter air monitoring); therefore, the UMTRCA cover alternative would meet this ARAR.

6.2.3.2.6 Missouri Well Construction Code

MDNR has promulgated regulations pertaining to the location and construction of water wells. The Well Construction Code (10 CSR 23-3.010) prohibits the placement of a well within 300 feet of a landfill. These rules should provide protection against the placement of wells on or near the Site. The regulations on monitoring well construction (10 CSR 23-4) would apply to the construction of new or replacement monitoring wells. The UMTRCA cover alternative would meet this ARAR through enforcement of the existing institutional controls[64] and by adhering to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

6.2.3.2.7 Missouri Stormwater Regulations

The Missouri regulations governing stormwater management at construction sites are set out in 10 CSR 20-6.200 (Table 3-3). A disturbance of greater than 1 acre or the creation of a stormwater point source during construction of the remedy would trigger these requirements. The UMTRCA cover alternative would meet these requirements through implementation of a Stormwater Pollution Prevention Plan (SWPPP), use of Best Management Practices (BMPs) during construction, installation and maintenance of an engineered landfill cover to prevent stormwater from contacting the waste materials, and construction and maintenance of stormwater diversion and control structures to control runon and runoff and reduced erosion potential as part of the design of the engineered landfill cover.

6.2.3.3 Long-Term Effectiveness and Permanence

These criteria refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. The UMTRCA cover alternative provides engineered containment in conjunction with monitoring, maintenance, and land use controls designed to be effective over the long term. Because RIM would remain on-site under this remedy alternative, the potential risks associated with the RIM would remain. Construction of an engineered cover for Areas 1 and 2 would reduce the potential for exposure from the following potential pathways: external gamma exposure; inhalation of radon gas or dust containing radionuclides or other constituents; dermal contact with impacted materials; and incidental ingestion of soil containing radionuclides or other chemicals. Maintaining the integrity of the engineered cover would protect the underlying RIM from erosion and intrusion. An intact cover provides a reliable method to control exposure of the RIM to surface receptors

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[64] In addition, the deed restrictions currently in place on Areas 1 and 2 and the Buffer Zone (and which are to be maintained in perpetuity as part of the ROD-selected remedy and UMTRCA cover alternative) prohibit the placement of water wells for drinking water or agricultural purposes.

and mitigates potential migration of radionuclides or chemicals from the covered waste materials.

The conceptual design of the engineered cover included in the UMTRCA cover alternative was based on a typical design (Smith, 1999 and DOE, 1989) developed to meet the UMTRCA performance standards. The cover design will be required to last at least 200 years with minimal maintenance required. Specifically, the engineered cover included in the UMTRCA cover alternative was evaluated for its protectiveness against gamma radiation and radon emissions, both in terms of both risks to workers and in terms of compliance with ARARs (*e.g.*, UMTRCA and NESHAP standards). These evaluations were performed based on the 95% UCL for the current levels of radium-226 in Areas 1 and 2 and the projected increase in radium-226 levels that will occur in the future (1,000 years) due to in-growth of radium-226 from decay of thorium-230. The engineered cover included in the ROD-selected remedy (and therefore by extension the UMTRCA cover alternative) was determined to be protective and compliant with the ARARs both under existing and future (1,000 year) conditions (Appendix F). Peak radium values are projected to occur in 9,000 years. The design of the engineered cover included in the ROD-selected remedy (and therefore by extension the UMTRCA cover alternative) was determined to be protective and compliant with ARARs based on the projected peak radium-226 levels that would occur in approximately 9,000 years (Appendix F).

Due to the long time-frames a containment system would need to remain in place and effective at limiting exposures to and migration of radionuclides, there are uncertainties associated with the long-term permanence of the ROD-selected remedy (or any remedy that entails containment). A potential exists for additional consolidation and settlement of the waste materials over time that could affect the structural integrity of the landfill cover, which could require repair, or potentially replacement, of all or portions of the landfill cover in the future. Such effects would be easily identified by visual inspection or comparison of successive aerial topographic surveys, such that repairs could be implemented before any waste materials were exposed or any contaminants were released; however, if such repairs are not performed in a timely manner, a potential for release could occur. The area with a 0.2% flood recurrence interval (i.e., the 500-year floodplain) is located adjacent to Area 2 and extends along St. Charles Rock Road to the east side of Area 1. The 500-year floodplain in the vicinity of the Site is protected from flooding through a combination of an engineered levee and stormwater management system operated by the Earth City Flood Control District to protect the commercial real estate in the Earth City Industrial Park. Although largely based on passive physical components (e.g., levee and stormwater collected basins), the Earth City flood control system does require operation of pumps to reduce pore water pressures within the levee system and gates to prevent backflow of flow water from the Missouri River into the Earth City stormwater channels and basins. Consequently, although the Site is not located within the area of the 500-year floodplain protected by levees, the proximity of the Site to the margins of the 500-year floodplain that is protected by levees, the reliance on external controls such as the Earth City levee and flood control system to prevent flooding from reaching the toe of the landfill, and location of the Site within the geomorphic floodplain raise uncertainty regarding the potential for future flooding and related impacts to the integrity of the containment system. This uncertainty would be addressed through design considerations (e.g., use of a thick starter berm to provide isolation of the waste materials from floodwaters, inclusion of rock armoring at the base of the starter berms/landfill toe, etc.) and performance of inspections and monitoring and implementation of any required maintenance, repairs or replacement of containment features.

Robust and durable long-term site management plans and institutional controls would be required to address such uncertainties. Long-term groundwater monitoring would require monitoring plans that specify the monitoring locations, sampling frequencies, parameters, sampling and analysis procedures, and evaluation approach. Such plans would be developed and submitted as part of the O&M Plan in the RD/RA process. The monitoring program may be optimized with time based on the monitoring results, e.g., monitoring locations or the list of analytes may be adjusted to increase effectiveness or efficiency. Monitoring plans and groundwater protection standards would need to be consistent with the requirements found in the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192 Subparts A and B) and the Missouri Solid Waste Rules for Sanitary Landfills [10 CSR 80-3.010 (11)]. The groundwater monitoring program is expected to be effective in verifying the remedy is performing as required and groundwater is protected.

Existing institutional controls cannot be removed or modified without the consent of EPA, MDNR, and the property owners. Revision of the institutional controls to be consistent with the Missouri Environmental Covenants Act would further prevent complications that could otherwise arise during future property transfer actions. While not anticipated, even with the loss of institutional controls and long-term management, the landfill cover would still act to passively prevent potential contaminant migration and human exposures for an indefinite period.

By moving the radiologically-impacted soil from the Buffer Zone/Crossroads Property to the Site (and thereby subjecting it to the remedial measures and controls described above), the UMTRCA cover alternative provides long-term effectiveness and permanence relative to the Buffer Zone/Crossroads Lot 2A2 Property.

6.2.3.3.1 Magnitude of Residual Risks

The calculated lifetime risks to the reasonably maximally-exposed individual (an on-site groundskeeper) from Areas 1 and 2 after the UMTRCA cover alternative has been implemented (Appendix H) are as follows:

- Area 1: 6.2×10^{-7} for year 1, 4.0×10^{-6} for year 1,000, and $8.9 \text{ x } 10^{-6}$ for year 9,000; and

- Area 2: 8.5×10^{-7} for year 1, 7.3×10^{-6} for year 1,000, and $1.7 \text{ x } 10^{-5}$ for year 9,000.

Based on the expected ingrowth of radium-226 over the period from 1,000 to 9,000 years (when peak radium levels are expected to occur), the projected risks at 9,000 years would be approximately 2.23 times greater for Area 1 and 2.34 times greater for Area 2 than those estimated for the 1,000-year time frames.

These calculated risks are attributable to gamma radiation and radon emissions from the RIM that would remain at the Site after implementation of the UMTRCA cover alternative. Given that the RIM would be capped and thus rendered inaccessible, along with the use of access restrictions and institutional controls, direct contact with RIM and exposure from ingestion, inhalation, or dermal contact with the waste materials would not be expected to occur. Ingestion, inhalation or dermal contact are the primary exposure pathways for any non-radiological COPCs that may also be present in Areas 1 and 2. Because no complete exposure pathway would exist for such materials after completion of the cap construction, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks from non-radiological COPCs.

The calculated risk levels are below or within EPA's target risk range of 1×10^{-6} to 1×10^{-4}, and therefore the magnitude of the radiological carcinogenic risk from capped RIM in these two remediated areas is acceptable. These risks do not specifically include potential exposures from non-radiological landfill waste after construction is complete. However, those wastes would also be covered by a cap which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

After soils containing radionuclide concentrations above the cleanup levels are removed from the Buffer Zone/Crossroads Lot 2A2 Property, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.3.3.2 Adequacy and Reliability of Controls

The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. The engineered cover included in the UMTRCA cover alternative was determined to be protective and compliant with the ARARs both under existing and future (1,000 year) conditions (Appendix F). Peak radium values are projected to occur in 9,000 years. The design of the engineered cover included in the UMTRCA cover alternative remedy was determined to be protective and compliant with ARARs based on the projected peak radium-226 levels that would occur in approximately 9,000 years (Appendix F).

In addition to being designed to be protective and compliant with ARARs based on the projected in-growth of radium over the next 1,000 years, the cover construction is based on and relies upon the use of natural materials that would be expected to remain in place and meet performance criteria for at least 200 years, as required by the UMTRCA longevity standard 40 CFR 192.02 (a). Post-closure inspection and maintenance of the cover, as required by the solid waste regulation ARARs and as routinely performed at thousands of landfills across the country, also would ensure long-term reliability of the landfill cover.

Currently the surfaces of Areas 1 and 2 are not graded to promote drainage of stormwater, but instead are generally flat with several surface depressions which act to increase precipitation accumulation and infiltration through the waste mass. In addition, no engineered landfill cover exists over these areas. Although the non-combustible cover installed over portions of Areas 1 and 2 in 2016 was intended to serve as a short-term measure to prevent potential risks from a surface fire, it also serves to reduce the potential for erosion of the waste and soil, reduce radon emissions and gamma radiation, and prevent direct contact with the waste and RIM, even though it was not primarily intended or designed for these purposes. The non-combustible cover was placed on the existing grades, and therefore it does not promote stormwater drainage or reduce the potential for infiltration of precipitation. Regrading to promote drainage and installation of the engineered landfill cover included in the UMTRCA cover alternative would significantly reduce infiltration of precipitation and potential for leaching, providing further protection against potential impacts to groundwater.

Modeling of potential landfill covers conducted as part of the Fate and Transport Evaluations (SSP&A, 2016) indicated that inclusion of a GCL would further reduce the potential for infiltration and therefore provide a greater degree of protection against precipitation infiltration and leaching to groundwater. A properly hydrated GCL is expected to possess a permeability coefficient of 10^{-9} cm/sec as compared to 10^{-5} or 10^{-7} for compacted clay. Although a GCL includes synthetic components such as a woven geotextile composed of polypropylene, which may degrade over time, it also includes a bentonite clay layer which is composed of natural material (bentonite) that in a flat-lying application, is expected to remain effective for hundreds of years. A refinement of the GCL would be a geocomposite clay liner that would include a flexible membrane (*e.g.*, high-density polyethylene or HDPE) in addition to a bentonite layer and woven geotextile. Studies of the projected life of geomembranes exposed to air, water and leachate have indicated that the service life of a geomembrane is on the order of hundreds of years, may exceed 700 years, and would probably be on the order of 1,000 years or longer (Marr and Christopher, 2003; Kavazanjian et al., 2006; National Research Council, 2007; Rowe, Rimal, and Sangam, 2009; Rowe and Rimal, 2008; Rowe and Islam, 2009; Rowe and Jones, 2015; and Benson, 2016). The service life of a GCL is influenced by a variety of factors (Rowe and Jones, 2015), including:

1. Loss of bentonite during placement;
2. Lateral movement;
3. Assumption that the geosynthetic component of the GCL is not critical to long-term performance of the bentonite component;
4. Proper installation performance of the seams;
5. No significant long-term loss of bentonite due to internal erosion through the GCL under hydraulic gradients that may occur;
6. Interaction (e.g., cation exchange) with the adjacent soil impact on hydraulic conductivity.

Temperature is an additional factor affecting the service life of a GCL (Stark, Jafari and Rowe, 2012).

Inclusion of a GCL in the engineered cover could also create a potential slip surface that could result in a failure (movement or displacement of portions of the cover material) on steeper slopes. This potential could be addressed by limiting use of a GCL to the upper, flatter (2%) slopes of the final grades of Areas 1 and 2, or potentially through inclusion of a drainage layer above the GCL. However, this approach would need to be evaluated during remedial design.

Long-term OM&M would include routine cover and stormwater ditch inspection and service, if necessary, to mitigate erosion and, if a landfill gas collection and treatment system is needed, OM&M of such a system. Long-term monitoring would also be implemented to assess compliance with groundwater standards. The performance of these engineering controls would also be re-evaluated during statutory 5-year reviews.

Covenant restrictions (Appendix A) have been recorded by each of the West Lake Landfill property owners against their respective parcels and the entire West Lake Landfill (including Areas 1 and 2), as well as the Buffer Zone, prohibiting residential use (including use as a day care, preschool, or other educational use) and use of groundwater for drinking water. With respect to Areas 1 and 2 and the Buffer Zone, restated and amended restrictive covenants filed in 2016 (Appendix A) also prohibit (1) the installation and use of wells for drinking water; (2) the construction of buildings or other habitable structures for any purpose; (3) the construction of underground pipes/utilities and excavation work (except in conjunction with approved remedial activities); and (4) use of the property for commercial or industrial purposes, including as a storage yard (whether indoor or outdoor).[65] Covenant restrictions cannot be terminated without the written approval of the parcel owners, MDNR, and EPA. It is assumed that the restrictions would be revised as necessary during RD to address the requirements set forth under the Missouri Environmental Covenants Act.

The current covenants and restrictions for Areas 1 and 2 and the Buffer Zone would be adequate to provide protection to human health under the UMTRCA cover alternative. Permanence of these restrictions is assumed to be adequate for the foreseeable future, as both EPA and MDNR approval are required to remove or modify the restrictions. The adequacy of the restrictions would be continually evaluated during the statutorily-required 5-year reviews.

6.2.3.3.3 Climate Change and Potential Impacts of a Tornado

Per EPA's SOW, the FFS is to include a discussion of climate change and vulnerabilities associated with extreme weather events—such as possible flooding or tornadoes—as part of the evaluation of long-term effectiveness. This evaluation should consider any system

[65] Construction work and commercial and industrial uses were also previously precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc. in January 1998. This Declaration prohibited the placement of buildings and restricted the installation of underground utilities, pipes and/or excavation upon the property. The 2016 Declaration of Covenants amends and restates the requirements of the May 1997 and January 1998 covenants but otherwise does not alter them.

vulnerabilities to potential climate change in accordance with EPA's "Climate Change Adaptation Technical Fact Sheet: Landfills and Containment as an Element of Site Remediation (EPA, 2014a) and the EPA Region 7 Climate Change Adaption Implementation Plan (EPA, 2014b). EPA also required the FFS to include information and results from the "Evaluation of Possible Effects of a Tornado on the Integrity of the ROD-Selected Remedy" (EMSI, 2013f).

The UMTRCA cover alternative includes an engineered landfill cover that would be classified as in-situ containment system (EPA, 2014a). Climate change adaptation for a containment system focuses on evaluating the vulnerability of the system to climate change and implementing adaptation measures, when warranted, to ensure the remedy continues to prevent human or environmental exposure to contaminants of concern (EPA, 2014a).

Evaluation of the vulnerability of a containment system to climate change may involve:

- Identifying climate change hazards of concern;
- Characterizing the system's exposure to those hazards of concern;
- Characterizing the system's sensitivity to the hazards of concern; and
- Considering factors that may exacerbate system exposure and sensitivity.

A climate change exposure assessment identifies climate change hazards of concern for a remediation system in light of a range of potential climate and weather scenarios (EPA, 2014a). EPA identified the following potential climate change impacts for landfills and containment remedies:

- Increased occurrence of extreme temperatures;
- Sustained changes in average temperatures;
- Decreased precipitation and increasing drought;
- Increased heavy precipitation events;
- Increased flood risk; and
- Increased intensity of tornadoes.

EPA indicated that precipitation changes that could degrade cover systems is a specific climate change hazard relative to landfills and containment systems.

A climate change sensitivity assessment evaluates the likelihood for the climate change hazards of concern to reduce the effectiveness of a landfill/containment system. Damage to cover materials and a potential washout of contaminated contents, as well as unexpected and additional costs for repairing or replacing a cover system, are particular concerns for a landfill containment system. Specific containment system components included in the UMTRCA cover alternative that could be affected by climate change include:

- Physical and water damage to the vegetative layer overlying the low-permeability cover layer;

- Physical and water damage to a GCL layer if such a layer were to be included in the cover system;
- Physical or water damage and reduced access to surface water drainage systems and structures; and
- Physical damage or reduced access to groundwater and landfill gas monitoring wells.

In particular, the vegetative layer could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and increases in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potentially increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence.

The CCL and GCL layers could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low permeability materials (CCL or GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Such impacts are not considered to be significant because the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. In addition, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards, and are projected to remain below these standards in the future (see prior discussion in Section 2.3.1 and in RI Addendum Section 7.1.1.1). Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality or radon emissions are not expected to be significant. More importantly, the vegetative layer would exhibit significant visual signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL/GCL. Therefore, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities such as temporary irrigation to maintain the grass cover, overseeding with grasses that required less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Further, such impacts are not expected to result in release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying low-permeability layer. Inclusion of the rock mulch layer is anticipated to provide additional protection against erosion and contribute to the longevity of the UMTRCA cover. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot-thick rock layer within the cover system, stormwater erosion—even under the most severe storm event—is not anticipated to result in erosion down through the entire landfill cover.

Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs (if any are needed). Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. However, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair, and replacement of cover material in response to any damage that may occur.

The UMTRCA cover alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, based on FEMA's flood insurance rate map (FIRM) the extent of the 500-year flood does not include areas where waste materials are present in Areas 1 and 2. The Buffer Zone and areas to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River are protected by the engineered levee and by the stormwater and flood control systems installed to protect the Earth City Industrial Park. In the event of a failure of the Earth City levee and flood control system, floodwaters associated with a 500-year recurrence interval flood could extend to the toe of Area 2. The conceptual design for the UMTRCA cover alternative includes construction of a perimeter (starter) berm along the toe of the entire northern boundary of Area 2 that would result in placement of approximately 26 feet of rock and soil between any possible floodwaters and the landfilled waste. This perimeter berm may be further protected from flooding by placement of rip-rap along the base of the berm. Therefore, although increased occurrences of flooding in the area of the Site may be a potential impact of climate change, the UMTRCA cover alternative is not expected to be vulnerable to flooding.

An evaluation of the potential impacts of a tornado on the ROD-selected remedy was previously performed and submitted to EPA (EMSI, 2013f). This evaluation concluded that the ROD-selected remedy (and therefore, by extension, the UMTRCA cover alternative) was not vulnerable to impacts from a tornado. Specifically, based on review of the impacts of tornados at other sites, a tornado is not expected to damage the vegetative layer. No published information regarding the potential impact of a tornado on grass or other vegetative cover was identified in conjunction with the review of published literature for this assessment. Review of published assessments and photographs of impacts associated with other tornadoes (EMSI, 2013f), such as the 2011 Joplin Missouri tornado, the April 22, 2011 "Good Friday" tornado in St. Louis, the April 2011 tornadoes in the southeastern U.S., (FEMA, 2012, 2010, 2007a, and 1999; FOXNews, 2012; Glass, undated; McCarthy, Ruthi and Hutton, 2007; Marshall et al., 2008; NOAA-NWS, 2013, 2012, 2011a 2011c and 2003; The Weather Channel, 2012d; and UPI, undated) and the St. Charles and Calvert Counties, MD 2003 tornado (Gailey, 2002) did not identify any damage or identifiable impacts to grassy areas. Even if a tornado were to impact the vegetative cover, such an impact is not considered to be significant because it could be easily identified and repaired. Further, due to the design and thickness of the engineered cover, any impacts from a tornado are not expected to result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy above-ground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the UMTRCA cover alternative is not considered to be vulnerable to impacts from a tornado.

Although the UMTRCA cover alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could nevertheless be considered during remedial design. Several aspects of the conceptual design of the UMTRCA cover alternative already provide a degree of adaptation for climate change. For example, regrading of the surface of Areas 1 and 2 to a 2% slope would reduce the velocity of runoff across these areas as compared to a 5% slope. Installation of runoff collection and diversion systems along the base of the above-grade portion of the North Quarry part of the Bridgeton Landfill adjacent to Area 1, as well as along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2, would divert runoff from these areas around Areas 1 and 2 to reduce the potential for impacts from heavy precipitation events. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls in order to increase the overall resilience of these features to heavy precipitation events. For example, use of grass-seed mixtures that are more tolerant of long-term changes in precipitation or temperature, and/or additional soil to increase water storage capacity, could be evaluated as part of the design. Similarly, inclusion of geotextile at the base of the vegetative or biointrusion layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low-permeability layer of the cap. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures can be included as part of the ongoing inspection and maintenance program.

6.2.3.3.4 Potential Impacts of a Subsurface Heating Event

The evaluation of potential impacts on the UMTRCA cover alternative if a subsurface heating event were to occur are the same as those previously discussed for the ROD-selected remedy (Section 6.2.2.3.4). In the event that a subsurface heating event were to occur in Area 1 or Area 2, such an event is not expected to impact the long-term effectiveness of this alternative. As previously discussed for the ROD-selected remedy (Section 6.2.2.3.4), the primary impact that may occur would be a temporary potential increase in radon emissions which is not expected to pose unacceptable risks to workers or the community (Appendix E). Destruction or modification of the waste material by increased temperatures could result in a reduction in volume which could cause subsidence and/or differential settlement of the waste mass. Subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time could result in displacement or disruption of an engineered cover system, thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

- Installation and operation of a heat extraction barrier or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2, the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills such as those located in the deeper quarry landfill, which provides a significant insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

6.2.3.3.5 Effects of an Isolation Barrier

EPA's SOW for the RI Addendum and FFS (EPA, 2015b) requires an evaluation of the effects of an isolation barrier to be included in the FFS. Installation of a heat extraction barrier consisting of various heat extraction points (regardless of location) would not have a significant impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability or cost of the UMTRCA cover alternative. Installation of heat extraction wells could result in bringing RIM to the ground surface which, if not properly managed, could result in a potential for an airborne release. However, most drilling at the Site has been performed using Sonic drilling techniques that generate little to no cutting material, thereby reducing the potential risk. Installation of heat extraction wells after installation of a new cover system would require repair of the cover system around such penetrations which could lead to additional maintenance or further repairs in the future; however, such activities are routinely performed at solid waste landfills and are not expected to significantly impact the OM&M costs.

Installation of a physical barrier, such as a vertical wall of inert material, would require excavation and regrading of the above-grade portion of the North Quarry part of the Bridgeton Landfill located over the southern portion of Area 1. If such a barrier were to be installed prior to implementation of the UMTRCA cover alternative, the design of the engineered cover included in the UMTRCA cover alternative would need to account for any changes in the surface grades, stormwater drainage system, and the presence of any above-grade features (*e.g.*, heat extraction points, temperature monitoring probes, or additional gas extraction wells) that may be installed in conjunction with a physical barrier. In contrast, if a physical barrier were installed after construction of the engineered cover included in the UMTRCA cover alternative, that portion of the engineered landfill cover that extended over the area of an isolation barrier and the associated revised landfill grades would need to be removed as part of construction of an isolation barrier.

Because only Area 1 is located contiguous to the Bridgeton Landfill, an isolation barrier would only be installed near Area 1. Area 2 is physically separated by native material (soil and rock) present beneath the leachate treatment facility and Site access road from the Bridgeton Landfill. Therefore, any potential impacts to or from a potential isolation barrier from or to the ROD-selected remedy would only affect Area 1.

6.2.3.3.6 Environmental Justice Considerations

EPA's SOW (EPA, 2015b) requires the FFS to include an acknowledgement of any environmental justice concerns to be included in both the short-term and long-term effectiveness sections of the alternatives analysis. As discussed under the evaluation of the ROD-selected remedy (Section 6.2.2.3.6), EJSCREEN analyses did not identify any environmental justice concerns in the vicinity of the Site. Discussions with EPA Region 7 personnel on August 1, 2016 indicated that EPA had not identified any environmental justice concerns near the West Lake Landfill. However, EPA did indicate that interviews with the residents of the Terrisan Reste mobile home park suggested that more traditional methods of communication, such as U.S. mail, would be more appropriate than electronic methods for providing information to this group of residents. These actions are addressed as part of the Community Involvement Plan for the Site.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

6.2.3.4 Reduction of Toxicity, Mobility or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Overall, the UMTRCA cover alternative, similar to the ROD-selected remedy, is a containment remedy and therefore generally would not result in any reduction in the toxicity, mobility, or volume of the waste material through treatment.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be fully neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout portions of the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. The UMTRCA cover alternative does not include excavation and off-site disposal of RIM but rather only includes regrading of a relatively small amount of solid waste material (currently estimated to be approximately 112,000 yards) in order to reduce the angle of the perimeter landfill slopes, achieve the required minimum surface grade, and create space for stormwater retention basins. A small portion of this material (approximately 15,750 cubic yards) is estimated to be RIM which would be placed back into Area 1 or 2 beneath the new engineered landfill cover. This alternative is a containment remedy and therefore does not include excavation of RIM as a component. Therefore, ex-situ treatment techniques are not applicable to the UMTRCA cover alternative. The heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within portions of the overall solid waste matrix in portions of Areas 1 and 2 suggest that in situ treatment techniques are not applicable. Specifically, the waste heterogeneity would impact the ability to deliver reagents uniformly or to specific materials, resulting in significant uncertainty regarding the potential effectiveness or implementability of such treatment. Additional evaluation of the potential effectiveness and implementability of potential treatment technologies is presented in Section 4 of this FFS. The UMTRCA cover alternative for the Buffer Zone/Lot 2A2 also would not reduce toxicity, mobility, or volume through treatment because it consists of moving radiologically-impacted soil from the Buffer Zone/Lot 2A2 to Area 1 or 2, where it would be consolidated with the RIM.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. Suspect material would initially be stored on site while test results were obtained to verify the presence, if any, and type of hazardous wastes encountered. Storage would be conducted in accordance with RCRA and State hazardous waste regulation requirements for storage containers or units and limitations on the duration of storage (90 days if the amount of hazardous waste exceeds 2,200 lbs. in a month or 270 days if the amount is less than 2,200 lbs. a month).[66] Procedures to be used for testing,

[66] These storage limitations assume that the off-site facility is located more than 200 miles from the Site. This distance is assumed based on the expectation that any identified hazardous waste would also be rad-contaminated and therefore shipped to one of the four off-site disposal facilities identified in Section 4.3.5.4.

storage, management, treatment, and disposal of any hazardous wastes or mixed wastes that could be encountered during implementation of the alternative would be documented as part of the RD activities.

To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's Land Disposal Restrictions (LDR) program and Universal Treatment Standards (UTS)) and in accordance with the permits and standard operating procedures of the receiving facility. Examples of treatment processes include stabilization of soil and micro- or macro-encapsulation of debris. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste or the radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies, but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

As the expected volume of waste material that would be disturbed during landfill regrading is relatively small, the amount of hazardous waste that may be encountered, if any, during implementation of the UMTRCA cover alternative is also expected to be relatively small. Therefore, it is anticipated that any hazardous waste that may be encountered during implementation of the UMTRCA cover alternative would be shipped to an off-site disposal facility by truck.

6.2.3.5 Short-Term Effectiveness

During the construction period, the UMTRCA cover alternative could pose radiation exposure and physical hazards for workers and result in additional local truck traffic. The UMTRCA cover alternative for the Buffer Zone/Lot 2A2 would be effective over the short term, and the relatively short duration required to remove the small amount of impacted soil should result in no significant adverse impacts.

The UMTRCA cover alternative includes excavation and relocation of waste material from the steeper slopes of Area 1 and 2 in order to meet the minimum and maximum slope angle requirements. Similar to the ROD-remedy, this alternative would include relocation of approximately 112,000 cubic yards waste materials. Of this amount, approximately 4,000 yards will be cut to achieve the minimum surface slope and promote drainage from the surfaces of Areas 1 and 2, 12,000 yards are expected to be cut to create space for construction of the starter berms, approximately 39,000 yards are expected to be cut to reduce existing perimeter slopes to below 25%, and approximately 23,000 yards are expected to be cut to create space for construction of a surface water detention basin in Area 1. The remaining approximately 35,000 yards reflect regrading of inert fill (*e.g.,* concrete rubble) piles on the surface of Areas 1 and 2. Of the 77,000 cubic yards of MSW that would be regraded (i.e., exclusive of the inert fill), approximately 15,750 cubic yards is anticipated to contain RIM. Therefore, this alternative would entail some excavation, handling, loading and transport of MSW and RIM within the Site associated with re-contouring to achieve slope requirements, and thus could pose some short-term exposure risks to on-site workers. The number of truck trips required to import construction materials to the Site would also result in additional physical risks to the community and/or workers due to the potential for traffic accidents.

Evaluation of potential short-term risks to the community and workers that may result from implementation of this alternative are presented in Appendix H and are discussed below. Potential short-term risks to the community and workers would be addressed through monitoring and dust control and other mitigative measures to assess and limit worker and community exposures during construction. Adherence to OSHA practices would be necessary to limit worker exposures and accidents.

6.2.3.5.1 Protectiveness of the Community During Remedial Actions

The projected carcinogenic risks that may be posed to off-site residents by this alternative would be 1.9×10^{-7}, which is below EPA's accepted risk levels (Appendix H). No non-carcinogenic risks are expected to occur.

In order to further ensure that construction activities do not pose unacceptable risks, effective dust control measures would be implemented from the start of the project. An extensive perimeter environmental monitoring system has already been installed at the Site. Results of monitoring along the perimeter of Areas 1 and 2, combined with monitoring performed in the work zone during various investigative activities, have indicated that no significant airborne migration of radionuclides is occurring and that workers and the general public are not being exposed to radionuclides above background levels. Continued monitoring during construction would identify any potential for releases that could impact the area outside the work location.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each alternative. For the UMTRCA cover alternative, the projected incidence of transportation accidents associated with the importation of materials for the multi-layer landfill cover is 0.62, meaning that there would be a 62% probability of at least one transportation-related accident occurring during implementation of the remedy. To address this risk, traffic control for the incoming shipment of the materials would be implemented from the project start. All drivers would be cautioned about the normal congestion existing on St. Charles Rock Road. Routing of trucks, safety briefings, and adherence to traffic laws would reduce but not necessarily eliminate the potential for accidents. To the extent possible, shipments would be scheduled to avoid the highest traffic times.

Vehicle operations during importation of the materials for the multi-layer landfill cover and during landfill regrading and cover construction for the ROD-selected remedy (and therefore by extension the UMTRCA cover alternative) are projected to emit 19,000 tons of carbon dioxide equivalent emissions to the atmosphere (Appendix I, Table I-3).

As Areas 1 and 2 are regraded during cap installation, the nuisance attraction to and congregation by birds at and above the affected areas could be problematic unless effectively controlled. Concerns include odor management, vector control, and the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. Excavation best management practices—including immediate re-deposition of cut material, limiting the area of excavation, and application of daily soil cover—are included in the UMTRCA cover alternative, and, if necessary, mitigation measures such as tarps, visual and auditory frightening devices, or wire or monofilament grids strung over exposed refuse to prevent bird access, could be implemented to minimize bird attraction to and congregation at and above the disturbed areas.

As Areas 1 and 2 are regraded during cap installation, stormwater controls would be implemented in accordance with Missouri Storm Water regulations 10 CSR 20-6.200.

6.2.3.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6, as part of the evaluation of long-term effectiveness, a screening-level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community.

6.2.3.5.3 Protectiveness of Workers During Remedial Actions

The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. The UMTRCA cover alternative), the projected increased carcinogenic risks are projected to be 2.8×10^{-5}, which is within EPA's accepted risk range. However, projected non-cancer risks to workers are estimated to be 27.0, primarily owing to potential exposures to zirconium. For the UMTRCA cover alternative, the projected incidence of industrial accidents is 5.7 over the life of the project (Appendix H). The projected radiation dose to a remediation worker is 60.2 millirems/year (mrem/yr) [Appendix H)].

A complete and comprehensive Health and Safety Program would form the core of worker protectiveness measures. The program would direct protective actions of all personnel on the Site. All workers at the Site would be trained to handle both radioactive materials (Rad Worker Training) and hazardous materials (HAZMAT Training). Protective clothing and equipment and constant monitoring for toxic hazards and radioactive emissions would be mandated. All workers on the project would be required to adhere to the project safety requirements, including any sub-contractors or vendors who are at the Site for an extended period of time. Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers including the projected non-carcinogenic risks identified above.

6.2.3.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from implementation of the UMTRCA cover alternative. A screening-level ecological assessment was performed as part of the original BRA (Auxier, 2000) and was revised as part of the updated BRA (Auxier, 2017a). The results of that assessment are presented in Section 7 of the BRA (Auxier, 2000) and Appendix B of the updated BRA (Auxier, 2017a). No wetlands are located within the on-site construction footprint of this alternative, and no endangered species were identified.

The activities to be conducted during Site regrading and cover construction would affect wildlife and plant life on Areas 1 and 2 and possibly adjacent portions of the Site. This disruption would be temporary and would last for the period of active construction. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Regrading of Areas 1 and 2 and construction of the engineered landfill cover included in the UMTRCA cover alternative would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.3.5.5 Ability to Monitor Effectiveness

Measurement of gamma radiation and radon flux through the newly constructed landfill cover would be conducted on Areas 1 and 2 after construction is complete. Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2. Measurements of subsurface occurrences of landfill gas and radon levels would be conducted along the property boundaries adjacent to Areas 1 and 2 to verify that off-site gas migration above regulatory thresholds does not occur.

6.2.3.5.6 Time Until Remedial Action Objectives Are Achieved

The RAOs of (1) preventing direct contact with contaminated media (2) preventing exposure by inhalation and external radiation; (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; and (5) controlling radon and landfill gas emissions from Areas 1 and 2 would be met once construction of the new engineered landfill cover over Areas 1 and 2 is completed. The RAO related to the Buffer Zone and Crossroads Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas.

Construction is estimated to require approximately 1.8 years after approval of the RD. Preparation of the RD should be completed within approximately one year of authorization to proceed with the RD. Therefore, the remedial action objectives should be achieved within approximately 2.8 years of authorization to begin (Appendix J).

6.2.3.6 Implementability

The design and construction of a landfill cover, with subsequent monitoring and maintenance as specified for the UMTRCA cover alternative, is not expected to pose any significant implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 are readily available and the technologies have been proven through application at other landfills. Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of landfill covers, and are easily implemented.

6.2.3.6.1 Ability to Construct and Operate the Technology

It is technically feasible to regrade existing materials and install a starter berm and/or place additional soil in order to achieve minimum and maximum slopes of 2% and 25% respectively. It is also technically feasible to construct an upgraded landfill cover over Areas 1 and 2. Regrading of existing landfills through placement of additional soil or regrading of existing materials is a common remedial action that has been implemented at many other CERCLA landfill sites as well as at RCRA corrective action sites.

Because of the configuration and location of Areas 1 and 2 within the overall existing Site footprint and the existing, relatively steep side slopes on portions of the northern and eastern edges of Area 1 and on the northern and western edges of Area 2, achieving the required maximum slope grades along the entire margin of Areas 1 and 2 cannot be achieved by placement of additional fill material alone. The toe of the landfill in the northern portion of Area 2 is located near or coincident with the property boundary/fence line, and therefore placement of additional soil or fill material is not an option to reduce the slope angle of the landfill berm in this area. Similar grading constraints exist for portions of the landfill in Area 1 due to the presence of the solid waste transfer station access road located along the northern toe of the landfill berm in Area 1, and the presence of the property/fence line along the eastern toe of the landfill. An existing drainage ditch located along the St. Charles Rock Road immediately outside of the fence line would also pose grading restraints around Area 1. For these areas, re-contouring the waste materials is a viable option to achieve the proper slope for construction of the cover. Re-contouring can be greatly reduced through use of a starter berm, as discussed elsewhere in this FFS report and in more detail in the prior SFS report (EMSI et al., 2011).

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarping of exposed wastes), visual and auditory frightening devices, and use of wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated technologies that can be readily constructed and operated as part of the UMTRCA cover alternative.

Effective stormwater controls can be readily implemented using conventional construction equipment, materials, and best management practices.

6.2.3.6.2 Reliability of the Technology

Landfill cover systems that are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance have been demonstrated to be reliable at: 1) minimizing percolation and infiltration of precipitation; 2) minimizing leachate generation; 3) minimizing impacts to groundwater quality; 4) minimizing impacts to surface water quality and quantity; 5) minimizing erosion of cover material; and 6) minimizing uncontrolled releases of landfill gas. In addition, existing security systems (*e.g.*, gates and fencing, signage, site surveillance, etc.) would be evaluated and enhanced, if necessary. These are reliable mechanisms to prevent unauthorized access to the Site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarps), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated reliable technologies. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. The FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are also well-established technologies that have been implemented and proven reliable at most landfill sites.

6.2.3.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

The only potential additional remedial actions that may need to be taken for the UMTRCA cover alternative would be maintenance activities to sustain the cover system, repair areas of differential settlement or erosion, or possible implementation of a contingent landfill gas control system. Regrading and contouring the existing waste materials to achieve final grades would require re-compaction of the regraded waste materials in order to minimize the potential for compaction or differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill cover may result in differential compaction of the waste materials, depending upon the nature, age, and amount of prior degradation of the waste materials. Runoff of stormwater can result in formation of erosional rills. Depressions caused by differential settlement of the wastes or erosional features can easily be (and commonly are) addressed at landfill sites through placement of additional soil material to fill such features.

In the event that monitoring of subsurface landfill gas and radon detects the presence of gas levels above regulatory thresholds along the perimeter of the Site, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system, and/or possible use of a carbon adsorption system to remove radon from the extracted gas stream. Installation of a contingent gas system can easily be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund site solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would be straightforward, primarily entailing placement of additional fill, regrading, and re-vegetation of the repaired area.

Storm water management measures other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures are not anticipated.

6.2.3.6.4 Ability to Monitor Effectiveness of Remedy

One purpose of installing a landfill cover would be to prevent direct contact with the waste materials. The integrity of a landfill cover relative to protection from direct contact can easily be monitored through visual inspection to identify the presence of exposed waste or the existence of erosional features that could impact the landfill cover.

Another long-term goal of constructing new landfill covers over the surfaces of Areas 1 and 2 would be to minimize percolation and infiltration of precipitation with subsequent leachate generation and potential impacts to groundwater. Visual inspection of the cover integrity relative to the potential for erosion and infiltration impacts to the landfill cover can be easily performed. Groundwater monitoring to detect the presence of, or verify the absence of, impacts to groundwater is a standard technology that also can easily be performed at the Site.

Demonstrating the effectiveness of the cover systems would be accomplished by implementing the monitoring programs required by the ROD-selected remedy, including programs for the cover surface, landfill gas system, groundwater, and surface water (as previously described in Section 5.3.1.11). These types of monitoring programs are proven at demonstrating cover effectiveness and can be easily implemented.

6.2.3.6.5 Ability to Obtain Approvals from Other Agencies

No approvals by other agencies would be required to implement the UMTRCA cover alternative. The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the Federal Aviation Administration (FAA) and the St. Louis Airport Authority (STLAA or Airport Authority). The effectiveness of best management practices and proposed bird nuisance mitigation measures would be of interest to the FAA and the Airport Authority.

6.2.3.6.6 Coordination with Other Agencies

Other than coordination with the STLAA regarding the bird hazard mitigation measures and effectiveness, coordination with other agencies would not be necessary to implement the UMTRCA cover alternative.

Although they would not be considered "agencies," coordination with the landfill owner and operator, the owners of the various parcels that comprise the West Lake Landfill property, and the asphalt batch plant tenant would be required during regrading and installation of an upgraded landfill cover under the UMTRCA cover alternative. Coordination would be necessary because:

- Access to operations conducted on other portions the Site would need to be maintained;
- Areas 1 and 2 are within a larger existing Site footprint, and use of areas on the West Lake Landfill property outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction; and
- For the time period during construction when trucks would be delivering rock, clay, and soil materials for cover construction, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the on-site solid waste transfer station and asphalt plant.

The owners of all of the various parcels that comprise the West Lake Landfill are participating PRPs and given this, coordination with owners is expected to be feasible.

Coordination with other agencies including the Earth City Flood Control District, MSD, and the Missouri Department of Transportation (MDOT), as well as the adjacent property owners and businesses (*i.e.*, Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities both during and after completion of construction;
- Coordinate with MSD regarding permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road (MO Route 180) and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from Crossroad Properties, LLC and AAA Trailer for testing and, if necessary, remediation of the Crossroads Property, and for implementation of remedial actions that may need to be performed along the property boundary (*e.g.* regrading, fencing, etc.).

6.2.3.6.7 Availability of Offsite Treatment, Storage and Disposal Services and Capacity

No off-site treatment, storage or disposal services are envisioned as part of the direct implementation of the UMTRCA cover alternative. Off-site treatment, storage, and disposal may be required in the event that hazardous wastes or regulated asbestos-containing materials (RACM) are encountered during re-contouring Areas 1 and 2. Additionally, the four off-site disposal facilities identified for the full excavation of RIM and partial excavation alternatives are permitted to accept liquid, hazardous, and mixed wastes and asbestos, as well as to treat soil and/or debris that contain hazardous or mixed waste.

Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact waste materials during the landfill re-contouring activities could also be required. Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater and initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.3.6.8 Availability of Necessary Equipment and Specialists

Personnel, equipment, and materials are readily available to implement the cover systems, institutional controls, and monitoring components of this alternative. The implementability and potential cost of this alternative would be influenced by the availability and location of clean fill materials and/or off-site soil borrow sources at the time this alternative is implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006), during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI et al., 2008), and during preparation of the SFS (EMSI, et al., 2011). These vendors indicated that rock, clay, and clean fill material were readily available from sources located near the Site at the time these inquiries were made. If these local sources of cover materials become exhausted prior to remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site; however, all of the materials are expected to be available.

The necessary materials, equipment and personnel required for assessment and removal of radiologically-impacted soil that may be present at the Buffer Zone/Crossroads Lot 2A2 Property are also readily available.

6.2.3.6.9 Availability of Prospective Technologies

The UMTRCA cover alternative is based on proven, established, commonly used technologies. Use of prospective technologies is not anticipated to be part of the UMTRCA cover alternative.

6.2.3.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the UMTRCA cover alternative are included in Appendix K-3 and summarized on Table 6-1. Conceptual bottom and top of final cover grading plans and stormwater control features used as the basis for the ROD-selected remedy capital cost estimate (and by extension for the UMTRCA cover alternative) are provided in Appendix M. The estimated costs to construct the UMTRCA cover alternative (i.e., design costs, capital costs, and costs for monitoring during the construction period) are $96 million. The estimated annual OM&M costs range from $176,000 to $389,000 per year, depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring, years when landfill cover repairs may occur, and years when 5-year reviews are conducted). The cost estimates provided in this FFS are feasibility-level cost estimates. That is, they were developed to a level of accuracy such that the actual costs incurred to implement this alternative are anticipated to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the UMTRCA cover alternative are projected to be $90 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $100 million. The total non-discounted costs for the UMTRCA cover alternative over 30 years are projected to be $102 million. Given the long life of the radionuclides present at OU-1, the costs for the UMTRCA cover alternative were also evaluated for 200- and 1,000-year periods (without consideration of any constraints on annual expenditures). The total non-discounted costs of the UMTRCA cover alternative are projected to be $134 million over a 200-year period. The total present-worth costs of the UMTRCA cover alternative are projected to be $90 million based on a 7% discount rate or $116 million based on a 0.7% discount rate over a 200-year period. The total non-discounted and present worth costs of the UMTRCA cover alternative are projected to be $287 million over a 1,000-year period. The present worth costs over a 1,000-year period are projected to be $90 million based on a 7% discount rate or $123 million based on a 0.7% discount rate.

Similar to the ROD-selected remedy, the total additional costs that may be incurred for off-site transport and disposal if hazardous/mixed wastes are encountered during waste regrading activities could range from $167,000 to $682,000 (see Section 6.2.2.7 and Appendix K-10).

6.2.4 Full Excavation of RIM with Off-site Disposal Alternative

This section presents the detailed analysis of the full excavation of RIM with off-site disposal alternative. As previously described in Section 5.5, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station building to provide access to RIM located adjacent to the building and construction of an overpass over the Site access road;
- Excavation and stockpiling of overburden from OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use as defined by the UMTRCA standards in 40 CFR 192.12 as modified by EPA's 1997 and 1998 OSWER guidance (EPA, 1997a and 1998);
- Loading, transport, and disposal of the RIM at an off-site disposal facility;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2 Property;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 Property that contains radionuclides at levels greater than those that would allow for unrestricted use and shipment of such soil to an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;
- Design, installation and maintenance of storm water runoff controls;
- Groundwater monitoring consistent with the requirements for sanitary landfills;
- Landfill gas monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Under this alternative, an estimated 309,700 bank cubic yards (bcy) of RIM and impacted soils would be excavated for off-site disposal from Areas 1 and 2, and an additional approximately 2,900 bcy of impacted soil from the Buffer Zone/Crossroads Property would be excavated for off-site disposal. Daily cover material would be added to the excavation areas increasing the total volume by 10% to 344,000 yds. In addition, the volume of material would increase upon excavation due to swelling, handling, and loading for off-site transport. Applying an assumed swell factor of 1.5 and accounting for daily cover, it is estimated that approximately 516,000 loose cubic yards (lcy) would be transported off-site for disposal at a permitted disposal facility.

As indicated in Section 5.5.3, it is unknown whether extending a rail spur onto the Site would be feasible. If feasible, loading RIM material directly onto railcars on-site would reduce material handling steps and probably reduce transportation costs. Based on information provided by US Ecology for turnkey transportation and off-site disposal, transportation costs might be reduced as much as $35 per lcy of RIM if a rail spur of sufficient length could be extended onto the Site; however, this estimate does not take into account the costs of property acquisition, regulatory approval, or capital construction associated with an on-site rail spur, so the true cost reduction, if any, is unknown. Preparation of an engineering feasibility evaluation and a conceptual design to potentially extend a rail spur onto the Site is outside the scope of this FFS.

Therefore, based on discussions with US Ecology, for purposes of preparing a cost estimate for this alternative in this FFS it was assumed that excavated RIM would be loaded into 30-cubic-yard metal DOT IP intermodal (IM) containers, which would then be loaded onto and hauled by trucks to a truck-to-rail transloading operation at a rail spur location within a 10-mile radius of the West Lake Landfill Site, where the containers would be placed onto flatbed rail cars for shipment to one of the off-site disposal facilities described in Section 4.3.5.4.

For purposes of this FFS, it has been assumed that the RIM would be shipped for disposal at the US Ecology, Inc. facility in Grandview, Idaho. US Ecology provided the most complete information regarding transportation mechanisms and transportation and disposal costs. US Ecology has prior experience with transport and disposal of radioactive materials from SLAPS and other DOE/FUSRAP sites (Latty Avenue and Denver Radium Site Operable Unit 8).

Once the RIM above levels which would allow for unrestricted use has been removed from each area, the remaining solid waste materials in Areas 1 and 2 would be regraded to meet the final closure standards for sanitary landfills. A final sanitary landfill cover would then be constructed over Areas 1 and 2. Because the RIM above unrestricted use levels would have been removed under this alternative, the landfill cover for this alternative would not include the additional hybrid components included in the ROD-selected remedy, UMTRCA cover alternative, or the partial excavation alternatives to address the UMTRCA requirements.

However, because solid wastes would still be present in Areas 1 and 2, this alternative includes installation and maintenance of storm water runon and runoff controls, groundwater and landfill gas monitoring, and institutional controls, as described for the ROD-selected remedy. Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site met UMTRCA and State groundwater standards or other ARARs. Monitoring of subsurface occurrences of landfill gas and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2 would be performed to ensure that migration of landfill gas above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls would ensure that land and resource uses are consistent with permanent waste disposal in Areas 1 and 2.

6.2.4.1 Overall Protection of Human Health and the Environment

Conditions at the Site would be protective of human health and the environment after completion of construction of this alternative. This alternative would protect human health and the environment by limiting potential exposure to the Site contaminants through the removal and off-site disposal of RIM and implementation of engineering methods and land use controls to address the remaining solid wastes.

6.2.4.2 Compliance with ARARs

The full excavation of RIM with off-site disposal alternative would comply with the ARARs discussed below.

6.2.4.2.1 UMTRCA

Removal of any soil containing radionuclides from the Buffer Zone and Crossroads Lot 2A2 Property would be done in a manner that meets the UMTRCA soil cleanup standards (40 CFR Part 192 Subpart B) as modified by the EPA guidance on the use of UMTRCA for cleanup at CERCLA sites (EPA, 1998 and 1997a). As specified by EPA (EPA, 2015b and 2010a), removal of RIM from Areas 1 and 2 would also be conducted in a manner that achieved the UMTRCA standard as modified by the EPA guidance.

6.2.4.2.2 CERCLA Off-Site Rule

Section 121(d)(3) of CERCLA (42 U.S.C. § 9621(d)(3)) applies to any CERCLA response action involving the off-site transfer of any hazardous substance, pollutant or contaminant (CERCLA wastes). These principles are stated in the Off-Site Rule (OSR) set forth in the NCP at 40 CFR § 300.440. The OSR requires that CERCLA wastes only be placed in a facility operating in compliance with RCRA or other applicable Federal or State requirements. The OSR prohibits the transfer of CERCLA wastes to a land disposal facility that is releasing contaminants into the environment, and requires that any releases from other waste management units at the disposal facility must be controlled.

The OSR establishes the criteria and procedures for determining whether facilities are acceptable for the receipt of CERCLA wastes from response actions authorized or funded under CERCLA. The OSR establishes both compliance and release criteria, and also establishes a process for determining whether facilities are acceptable based on those criteria. The OSR also establishes procedures for notification of unacceptability, reconsideration of unacceptability determinations, and re-evaluation of unacceptability determinations.

EPA verifies the acceptability of off-site treatment, storage, and disposal facilities (TSDFs) on a frequent basis. Consequently, before any off-site shipment occurs, a verification of current acceptability (VCA) must be obtained from EPA certifying that the proposed receiving facility is operating in compliance with the requirements of CERCLA Section 121(d)(3) and 40 CFR § 300.440. EPA (usually the EPA Regional Office) would determine the acceptability under this section of any facility selected for the treatment, storage, or disposal of CERCLA waste. EPA would determine if there are relevant releases or relevant violations at a facility prior to the facility's initial receipt of CERCLA waste. EPA typically makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during RD and would need to be regularly evaluated and updated during remedy implementation.

6.2.4.2.3 Off-site Transportation Requirements

Transportation to an off-site disposal location would need to comply with both the substantive and administrative requirements of any regulations applicable to transportation of radiologically-contaminated materials. These would include U.S. Department of Transportation (DOT) regulations for transport of hazardous materials (49 CFR Parts 100 – 178), and specific regulations related to transport of radioactive materials (49 CFR Parts 171 – 180). These include regulations governing hazardous materials communications, emergency response information, training requirements and security plans (49 CFR Part 172) which address special provisions, preparation and retention of shipping papers, packaging and container marking, emergency response, security, and planning. The regulations contain specific requirements associated with shipment of radioactive materials (*e.g.*, 49 CFR §§ 172.310, 172.436-440, and 172.556). Other regulations (49 CFR Part 173) describe requirements for shipment and packaging that are applicable to shippers and again include specific requirements for shipment of radioactive materials. Regulations set forth in 49 CFR Part 174 address shipment by rail and include special handling requirements for radioactive materials (49 CFR § 174.700). Required emergency response information is described in 49 CFR Subpart G (49 CFR § 173.602). The NRC, through a Memorandum of Understanding with DOT, also has promulgated regulations regarding transport of radioactive materials (10 CFR Part 71).

Requirements established by common carriers (including rail carriers) for transport of waste materials or radioactive wastes would also be applicable to this alternative. Given that the specific carriers that might be used to transport the wastes under the full excavation of RIM alternative cannot be identified at this time, identification and evaluation of the carrier-specific requirements has not been performed.

Discussions with representatives of potential off-site disposal facilities indicate that most of the facilities would provide a turnkey service that includes transport of the RIM from the West Lake Site and subsequent treatment and disposal. As such, the disposal company would be responsible for arranging for transport, preparation of waste/shipping manifests, testing of RIM materials after they are loaded into transportation vehicles/containers, securing of vehicles/containers, unloading of vehicles/containers, safety and emergency response plans, and all other aspects associated with transport of RIM from the West Lake Site to an off-site disposal facility.

6.2.4.2.4 Waste Acceptance Criteria (WAC) for Off-site Disposal

WAC are established pursuant to the specific permit or license issued to each waste disposal facility, and consequently are different for each facility. Summaries of the WAC for each off-site disposal facility were presented in Section 3.1.4.3 of this FFS and would be complied with, as appropriate. Copies of the WAC provided by each of the facilities are contained in Appendix C.

6.2.4.2.5 Missouri Solid Waste Rules for Sanitary Landfills

Regrading, cover, and closure of the remaining solid waste at OU-1 Areas 1 and 2 after RIM removal would need to comply with the MDNR regulations described in Section 6.2.2.2.1 of this FFS. The only difference between the full excavation of RIM and the ROD-selected remedy would be that regrading Areas 1 and 2 after removal of the RIM under the full excavation of RIM alternative would need to meet a minimum slope angle of 5% instead of the 2% permitted for the ROD-selected remedy. The increased surface slope would be necessary to account for the increased risk of differential settlement resulting from the greater extent of excavation and material disturbance caused by the RIM removal including excavation, stockpiling, and relocation of relatively younger waste contained in the above-grade portion of the North Quarry part of the Bridgeton Landfill that overlies the southern portion of Area 1.

6.2.4.2.6 Safe Drinking Water Act

40 CFR Part 141 establishes primary drinking water regulations including maximum contaminant limits (MCLs) pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Public Law 93-523), and related regulations applicable to public water systems. These MCLs apply to public drinking water systems. Missouri regulations (10 CSR 60-4.010, et seq.) also establish MCLs for public drinking water systems. MCLs are considered relevant and appropriate to all potentially usable groundwater. As set forth in the NCP, non-zero maximum contaminant level goals (MCLGs) are also potentially relevant and appropriate to potentially usable groundwater. Regrading of the landfill surface and installation of an engineered landfill cover to promote runoff and minimize infiltration are included as part of this alternative. These measures should ensure groundwater quality that meets the MCLs and non-zero MCLGs.

6.2.4.2.7 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against Ionizing Radiation (10 CFR Part 20) contain chemical-specific standards that address radiation protection. These regulations establish dose limits for individual members of the public and radiation workers, and define maximum permissible exposure limits for specific radionuclides in air and water at levels above background both inside and outside of controlled areas. These requirements are considered applicable during implementation of any remedial action. Specifically, these regulations would require perimeter air monitoring during implementation of the full excavation of RIM alternative. In addition, Site health and safety plans would address worker protection consistent with these requirements.

6.2.4.2.8 Missouri Well Construction Code

MDNR has promulgated regulations pertaining to the location and construction of water wells. The Well Construction Code (10 CSR 23-3.010) prohibits the placement of a well within 300 feet of a landfill. These rules would provide protection against the placement of wells on or near the Site. The regulations on monitoring well construction (10 CSR 23-4) would apply to the construction of new or replacement monitoring wells. The full excavation of RIM alternative would meet these requirements through enforcement of the existing Institutional Controls[67] and adherence to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

6.2.4.2.9 Missouri Stormwater Regulations

The Missouri regulations governing stormwater management at construction sites are specified in 10 CSR 20-6.200 (Table 3-3). A disturbance of greater than 1 acre or the creation of a stormwater point source during construction of the remedy would trigger these requirements. The full excavation of RIM alternative would meet these requirements through implementation of a SWPPP, use of BMPs during construction, installation and maintenance of an engineered landfill cover to prevent stormwater from contacting the waste materials, and construction and maintenance of stormwater diversion and control structures to control runon and runoff and to reduce erosion potential as part of the design of the engineered landfill cover.

6.2.4.3 Long-Term Effectiveness and Permanence

Because the full excavation of RIM alternative is defined by EPA to result in removal of RIM containing radionuclides above unrestricted use levels from the Site, this alternative would provide permanent protection against exposures to radionuclides. This conclusion assumes there would be no long-term impacts to the environment in the vicinity of the off-site disposal facility

[67] In addition, the deed restrictions currently in place on Areas 1 and 2 and the Buffer Zone (and which are to be maintained in perpetuity) prohibit the placement of water wells for drinking water or agricultural purposes.

or to any communities along the transport route from transport to and disposal of RIM at the off-site disposal facility.

RIM containing radionuclides at levels above those that would allow for unrestricted use would be removed from the Site under this alternative; however, other solid wastes would still remain at the Site, and it would still remain a landfill subject to the applicable requirements for closed solid waste landfills. Therefore, a new landfill cover would need to be installed over the remaining solid wastes after removal of the RIM above cleanup levels. Groundwater monitoring would need to be performed consistent with the applicable or relevant and appropriate requirements for a solid waste landfill. Institutional controls would also be required to ensure that future land uses at the Site would be compatible with the presence of a solid waste landfill and to prevent intrusion into the waste materials, disruption of the landfill cover, monitoring points, or other aspects of the solid waste landfill containment system.

6.2.4.3.1 Magnitude of Residual Risk

The calculated lifetime risks from radiological materials that would remain in Areas 1 and 2 after implementation of the full excavation of RIM alternative are as follows:

- Area 1: 3.4×10^{-8} for year 1, 3.7×10^{-8} for year 1,000, and 4.6×10^{-8} for year 9,000.
- Area 2: 3.6×10^{-8} for year 1, 5.4×10^{-8} for year 1,000, and 9.0×10^{-8} for year 9,000.

These calculated risks are attributable to gamma radiation and radon emissions from the radionuclide occurrences that would remain after implementation of the full excavation of RIM alternative. Any such residual materials would be present at levels which do not require further remediation. The calculated risk levels are below EPA's target risk range of 1×10^{-6} to 1×10^{-4} and the magnitude of the radiological carcinogenic risk from residual RIM in these two remediated areas is acceptable. These risks do not specifically include potential exposures from non-radiological landfill waste after construction is complete; however, those wastes would also be covered by a cap which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

Additionally, the remaining landfill wastes, including any residual radionuclides below unrestricted use levels, would be capped with access to and future use of the capped waste disposal areas limited by Site access restrictions and institutional controls. Direct contact with residual RIM under the cap, or ingestion, inhalation, or dermal contact with such materials, is not expected to occur. These also are the primary exposure pathways for any non-radiological COPCs which may be present in the landfill wastes remaining in Areas 1 and 2 after removal of the RIM. Because no complete exposure pathway would exist for such materials after completion of the cap construction, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks.

After soils containing radionuclide concentrations above the cleanup levels are removed from the Buffer Zone/Crossroads Property, residual risks posed by the remaining radionuclide-impacted soils on these properties, if any, are expected to be indistinguishable from variations in background levels.

6.2.4.3.2 Adequacy and Reliability of Controls

Although the full excavation of RIM alternative as defined by EPA (2015b and 2010a) is presumed to result in removal of RIM such that the remaining materials would allow for unrestricted use relative to the presence of radionuclides, there is uncertainty as to whether all of the RIM above cleanup levels could be removed. There are several areas where RIM is located at depths below 15 feet. In addition, some of the RIM in OU-1 Area 1 is located adjacent to or beneath the above-grade portion of the North Quarry part of the Bridgeton Landfill, and some of the RIM in OU-1 Area 2 is located very close to the adjacent Closed Demolition Landfill or the Inactive Sanitary Landfill, which are not known to contain radionuclides and are therefore part of OU-2. The proximity of these adjacent landfills greatly increases the level of difficulty and the amount of overburden material that would have to be moved to access and remove some of the RIM. These conditions would increase the potential for failure of the adjacent landfill units during implementation of the OU-2 remedy and the potential that all of the RIM above cleanup levels may not be able to be removed from Areas 1 and 2.

There are a very limited number of possible off-site facilities where the RIM could be disposed, and there are therefore uncertainties regarding land disposal. At this time, only four facilities have been identified that might be able to accept these wastes. See the discussion in Section 3.1.4.3 for a description of these facilities and their capabilities. Discussions with representatives of these waste disposal facilities during preparation of the SFS (EMSI, et al., 2011) and subsequent discussions with representatives of U.S. Ecology during preparation of this FFS indicated that the facilities currently have sufficient capacity and anticipate having sufficient capacity for disposal of the estimated volume of material that would be removed from the West Lake Landfill OU-1 under a full excavation alternative. Comparison of the radioactivity levels estimated to be associated with a full excavation alternative to the U.S. Ecology Waste Acceptance Criteria (WAC) is presented on Table 6-2 and indicates that this material should be acceptable for disposal at U.S. Ecology's Idaho facility. However, waste acceptability will not be able to be confirmed until the RD phase.

The engineered measures and institutional controls that would be implemented for Areas 1 and 2 under the full excavation of RIM alternative (landfill cover, groundwater and landfill gas monitoring, and institutional controls) are considered to be adequate and reliable. OM&M requirements for the full excavation of RIM alternative would be the same as those included in the ROD-selected remedy. No difficulties or uncertainties or potential need to replace significant components are envisioned for the long-term OM&M functions for the full excavation of RIM alternative.

Because the full excavation of RIM alternative entails removal of all RIM above the criteria that would allow for unrestricted use relative to radionuclide occurrences, the remedial actions included in this alternative are expected to be a final action for OU-1, and it is assumed that no components of the remedy would need to be replaced in the future. The landfill cap would need to be maintained but because it would be composed of natural materials (*e.g.*, soil) it should not need to be replaced. However, in the unlikely case that components of the remedy need replacement in the future, unacceptable risks are not expected to occur because the Site presents only slight risks under current conditions. Moreover, given that the components of the final covers at Areas 1 and 2 would be constructed from natural materials with properties that limit migration potential of any residual radionuclides below unrestricted levels or solid waste constituents, there is a high degree of confidence that the engineered controls would prevent or otherwise address potential problems.

6.2.4.3.3 Climate Changes and Potential Impacts of a Tornado

Because municipal solid waste would still remain in Areas 1 and 2, a new engineered landfill cover would be installed over these areas. Because radionuclides above unrestricted use levels would be removed from the Site under this alternative, the engineered landfill cover to be installed under this alternative would not include the 2-foot-thick rock/rubble biointrusion layer. Instead, the engineered cover would consist of a standard landfill cover for a Subtitle D MSW landfill without a liner system, which would consist of a 2-foot-thick low-permeability layer and a 1-foot-thick vegetative layer. This engineered landfill cover would be classified as an in-situ containment system (EPA, 2014a).

Because of the general similarity between the engineered landfill cover to be installed over Areas 1 and 2 under the full excavation of RIM alternative with the landfill cover to be installed under the ROD-selected remedy, the analysis of the potential effects of climate change or impacts of a tornado are essentially the same for both alternatives. These effects were previously discussed in Section 6.2.2.3.3 for the ROD-selected remedy and therefore the overall evaluation of climate change effects and potential impacts from a tornado will not be repeated again here.

Similar to the capping alternatives, the vegetative layer of the landfill cover to be installed under the full excavation of RIM alternative could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation and increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potential increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence.

The low permeability layer (CCL) could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include the desiccation of the CCL, which could increase the CCL's permeability and therefore also increase the potential for precipitation infiltration. These potential impacts are not considered significant because the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality are not expected to be significant. More importantly, the vegetative layer would likely show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer and thereby provide advance notice of a potential impact to the CCL. Accordingly, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. For these reasons, potential degradation of the CCL due to extreme temperatures or drought is not expected to result in release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying low permeability layer. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given that the landfill cover under the full excavation of RIM alternative would not include the 2-foot-thick rock layer in the base of the cover system, stormwater erosion under a severe storm event could potentially erode down through the entire landfill cover, resulting in temporary exposure of waste materials. Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including the erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs (if any are needed). Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. This could result in exposure of the waste material or the release of contamination. However, because it is presumed that all RIM above unrestricted use levels would be removed as a part of the full excavation of RIM alternative, such impacts would not result in release of radionuclides above risk-based levels. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair, and replacement of cover material in response to any damage that may occur.

The full excavation of RIM alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, FEMA has determined that Areas 1 and 2 are located outside of the 500-year floodplain. In addition, the area to the north and west of Area 2 (*e.g.,* Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River, are protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park.

Similar to the ROD-selected remedy as discussed in Section 6.2.2.3.3, the full excavation of RIM alternative, upon completion, is not vulnerable to impacts from a tornado. Specifically, based on a review of the impacts of tornados at other sites, a tornado is not expected to damage the vegetative layer. However, even if a tornado were to impact the vegetative cover, such an impact would not be significant because it could be easily identified and, due to the design and thickness of the engineered cover, would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy aboveground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the full excavation of RIM alternative is not considered to be vulnerable to potential impacts from a tornado.

Although the full excavation of RIM alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could be considered during remedial design to provide a degree of adaptation for climate change. For example, although this alternative includes regrading of the landfill surface to a minimum grade of 5% to allow for possible increased decomposition that may occur as a result of exposing a large volume of waste to atmospheric air (oxygen), regrading of the surface of Areas 1 and 2 to a 2% slope instead of a minimum 5% slope could be considered as a potential adaptation measure for possible climate change. Reducing the slope of the landfill surface to 2% would reduce the velocity of runoff across the surface of Areas 1 and 2 and thereby reduce erosion and soil loss potential under extreme precipitation events. Potential increased settlement of the waste material and cover system that may occur if there is increase decomposition of the waste could be addressed through routine cover maintenance and repair activities. Installation of runoff collection and diversion systems along the base of the above-grade portion of the North Quarry portion of the Bridgeton Landfill adjacent to Area 1 and along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2 could be installed to divert runoff from these areas around Areas 1 and 2 to reduce the potential for impacts from heavy precipitation events. Use of grass seed mixtures that are more tolerant of long-term changes in precipitation or temperature and/or soil addition to increase water storage capacity could be evaluated as part of the design. Similarly, inclusion of a geotextile at the base of the vegetative layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low permeability layer. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls to increase the overall resilience of these features to heavy precipitation events. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures would be included as part of the ongoing inspection and maintenance program.

6.2.4.3.4 Potential Impacts of a Subsurface Heating Event

Because it is presumed that all radionuclides above unrestricted use levels would be removed from the Site under the full excavation of RIM alternative, radionuclide-related impacts would not be expected to occur if a subsurface heating event were to occur in Areas 1 or 2. Odor emissions, ground settlement, disruption of an engineered cover, and other potential impacts associated with a heating event could potentially still occur under the full excavation of RIM alternative. These would be addressed as part of OM&M activities including activities such as placement of additional soil to fill areas of subsidence, repair and/or enhancements to the landfill cover system, and efforts to manage, control and reduce odor emissions.

6.2.4.3.5 Effects of an Isolation Barrier

Because it is presumed that all of the radionuclides above unrestricted levels would be removed under the full excavation of RIM alternative, there would be no need for installation of an isolation barrier system. If an isolation barrier system were installed prior to implementation of a full excavation of RIM alternative, large portions of the barrier system may need to be removed to gain access to RIM in the vicinity of a barrier.

6.2.4.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6 as part of the evaluation of long-term effectiveness of the ROD-selected remedy, a screening level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. The full excavation of RIM alternative is an off-site disposal action that does not include treatment as a primary component.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. Consequently, ex-situ treatment techniques are considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix in portions of Areas 1 and 2 make in-situ treatment techniques equally impracticable. The remedy for the Buffer Zone/Crossroads Property also would not reduce toxicity, mobility, or volume through treatment because it consists of removing radiologically-impacted soil from the Buffer Zone/Crossroads Property and shipping it off-site for disposal.

An on-site technology that may potentially be applicable to the full excavation of RIM alternative is physical separation of impacted soil from the solid wastes by using solids separation techniques such as hand-picking for large bulky items and various fixed, vibrating, or rotating screens, among others (see discussion in Section 4.3.5.2). Physical separation would not decrease the mobility or toxicity of the radiologically-impacted materials, but has the potential to separate existing RIM from non-radiologically-impacted materials. As previously discussed, any solids separation techniques would need to be pilot tested at full-scale using materials from Areas 1 and 2 during remedial design to ascertain the potential effectiveness, implementability, and cost of this technology. Of particular interest in conducting pilot-testing with material from Areas 1 and 2 would be obtaining an estimate of the degree of RIM volume reduction that could be achieved, assessing the moisture content of the filled material, determining the fraction of soil that would be contained in or adhered to the segregated refuse, and determining the residual levels of radioactivity that would be present in the non-soil refuse after screening out the soil fraction. Assuming that solids separation could prove to be an effective and implementable technology (that is, it could effectively separate the radiologically-impacted soil from the other landfilled waste materials such that the other landfilled wastes would contain radionuclide activities below the levels that would allow for unrestricted use), it has the potential to reduce the volume of radiologically-impacted material that would need to be transported to an off-site disposal facility. However, little is known about the potential application of a soils separation technology to this situation, and it is possible that pilot testing could demonstrate that physical separation would not be effective at separating RIM from non-radiologically-impacted materials, in which case, the non-radiologically-impacted materials would also need to be shipped off-site for disposal. At this stage of analysis, neither the estimated costs nor the estimated schedules in this FFS include any allowance for solids separation pilot testing or implementation.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's Land Disposal Restrictions (LDR) program and Universal Treatment Standards (UTS)) and in accordance with the permits and standard operating procedures of the receiving facility. After arriving at an off-site disposal facility and undergoing a waste receipt analysis, RCRA soil/debris and RCRA soil/debris with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on its physical characteristics, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste and radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

For the full excavation of RIM alternative, any hazardous waste or mixed waste would be shipped to the off-site disposal facility either separately by truck or, depending upon the volume, possibly by rail in conjunction with shipment of the RIM. If the volume is small, the material may be placed in drums, metal boxes or other containers and shipped by truck, although if the volume is sufficient to fill an IM container, it may be shipped by rail. Shipment of mixed waste to an off-site disposal facility by rail would not be significantly different than shipment of RIM. Like the RIM, the mixed waste would be loaded into 30-cubic-yard metal DOT intermodal containers and hauled by truck to a truck-to-rail transloading station. The IM containers would be placed on flatbed rail cars and transported via rail to one of the off-site disposal facilities described in Section 4.3.5.4. Either way, any material that is identified as hazardous would be handled and shipped as discrete material and not mixed with a larger volume of RIM. Both types of materials would be subjected to a radiation survey and classification in accordance with DOT requirements; however, the shipping documentation would be slightly different. While the RIM would be shipped under a bill of lading with appropriate placarding identifying the material as radioactive, the mixed waste would require use of a uniform hazardous waste manifest and specific placards and markings on the semi-trucks and rail cars identifying the material as hazardous waste in addition to being radioactive.

Beyond the shipping aspect, the hazardous component of any mixed waste would present additional issues with respect to waste segregation, sampling/analysis, and ultimate disposition at the off-site disposal facility. During excavation, any suspected hazardous or mixed waste would be segregated from the waste containing only overburden material or RIM, stockpiled in a separate area, sampled and analyzed for toxic characteristic leaching procedure (TCLP) parameters, and covered with a tarp or other cover material until analytical results were available. Sampling procedures and analytical methods would be addressed in a Remedial Action Sampling and Analysis Plan to be developed during the remedial design phase.

Based on analytical results, segregated materials would be assigned a waste profile of non-RCRA soil and debris, non-RCRA soil and debris with radionuclide material, RCRA soil, RCRA soil with radionuclide material, RCRA debris, or RCRA debris with radionuclide material. The non-RCRA soil and debris would be relocated with the overburden stockpile; the non-RCRA soil and debris with radionuclide material would be managed along with the RIM; and the RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would be packaged and shipped to the off-site disposal facility in containers separate from the RIM with appropriate marking/placarding under a unique manifest. In order to comply with the RCRA waste storage limitations, stockpiled RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would not be stored on site beyond the RCRA specified maximum accumulation periods prior to shipment to the off-site disposal facility.

The four off-site disposal facilities identified and discussed in Section 4.3.5.4 are all permitted to accept RCRA wastes and mixed wastes (Section 3.1.4.3) subject to their WAC (Appendix C). After arriving at the selected off-site disposal facility and undergoing a waste receipt analysis, RCRA waste/soil and RCRA waste/soil with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on the physical characteristics of the debris, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell.

6.2.4.5 Short-Term Effectiveness

The full excavation of RIM alternative poses significant potential short-term risks, as described below. During a public meeting held as part of the ROD-selected remedy process, EPA identified and discussed the following short-term risk issues for waste excavation: waste handling, sorting, and stockpiling; water management; noise, odor and windblown trash; worker health and safety (PPE, gamma exposure, physical stress, physical hazards, workplace monitoring); contaminant migration/spreading (fugitive dust and airborne migration, fugitive dust control and water application, leachate generation, equipment decontamination water, and water from open excavations); and waste hauling and transportation/truck decontamination issues (transfer facilities, increased local traffic, waste handling on public roads, interstate transport by rail, DOT requirements, safety issues).

6.2.4.5.1 Protection of the Community During Remedial Actions

The projected incremental carcinogenic risks that may be posed to off-site residents by this alternative are expected to be approximately 5.5×10^{-6}, which is within EPA's acceptable risk range. No non-carcinogenic risks are expected to occur.

Unless a rail spur is extended onto the West Lake Landfill Site (the feasibility of which, as discussed in Section 5.5.3, is currently uncertain), significant additional local truck traffic would occur during the construction period for the full excavation of RIM alternative, in order to implement the transfer of the excavated RIM to a local off-site truck-to-rail transloading location. It is estimated that 34,350 round trips of semi-trucks would be required to truck the excavated RIM from the Site to a rail spur location in the vicinity of the Site and from a rail spur transloading location near the off-site disposal facility to that facility. These additional truck trips would result in additional physical risk to the local communities and truck drivers due to potential traffic accidents. Transfer of RIM from the Site by truck to an off-site rail transloading facility, by rail to the general geographic area of the disposal facility, and off-loading and transfer by truck to the actual off-site disposal facility location would be required, all of which would result in the increased potential for release of RIM as a result of traffic or train accidents and the amount of additional handling of the RIM required for this alternative.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each FFS alternative. For the full excavation of RIM alternative, the projected incidence of transportation accidents associated with removal of RIM, regrading of the landfill, and importing of materials for construction of the multi-layer landfill cover is 41.6, meaning that approximately 42 accidents are projected to occur if this option were implemented.

The excavated waste to be shipped off-site would be placed in sealed metal containers (sealed DOT Industrial Packaging [IP] intermodal [IM] containers) or possible 35-cubic-yard soft-sided DOT IP-1 bags before leaving the Site, so there should not be any spillage or other release of RIM from the containers during transport, unless a major vehicular accident occurs that results in significant damage to both the transport vehicle (truck trailer or railroad car) and the DOT IP container. Notwithstanding the implementation of appropriate protective measures, a potential does exist for loose debris that may contain RIM to adhere to the wheels, under-carriage, or sides of the transport vehicles. All vehicles leaving the Site would be subject to screening for potential radioactivity and cleaning as necessary to remove any debris that may contain radioactivity prior to leaving the Site. In the event that such material is not identified during screening or removed during cleaning, a potential exists for this material to be released along the route of transport from the Site to the off-site disposal facility. If such releases were to occur, members of the public that traverse the same roads or that trespass onto the railroad tracks could potentially be exposed to RIM that may be released. Such exposures are not expected to pose a significant risk due to the anticipated small amounts of material that potentially could be released, the distance between such materials and possible receptors, the limited duration of exposure, and the presence of shielding associated with vehicular use of the roads or limited trespass onto the rail lines (see Appendix H).

Disturbing the waste material during implementation of the full excavation of RIM alternative may expose the community to radioactive waste, methane and radon gas, and other contaminants, and also may cause a release of undesirable odors. Excavation of existing waste materials would undoubtedly result in odor emissions during the period of time that existing wastes may be handled or exposed. Mitigation of odors through engineering means is limited.

The full excavation of RIM alternative would contribute significant carbon dioxide equivalent emissions as a result of ongoing vehicle operations associated with remedial work. Specifically, approximately 90,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere due to: landfill regrading work; construction of the landfill cover; the excavation, loading, and transport of the RIM to an off-site disposal facility; and the importation of materials used to construct the multilayer landfill cover (Appendix I, Table I-4).

Because RIM in Areas 1 and 2 would be excavated under this alternative, overburden containing putrescible wastes would be stockpiled and stored, while RIM would be loaded into transport containers. Under this alternative, a large volume of waste material (approximately 1.9 million in-place cubic yards) would need to be handled, including a substantial amount of the above-grade material in the North Quarry portion of the Bridgeton Landfill, which is relatively younger waste, and therefore less decomposed. During these activities, the nuisance attraction to and congregation by birds at and above the affected areas would be problematic unless effectively controlled. The long duration of the construction activities associated with this alternative (see Section 6.2.4.5.6 below and Appendix J-2) increases the potential for attraction of birds. The FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007). The main concern would be the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. For the full excavation of RIM alternative, an enclosed waste staging and loading structure (Figure 5-8) would be constructed to minimize the outdoor handling of waste and associated attraction of birds or other vectors. Additional mitigation measures (such as excavation best management practices, which include application of daily soil cover and/or tarping of exposed waste, visual and auditory frightening devices, or use of wire or monofilament grids positioned over exposed refuse to prevent bird access) could be implemented to attempt to minimize bird attraction to and congregation at and above the disturbed areas.

Excavation of waste materials from Areas 1 and 2 would require removal of the existing landfill cover and overburden from Areas 1 and 2 and from portions of adjacent areas of OU-2. Excavation of overburden and RIM would create depressions in the landfill area during the period of time required to remove the RIM and regrade and cover the remaining landfill wastes. Precipitation that falls on the landfill while such depressions are open would potentially flow into and accumulate in the depressions. Any accumulation of precipitation[68] in depressions created during waste excavation could result in increased infiltration of precipitation runoff through the underlying waste materials, which could result in increased leaching of volatile organic compounds (VOCs) or other soluble contaminants from the waste materials.

This alternative could be adversely impacted by severe weather impacts. Due to the extended duration required for implementation of this alternative, one or more severe weather events may occur during implementation of the full excavation of RIM alternative. Such an event(s) could result in direct delays to excavation work, and also indirect delays if such an event results in diversion of resources (*e.g.*, equipment) from waste excavation activities to mitigation of impacts of a severe weather event. Severe weather events could potentially greatly increase the volume of contact stormwater that would need to be contained and managed which may further limit waste excavation activities and increase the amount of time required to implement this alternative. In addition, severe weather events could increase the potential for loss of stormwater containment through failure of best management practices for controlling stormwater impacts. Such failures may include soil/waste scouring and suspended phase transport resulting in an increased potential for release and off-site transport of stormwater that has been in contact with waste material or soil containing radionuclides.

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[68] Accumulation could be significant during a heavy rainstorm insofar as the maximum historical 24-hour rainfall for the St. Louis area ranges from a low of 3.7 inches in November to a high of 8.8 inches in August (NOAA, 2011).

Because Areas 1 and 2 would be excavated and RIM loaded into transport containers, stormwater controls would be implemented in accordance with the Missouri Storm Water regulations 10 CSR 20-6.200 to protect the community. During construction, consideration would be given to minimizing the areas of excavation that would be open and the areas of exposed waste materials at any given time. Temporary diversion berms would also be constructed above the open excavation areas and any previously excavated (and temporarily covered) surfaces in order to divert precipitation runoff around the open excavation to prevent the runoff from contacting uncovered waste materials. Precipitation that would contact uncovered waste materials would flow into the low point of the excavation and be pumped out into temporary storage tanks using portable gas-driven pumps. Samples would be collected from the tanks and sent to a laboratory for analysis. The stored water would be directly discharged or treated and disposed appropriately based on the analytical results.

6.2.4.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.5.2 as part of the evaluation of short-term impacts associated with the ROD-selected remedy, a screening level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.4.5.3 Protection of Workers During Remedial Actions

The full excavation of RIM alternative would entail significant excavation, handling, loading and transport of RIM at the Site and therefore would pose both significantly increased radiological exposure risks as well as construction safety risks to on-site workers. The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the full excavation of RIM alternative, the projected incidence of industrial accidents is 25.9 over the life of the project (Appendix H). The projected carcinogenic risk to the maximally exposed individual (radiation field technician) is 3.67×10^{-3}, and the projected hazard index is 27.0 (Appendix H). The projected radiation dose to a remediation worker is 1,820 mrem/yr (Appendix H).

Workers involved in the excavation activities may be subject to potential short-term risks associated with excavation of the waste materials, including exposure to contaminated waste; excavation/trenching instability; stormwater runoff entering areas where waste is exposed, resulting in the exposure to contact storm water; odor emissions; and other aesthetic issues (*e.g.*, windblown trash) arising from exposed waste. Worker exposures would be addressed through development and implementation of a site safety plan, use of personal protective equipment, and performance of personnel and environmental monitoring during implementation of remedial action. Workers would be protected during construction by adhering to OSHA practices. However, as this alternative entails large amounts of excavation, handling, and transportation of RIM, OSHA work practices and personal protective equipment may not provide full protection against exposure to external gamma radiation.

Excavation would require construction workers and equipment that would initially disturb the overburden soil and underlying waste materials. Dust control measures would be required to limit worker exposure to fugitive dust during construction. As discussed in Section 4.4.1.2, the separation of radiologically-impacted soil from solid wastes and construction/ demolition debris may (if feasible) may be a potential means of reducing the overall volume of material and resultant cost of off-site transport and disposal. However, this action would increase short-term exposures and risks to remediation workers because the screens or other equipment used to segregate large items and debris from the soil become fouled with plastic, wood, and other debris that potentially would need to be physically removed by workers. Such activities would require workers to be in close proximity to the RIM, thereby increasing their short-term exposure risks. The risk assessment conducted for this FFS does not account for such increased physical separation/segregation exposures to workers.

Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers, including the projected non-carcinogenic risks identified above. Protective clothing alone would not reduce the carcinogenic risk or projected radiation dose these risks result from exposure to gamma radiation. The only way to address these risks is to limit the amount of time (exposure duration and frequency) that workers are exposed to gamma radiation. This could be done by measuring and tracking worker exposures and shifting workers to other tasks with less potential for gamma exposure to reduce the overall level of exposure to radiation. However, even this option may not be sufficient for workers involved with RIM sorting and handling prior to loading. For example, it is anticipated that the disposal facility would provide qualified individual to supervise loading of RIM into transport containers to ensure that each container meets the WAC for the disposal facility. The disposal facility may not be able to provide sufficient workers to allow for substitution to minimize gamma exposures. Implementation of the remedial action would not be performed in a manner that would result in an unacceptable risk to any worker or anyone else. However, managing worker exposures, especially for those involved in the RIM sorting and loading operations, who are expected to be the maximally exposed individuals, could present challenges for implementation of this alternative and therefore represents a short-term risk for this alternative.

6.2.4.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from this alternative. As noted in the original and updated BRA (Auxier & Associates, 2000 and 2017b), some of the ecosystems present at the Site are the result of existing institutional controls and other limitations on land use within or adjacent to OU-1 that have allowed field succession to take place. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Excavation of RIM, regrading of Areas 1 and 2, and construction of the engineered landfill cover under the full excavation of RIM alternative would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.4.5.5 Ability to Monitor Effectiveness

Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2 to assess the effectiveness of this alternative.

6.2.4.5.6 Time Until Remedial Action Objectives Are Achieved

The RAO related to the Lot 2A2 Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas. The RAOs related to Areas 1 and 2 and the Buffer Zone would be met once the RIM excavation and construction of the new landfill cover over Areas 1 and 2 were completed and the Buffer Zone is either covered as part of the landfill regrading work or any soil containing radionuclides above unrestricted use levels are removed from this area. Excavation and off-site disposal of RIM makes achievement of these RAOs post-excavation more certain because the full excavation of RIM alternative is predicated on the assumption that all RIM above unrestricted use levels would be removed from the Site, thereby greatly reducing the RIM source term and the magnitude of potential exposures to radionuclides, potential future radon emissions, and potential leaching of radionuclide constituents in the unlikely event that the landfill cover or institutional controls were to fail.

Initiation of this alternative would require significant planning and permitting due to the limited number of off-site disposal facilities capable of taking RIM and the logistics associated with identifying, handling, classifying and loading the materials for transport to the selected off-site facility. Preparation of the remedial design should be completed within approximately 15 months of authorization to proceed with the RD. RD could take significantly longer if full-scale pilot testing of solids separation equipment is performed. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 13.3 years after approval of the RD. Therefore, the remedial action objectives should be achieved within 14.6 years of approval to proceed with the RD (Appendix J). This schedule estimate assumes that the buyout of the asphalt company lease and potential permitting for and subsequent relocation of the solid waste transfer station occurs during the remedial design phase; otherwise, the schedule would be longer.

The projected construction schedule and the cost estimate for the full excavation of RIM alternative are highly dependent on the waste material swell factor; that is, the amount the in-place waste volume expands as it is excavated, handled and loaded for transport to an off-site disposal facility. For purposes of this FFS, a swell factor of 1.5 has been assumed. A swell factor greater than 1.5 would result in an increase to the overall construction schedule and the estimated costs. The projected construction schedule and the cost estimate for the full excavation of RIM alternative also are highly dependent on the number of rail cars that could be loaded and shipped per day. The schedule and cost estimate developed in this FFS for this alternative are based on an assumption that a sufficient number of IM containers and rail cars can be made available, loaded, switched out and replaced every day. The schedule is also based on (1) a "fleet" (*e.g.*, approximately 20) of flat railcars being dedicated to the project that would be continuously cycled between the off-site disposal facility and the St. Louis area during the period required to transport RIM to the off-site disposal facility and (2) the RIM loading operation being performed in a relatively continuous manner with a constant volume of RIM being transported off site per day. If the actual rate is less than the projected rates of RIM excavation used to develop the construction schedule or if the RIM loading and transport operation is not relatively continuous, the time required to complete construction and the costs for the full excavation of RIM alternative would increase.

6.2.4.6 Implementability

This alternative would involve excavation and off-site disposal of RIM in Areas 1 and 2, repair and restoration of the disturbed portions of the OU-2 landfill units and associated control systems adjacent to Areas 1 and 2, grading of the surfaces and installation of upgraded landfill covers over Areas 1 and 2, long-term monitoring and maintenance of the covers, and long-term monitoring of landfill gas and of groundwater and surface water quality.

Excavation of RIM would require removal of substantial amounts of overburden and material from the sidewalls of the excavations in order to maintain stability of the excavation areas. Overburden removal would entail removing and temporarily relocating a large amount of the above-grade portion of the North Quarry part of the Bridgeton Landfill in order to access the underlying RIM in OU-1 Area 1. This area of the landfill has substantially newer waste than that contained in Areas 1 and 2 since waste was placed in the area until 2004. Based upon the age and state of decomposition, this waste will present a relatively higher risk of odor and bird attraction. Removal of this overlying area will require modification of the existing landfill gas and leachate collection systems for the North Quarry portion of the Bridgeton Landfill. Open excavation into this area also presents a risk of oxygen intrusion into the Bridgeton Landfill. Control systems will have to be modified and appropriate cover implemented to minimize the risk of oxygen intrusion given the subsurface fire risk presented by oxygen intrusion.

The total amount of non-RIM waste required to be removed is estimated to be approximately 1,675,000 bcy, which, based on an expansion factor of 1.5, would result in the need to handle, stockpile and replace 2,325,000 lcy of waste. In addition, daily cover would be added to the excavated areas, the stockpiles and again during replacement of this material. Assuming 10% volume for daily cover for each activity, this would increase the total amount of material to be handled by approximately 30% or approximately 700,000 yards resulting the total volume handled of over 3,000,000 lcy. This material would be handled twice, once at the time of excavation and initial stockpiling and a second time for movement from the stockpiles back to Areas 1 and 2. Management of such a large amount of exposed waste in both the excavation areas and the stockpiles (including management of stockpiles, stormwater runon and runoff, odor emissions, attraction to birds and other vectors, and litter control) would be a significant undertaking. The amount of space available for stockpiling the overburden material is limited, and therefore overburden material from Area 1 would need to be transported to Area 2 for temporary stockpiling while waiting for final placement and capping. Similarly, the total volume of RIM that would be excavated under this alternative is estimated to be 310,000 bcy, equivalent to approximately 465,000 lcy although due to the inclusion of daily cover material would require shipment of 512,000 lcy. Due to the double-handling (at a minimum) of the overburden material plus the RIM handling, it is anticipated that approximately 5,820,000 lcy of waste would be handled under this alternative. Following re-disposal of this waste, a reconstruction of the leachate and gas control systems would be necessary for the North Quarry portion.

An additional complication arises from the proximity of the Bridgeton Transfer Station. In order to access the RIM in the southwest portion of Area 1, the solid waste transfer station would need to be relocated, because removal of waste material would extend up to and along the base of the transfer station such that the integrity of the transfer station building foundation and above-grade structure would be compromised. The only available space for relocation of the transfer station is the area currently occupied by Simpson Asphalt Company, which holds a long-term (99-year) lease on this area. This lease would have to be bought out and the asphalt company would need to be relocated before the transfer station could be relocated to this area. The estimated construction schedule (Appendix J) and costs (Appendix K-4) for this alternative are predicated on the solid waste transfer station being relocated prior the start of RIM excavation and transport.

It is anticipated that a new structure (Figure 5-8) would be constructed to shelter the RIM staging and loading operations in order to minimize stormwater contact, odor emissions and bird attraction and to allow RIM loading for off-site disposal would occur on a relatively continuous basis. Such a structure would likely be constructed along the north side of the Site access road in the area that is currently being used to store new, reclaimed and surplus equipment and materials associated with ongoing operation and maintenance and closure activities for the Bridgeton Landfill. These materials would need to be relocated to another portion of the Site prior to construction of such a structure.

In order to minimize potential vehicle interactions between normal traffic to and from the re-located solid waste transfer station and the construction operations associated with this alternative, a temporary overpass would likely need to be constructed over the Site access road to allow for uninterrupted movement of construction traffic between Areas 1 and 2 and uninterrupted traffic of refuse trucks to/from the relocated solid waste transfer station. An overpass is considered the most efficient and safest means for transfer of overburden waste from Area 1 to stockpile locations in Area 2 and then back to Area 1. In addition, as discussed above, a single RIM staging and loading building would be constructed and operated as part of this alternative. RIM removed from Area 1 would need to be transferred over the Site access road to the RIM staging and loading building. Installation of an overpass would eliminate the potential for RIM material to be tracked across the Site access road and potentially tracked off-site. An overpass would also eliminate the need for traffic control and potential for accidents that would be associated with an intersection of the solid waste transfer station access road and the temporary construction traffic road between Area 1 and Area 2.

While excavation with subsequent off-site transportation and disposal have been implemented at other sites containing radioactively-impacted materials, materials from these other sites have not included significant amounts of landfill solid wastes and debris, and it is expected that these landfill wastes could complicate the implementation of any RIM removal. Significant technical and administrative implementability issues are also associated with excavating the RIM and loading it into IM containers for transportation if this alternative were to be implemented. These include the following:

- Reduced excavation production rates and increased volume of RIM ultimately subject to excavation and disposal resulting from application of daily cover over an extended excavation schedule;

- Ability to locate and obtain a lease to an off-site rail spur for use as a truck-to-rail transfer facility, or alternatively, the ability to construct an on-site rail spur and rail loading facility;

- Increased potential over an extended period of time for bird strikes to aircraft as a result of excavation of putrescible or organic solid waste overburden waste from the North Quarry portion of the Bridgeton Landfill and Areas 1 and 2 and excavation RIM contaminated waste from Areas 1 and 2, all of which are located within flight paths of Lambert–St. Louis International Airport;

- Increased risk of oxygen intrusion into North Quarry portion of Bridgeton Landfill resulting from removal of portion of North Quarry waste overlying Area 1;

- Ability to remove all of the RIM due to the proximity of some of the deeper RIM in OU-1 Area 1 beneath and adjacent to the above-grade portion of North Quarry portion of the Bridgeton Landfill and in OU-1 Area 2 adjacent to other landfill units (*e.g.*, Closed Demolition Landfill and Inactive Sanitary Landfill); and

- Impacts to other Site operations and traffic on surrounding roads from additional truck traffic used to haul wastes to an off-site truck-to-rail transfer facility and to haul earthen materials to the Site for daily cover, stockpile covers, and construction of the final cover.

Design and construction of post-RIM-excavation landfill covers over Areas 1 and 2, with subsequent monitoring and maintenance, are not expected to pose any implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 after RIM removal are available, and the technologies have been proven through application at other landfills.

The actions included for the Buffer Zone/Lot 2A2—that is, the testing and excavation of surface soil—are regularly and easily implementable.

Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of the covers placed over Areas 1 and 2 and are easily implemented.

6.2.4.6.1 Ability to Construct and Operate the Technology

In general, excavation and off-site disposal are standard technologies. However, there are unique circumstances associated with excavation of RIM in Areas 1 and 2, insofar as Areas 1 and 2 are located within an overall larger closed/inactive landfill site, which would complicate implementation of standard excavation technologies.

There are questions regarding the ability to remove all of the RIM from Area 1 and Area 2 due to the depth of some of the RIM and/or the proximity of OU-1 Areas 1 and 2 to the OU-2 landfill units such as the North Quarry portion of the Bridgeton Landfill, closed construction and demolition waste landfill (the C&D landfill) and the OU-2 inactive solid waste landfill. RIM is not present in these other landfill units, but it would be necessary to excavate into these OU-2 units in order to access some of the RIM in OU-1. Although sheet piling as a Site-wide replacement for excavation sidewall sloping was evaluated as part of the SFS and again for this FFS (Appendix D-1) and determined not to save costs or time compared to sloping the sidewalls, small areas of sheet piling where the OU-1 RIM is closest to the transfer station or areas adjacent OU-2 landfill units may prevent or minimize damage to the transfer station foundation or encroachment of excavation slopes into the OU-2 units and therefore prove economical for the full excavation of RIM alternative. Such targeted use of sheet piling could be further evaluated during remedial design.

Upon completion of removal of the RIM from OU-1, disturbed portions of the adjacent landfill units in OU-2 would need to be repaired and restored to a condition that meets or exceeds existing closure conditions prior to implementation of this alternative and subject to the requirements of any additional remedial actions required for either of these areas as part of implementation of the OU-2 remedy.

RIM excavation and placement in IM containers and hauling of the containers by truck for subsequent transfer to rail is also expected to present implementability concerns, challenges, and risks, specifically those associated with the following:

- Excavation and handling of contaminated materials;
- Safety risks associated with encountering methane gas during excavation;

- Safety risks associated with potential for oxygen intrusion into the waste mass of the landfill, especially in conjunction with any removal of portions of the Bridgeton Landfill that overly portions of Area 1;

- Management of fugitive dust and potential odors;

- Mitigation of bird hazards;

- Management and treatment of stormwater exposed to RIM during excavation; and

- Identifying, segregating, and disposing off-site of any hazardous wastes, polychlorinated biphenyls (PCBs) or RACM that may be encountered during RIM excavation.

If hazardous wastes, PCBs, or RACM are encountered during excavation of RIM, these materials would need to be segregated from the other waste materials, characterized, and transported to an off-site disposal facility in containers separate from the other RIM. Additional health and safety procedures would be required during excavation of these materials. These materials would require separate handling at the off-site disposal facility and could require treatment prior to disposal. Depending on the characteristics of any hazardous waste encountered during excavation, the hazardous waste could need to be transported to a different off-site facility for treatment and disposal in accordance with RCRA.

Directing and controlling the RIM excavation process using radiological scanning and sampling techniques would significantly impact overburden and RIM excavation production rates. Based on experience in excavation of radiologically-impacted waste at other sites, a reduction in efficiency is expected for overburden excavation and a greater reduction is expected for RIM excavation. Because thorium-230 cannot be detected using field survey instruments, excavation activities would have to rely on collection and laboratory analyses of samples for guidance. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities and initial confirmation that all of the RIM had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that all RIM has been removed from a particular area would also be subjected to off-site laboratory analyses and data validation.

While potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses and by moving excavation activities to other areas while waiting on the results of verification of confirmation sample analyses, even with these measures it is likely that some short-term delays to the construction work on the order of hours to days will likely occur as a result of waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedule developed for this alternative.

Daily soil cover and tarps would need to be placed over open excavation areas and stockpiled overburden to minimize dust, odor, and the attraction of birds and other wildlife. The proximity of Areas 1 and 2 to Lambert-St. Louis International Airport poses a potential risk to aviation operations. The St. Louis Airport Authority and the U.S. Department of Agriculture have identified as a problem the potential for increased bird activity in conjunction with waste excavation at the Site and the resultant increased risk of aviation bird strikes. Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed overburden and wastes), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be evaluated for use at Areas 1 and 2. The size of open excavations may limit the constructability of wire or monofilament grids. Careful evaluation of material properties would be necessary during remedial design to assure that the appropriate strength and elasticity of materials are considered, that the materials are available, and that grids can be reasonably constructed.

Effective stormwater controls could be readily implemented using conventional construction equipment and materials. Temporary berms to direct stormwater away from open excavations would need to be constructed, and precipitation accumulation in depressions created by the excavation activities would need to be pumped out and managed. Direct precipitation or runoff that may contact waste material could become contaminated with soils or wastes containing thorium or radium. These elements would be entrained in colloidal material that would readily settle in low areas or in the tanks used to collect and store stormwater prior to treatment and discharge. At the end of excavation activities, accumulated sediment in any low areas or the tanks would also be removed and, depending upon the activity levels, either placed in Area 1 or 2 or transported to the off-site disposal facility.

Excavated RIM exposed to precipitation would be subject to the paint filter liquids test (PFLT) as necessary to determine if free liquids exist prior to being loaded for off-site disposal. If the excavated material to be hauled off-site does not pass the PFLT, a dewatering area would need to be staged and collected water treated and/or disposed, potentially through off-site disposal. The current estimated costs and schedules do not address any dewatering activities. Should such activities be necessary, a suitable area would have to be identified within the Site.

Truck hauling of IM containers of RIM to a truck-to-rail transloading facility and transferring the RIM to railcars is technically implementable. Loading RIM directly into railcars on-site if a rail spur could be extended onto the West Lake Landfill property is theoretically implementable; however, it is not known whether extension of a spur onto the property is actually feasible. If construction of an on-site rail spur were to be considered, an engineering study and development of a detailed design would be necessary to determine the feasibility and implementability. As previously discussed in Section 5.5.3 and as further discussed in Sections 6.2.4.6.5 and 6.2.4.6.6

below, construction of an on-site rail spur would also require coordination with a number of local and state regulatory authorities as well as private landowners.

An initial comparison of the US Ecology Grand View facility WAC to estimated activity levels in the OU-1 RIM under the full excavation of RIM alternative is presented on Table 6-2. Although a representative of the turnkey contractor would be on-site during RIM excavation to coordinate loading of containers, there is a potential that one or more shipping containers could contain activity levels that exceed the WAC and may have to be unloaded and re-distributed prior to shipment or, in the worst case, returned to the Site by the disposal facility and/or sent to a different disposal facility. These additional activities could result in additional worker exposures, additional time to complete the project, and potentially additional costs.

Regrading the landfills and placement of final cover is implementable and has been performed at other landfills, including CERCLA sites. Environmental monitoring is routinely performed at most sites and is not expected to present any feasibility challenges.

6.2.4.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material generally is a reliable technology, and has been implemented at a number of other sites including other CERCLA sites, FUSRAP sites, and DOE Land Management sites. Notably, waste deemed “inaccessible” has generally been allowed to remain in place, including in the case of the St. Louis North County Sites, which were successfully remediated to conditions that pose no risk to human health and the environment under any future use scenarios. Additionally, none of these FUSRAP sites involved such large-scale excavations of radiological materials commingled with municipal solid waste and disposed in a landfill setting such as what is included under this alternative for OU-1. The reliability associated with disposal in an off-site facility would be dependent on the integrity of the liner and cover systems at the off-site facility being maintained, as well as the effectiveness of the various off-site facility monitoring programs.

Landfill cover systems such as those that would be implemented over Areas 1 and 2 after RIM removal, and which are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance, have been demonstrated to be reliable at: (1) minimizing percolation and infiltration of precipitation; (2) minimizing leachate generation; (3) minimizing impacts to groundwater quality; (4) minimizing impacts to surface water quality and quantity; (5) minimizing erosion of cover material; and (6) minimizing uncontrolled releases of landfill gas. Landfill cover systems have been demonstrated to be reliable methods for isolating waste materials. Similarly, access restriction measures have been demonstrated to be reliable mechanisms to prevent unauthorized access to a site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed RIM and waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated, reliable technologies under proper operating and excavating conditions. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. In addition, the FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are well-established technologies that are implemented at most landfill sites. For this alternative, gravity settling of suspended solids potentially containing radionuclides is a well-established and reliable technology.

6.2.4.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

It is possible that all of the RIM may not be removed during implementation of the full excavation with off-site disposal alternative. In accordance with the Supplemental Standards provision of UMTRCA (40 CFR § 192.21), a decision could be made by EPA to leave some RIM at the Site. EPA could determine that RIM that is deeply buried beneath large volumes of waste or that is located adjacent to buildings (*e.g.*, adjacent to the solid waste transfer station) such that removal could impair/ undermine the integrity of those structures, would be better left at the Site. If this were to occur after completion of the full excavation of RIM alternative, regrading of the landfill, and construction of a new engineered landfill cover, performance of additional remedial action in the future to remove such materials would be very difficult and costly.

The only anticipated additional remedial actions that may need to be taken for the full excavation of RIM alternative would be maintenance activities needed to sustain the cover system, repair areas of differential settlement or address erosion, or possible implementation of a contingent landfill gas control system. Differential settlement or compaction of the underlying remaining waste materials after RIM excavation could necessitate placement of additional soil over all or portions of Areas 1 or 2 to maintain the required final grades. Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term monitoring and maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would involve placement of additional fill, regrading, and revegetation of the repaired area.

Under this alternative, part of the landfill gas system currently being operated in the North Quarry portion of the Bridgeton Landfill would likely have to be removed in conjunction with the waste excavation activities and replaced upon completion of the excavation and regarding activities. In the event that monitoring of subsurface landfill gas detects the presence of gas levels above regulatory thresholds along the perimeter of Areas 1 and 2, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system. Installation of a contingent gas system could be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be applied to additional excavated area in the event that additional waste volume is encountered.

Stormwater management measures, other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures, are not anticipated to be necessary to support implementation of the full excavation of RIM alternative.

6.2.4.6.4 Ability to Monitor Effectiveness of Remedy

Demonstrating the effectiveness of the cover systems constructed over Areas 1 and 2 after RIM removal above unrestricted use levels would be accomplished by implementing monitoring programs for the cover surface, landfill gas system, groundwater, and surface water programs as previously described in Section 5.5.6. These types of monitoring programs have been proven at demonstrating cover effectiveness and are easily implemented.

6.2.4.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the full excavation of RIM alternative would require approvals from other agencies, including the following:

- Approval from the FAA to conduct waste excavation activities within 10,000 feet of an active airport runway. FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, “Hazardous Wildlife Attractants On or Near Airports,” recommends “against locating a MSWLF [municipal solid waste landfill] within the separation distances identified in Sections 1-2 through 1-4. The separation distances should be measured from the closest point of the airport’s AOA [airport operations area] to the closest planned MSWLF cell.” AC 150/5200-33B, p. 4. The separation distances referenced are 5,000 feet from the end of a runway for airports serving piston-powered (propeller) aircraft; 10,000 feet for airports serving turbine-powered (jet) aircraft; and 5 miles of protection from hazardous wildlife movement for approach, departure and circling airspace. The FAA strongly recommends against allowing a waste disposal operation within 10,000 feet of a jet aircraft runway if the material contains putrescible waste and so has the potential to attract wildlife that could threaten air traffic. The excavation of RIM material containing putrescible waste within 10,000 feet of the westernmost runway (11/29, formerly known as 12W/30W) at Lambert-St. Louis International Airport, as would occur during excavation of the RIM in Areas 1 and 2, is limited by the need to mitigate potential bird activity during excavation to address the requirements of the FAA Advisory Circular and to comply with the same prohibitions in the Missouri solid waste regulations. It may be necessary to work directly with the FAA and MDNR to identify specific bird mitigation measures during implementation.

- Approval of St. Louis Airport Authority (STLAA) relative to obtaining a release for the Negative Easement and Declaration of Restrictive Covenants Agreement (Appendix A-2). Excavation of RIM from Areas 1 and 2 poses a potential to increase the bird populations at the Site if mitigation procedures are not employed or prove ineffective. An increase in bird populations presents a greater potential for aircraft bird strikes. The STLAA and USDA have identified this as a concern relative to construction and operation of a new on-site disposal cell that was included in the full excavation of RIM with on-site disposal alternative evaluated in the SFS. Based on the STLAA's position stated in the STLAA's September 20, 2010 letter to EPA (Appendix A-5), STLAA acceptance of RIM waste excavation would not be likely if bird activity were to increase. It may be necessary to work directly with the FAA and the STLAA to address these concerns, either by amending the FAA ROD, amending the Negative Easement, requiring specific bird mitigation measures during implementation, or making other changes to secure STLAA's cooperation. By letters dated August 11, 2014 and August 11, 2017 (Appendix A), the Airport again submitted comments to EPA, emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives.

- Location of an off-site truck-to-rail loading facility. At a discussion held in September 2010, the STLAA indicated that they would not allow the use of the existing SLAPS truck-to-rail transloading facility for loading waste from the West Lake Landfill into railcars (see Appendix A-4). The SLAPS rail spur is reportedly owned by the U.S. Army Corps of Engineers and the land upon which the rail spur is built is owned by the City of St. Louis. It is not clear that the STLAA could prevent use of the SLAPS rail spur for loading and shipping via contractual means; however, as the STLAA is the owner of the property, their concurrence must be considered. Therefore, it appears unlikely that the rail spur at the airport would be available for implementation of a remedial action for West Lake Landfill. No other nearby off-site truck-to-rail loading facilities have been identified. Discussions with US Ecology have indicated that as part of the transportation and disposal activities, US Ecology would locate and lease an existing rail spur in the area or otherwise construct a rail spur somewhere in the area that could serve as a transloading facility.

- Approval for construction of on-site rail spur. If a rail spur were to be extended onto the Site, necessary permitting and approval to construct a rail spur across St. Charles Rock Road (Missouri Route 180) and associated rail crossing traffic control facilities would need to be obtained from the Missouri Department of Transportation, St. Louis County, and/or the City of Bridgeton.

- Compliance with EPA's Off-Site Rule (OSR). The EPA Region where the off-site disposal facility is located would need to be contacted every 60 days during the period of off-site waste shipments to obtain a compliance determination as to whether the disposal facility currently meets the criteria under the OSR to accept CERCLA waste. If, during RIM excavation, the contracted off-site disposal facility was to fall out of compliance for a period of time, excavation and transportation would either need to cease until the facility becomes compliant again, or RIM would need to be transported to another facility that is determined to be in compliance with the OSR. Besides schedule delays, temporary stoppage of construction would present significant technical implementability concerns regarding open excavation areas.

- Rocky Mountain Low Level Radioactive Waste Compact Consent. If RIM were to be disposed at the Clean Harbors Deer Trail, CO facility, an application would have to be submitted to and accepted by the Rocky Mountain Low Level Radioactive Waste Compact. Disposal at the US Ecology Grand View, ID or Wayne, MI facilities, or the Energy*Solutions* Clive, UT facility would not be subject to a Waste Compact consent.

6.2.4.6.6 Coordination with Other Agencies

Coordination with many entities would be necessary to implement the full excavation of RIM alternative (although not all of them are considered "agencies"). Coordination with the Site owner and operator and owners or occupants of the various parcels that comprise the West Lake Landfill Site would be necessary because of the following:

- Termination of the asphalt company lease and removal of the asphalt plant followed by relocation of the Bridgeton solid waste transfer facility and construction of an overpass between Areas 1 and 2 over the Site access road would need to occur prior to the start of RIM excavation;

- Access to operations conducted on other portions of the Site would need to be maintained.

- Areas 1 and 2 are within the existing Site footprint, and the use of areas on the West Lake Landfill Site outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction.

- Implementation of this alternative would require excavation of portions of landfill units located outside of OU-1. Upon completion of removal of the RIM, disturbed portions of the adjacent landfill units would need to be repaired and restored, and regrading and installation of a replacement landfill cover over areas outside of OU-1 would need to be performed. Coordination would also be required relative to integration of the slopes and grading for adjacent landfill areas, as well as routing and design of stormwater diversion and conveyance structures between OU-1 and other landfill areas. Finally, modification and ultimate restoration will be necessary for the landfill gas and leachate collection systems for the North Quarry portion of the Bridgeton Landfill.

- Use of other areas of the West Lake Landfill Site that may be necessary for stockpiling of overburden and staging or routing of trucks or rail cars used to haul the excavated RIM off site.

- Implementation of any additional institutional controls or modifications of any of the existing institutional controls that EPA may require would need to be approved and accepted by the individual entities that own the various parcels that compose the Site.

For the duration of excavation, off-site transport, and import of cover materials, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the current on-site solid waste transfer station and other Site tenants.

If a truck-to-rail transloading facility at an off-site rail spur location were to be used, a suitable location would need to be identified and a lease secured with the land/rail spur owner for the duration of the RIM loading and transport operations. As noted above, it does not appear that the existing SLAPS truck-to-rail transloading facility would be available, so costs for establishing a new facility would need to be considered[69].

If a rail spur were to be extended onto the West Lake Landfill Site:

- Land located across St. Charles Rock Road would either need to be purchased or long-term leases would be needed with landowners;

- State and local government, private landowner, facility occupant, and community approval would need to be obtained to construct a rail spur across private property located to the east of St. Charles Rock Road, across St. Charles Rock Road, and along the access roads which serve the existing solid waste transfer station and asphalt plant operations located at the Site;

- Appropriate safety measures for the crossing at St. Charles Rock Road would have to be installed, consistent with requirements of state and local governments;

[69] The unit cost estimates provided by US Ecology for purposes of this FFS include costs to secure an off-site rail spur for a truck-to-rail transloading facility.

- The long-term lease of the asphalt plant for land south of the solid waste transfer station, would need to be bought out or otherwise acquired; and

- Because of the high traffic volume on St. Charles Rock Road during the day, dropping off empty and picking up loaded railcars would likely be possible only during late night and early morning hours.

Provision and switching of gondola railcars either at a truck-to-rail transloading facility spur or an on-site rail spur would need to be coordinated with the railroad company that would be hauling the railcars to the off-site disposal facility.

Future groundwater monitoring activities could require obtaining and maintaining access to off-site properties if off-site groundwater monitoring were required as part of the remedy.

The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the FAA and St. Louis Airport Authority. The effectiveness of proposed bird nuisance mitigation measures would be of interest to the FAA and Airport Authority. Consequently, the FAA and Airport Authority would need to be involved in the remedial planning process.

Coordination with other agencies, including the Earth City Flood Control District, MSD, and MDOT, as well as adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities, both during and after completion of construction;

- Coordinate with MSD regarding the permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from AAA Trailer for testing and, if necessary, remediation of the Crossroads Property and possibly for implementation of remedial actions that may need to be performed along the property boundary (e.g. regrading, fencing, etc. in Area 2).

As discussed at the beginning of this section (6.2.4.6), in order to access RIM in Area 1, the Bridgeton Transfer Station building would need to be relocated. The only suitable area for relocation of the solid waste transfer station is the area currently under lease and occupied by

Simpson Asphalt Company. The asphalt company lease would need to be bought out and their equipment removed from the Site before the transfer station could be relocated. Relocation of the transfer station would normally be subject to permitting by the City of Bridgeton and St. Louis County; however, because relocation of the transfer station would be performed as part of a Superfund remedial action and the transfer station would remain on site, additional permitting is not anticipated to be required. However, it is likely that public meetings and hearings may be necessary, which would require coordination with the City of Bridgeton and St. Louis County and could impact the timing for the start of construction of a full excavation of RIM alternative.

6.2.4.6.7 Availability of Off-site Treatment, Storage, and Disposal Services and Capacity

As discussed in Section 4.3.5.4, four off-site disposal facilities that could accept excavated RIM from the West Lake Landfill OU-1 have been identified. At least three of these facilities (located in Idaho, Utah and Colorado) have accepted radiologically-impacted soil from projects or sites in the United States. All four of the identified facilities have available capacity to accept the estimated volume of RIM from the Site. The volumetric rate of acceptance for all facilities would be limited by the number of IM containers and railcars that could be provided and loaded at or near the Site, as well as the number that could be unloaded at or near the disposal facility. Off-site treatment, storage, and disposal may be required in the event that hazardous wastes or regulated asbestos-containing materials (RACM) are encountered in the overburden or RIM excavated from Areas 1 and 2.

The identified off-site disposal facilities are also permitted to: (1) accept liquid wastes, should any stormwater that may accumulate in excavations during RIM excavation become contaminated and require disposal off-site; (2) accept mixed wastes, if mixed wastes are encountered during excavation; and (3) treat soil and/or debris that contains hazardous waste or mixed waste.

As discussed in Section 3.1.4.1, the CERCLA Off-Site Rule requires that waste materials removed from a CERCLA site only be placed in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during remedial design and would need to be regularly evaluated and updated during remedy implementation.

Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater. Initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.4.6.8 Availability of Necessary Equipment and Specialists

Materials, equipment and personnel required for excavation and transport of RIM to an off-site disposal facility are readily available. Trained health physics technicians and specialized equipment required to monitor personnel, monitor environmental conditions, and assist in directing the RIM excavation sequencing are also available.

As discussed above, there are a limited number of disposal facilities that can accept these types of wastes, and most of these have stringent waste acceptance criteria which may limit the ability of some of the facilities to receive the wastes.

Availability of rail service, particularly the number of rail cars that can be made available and switched daily by the railroad, would also affect the production rate of RIM excavation and disposal, and therefore the cost.

All of the materials, equipment and personnel needed to construct the covers over Areas 1 and 2 after RIM removal are readily available and the technologies have been generally proven through application at other landfills. The implementability and potential cost of the covers would be influenced by the availability and location of clean cover materials and/or off-site borrow sources at the time this alternative would be implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006) and during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI, 2008). Information obtained from the vendors at these times indicated that rock, clay and clean fill material were readily available from sources located near the Site. If these local sources of cover materials become exhausted prior to or during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

The necessary materials, equipment and personnel required for assessment and removal of RIM that may be present at the Buffer Zone/Lot 2A2 to unrestricted use levels, and to implement the institutional controls and monitoring components of this alternative are also readily available.

6.2.4.6.9 Availability of Prospective Technologies

The full excavation of RIM alternative is based on proven, established, and commonly used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.4.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the full excavation of RIM alternative are included in Appendix K-4 and summarized on Table 6-1. Conceptual excavation, backfill, and bottom and top of final cover grading plans, as well as stormwater control features used as the basis for the full excavation of RIM alternative capital cost estimate, are provided in Appendix M. The estimated cost to conduct the full excavation of RIM with off-site disposal alternative (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $695,000,000 based in part on unit costs provided by US Ecology.

These costs do not include costs to conduct full-scale pilot testing of solids separation equipment, which is beyond the scope of the FFS and is something that could be evaluated further during remedial design. If a full-scale test of physical separation and radiological segregation were to be performed, it is anticipated that such a test would add approximately $1,000,000 to the cost of this alternative and require an additional nine months for design, obtaining approvals, procurement, mobilization and implementation, laboratory testing, and evaluation and reporting.

The estimated annual OM&M costs range from $173,000 to $337,000 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring and years when landfill cover repairs may occur). The cost estimates provided in this FFS are feasibility-level cost estimates which were developed to a level of accuracy such that the actual costs incurred to implement this alternative are expected to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the full excavation of RIM with off-site disposal alternative are projected to be $455 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $667 million. The total non-discounted costs for the full excavation of RIM alternative over 30 years are projected to be $699 million. Because the scope of this alternative includes removal of all RIM such that no additional engineering measures or institutional controls would be required beyond those associated with a standard MSW landfill, present-worth cost estimates were not calculated for 200-years and 1,000-years as was done for the other alternatives.

For purposes of demonstrating how much shipping of mixed waste could influence costs, it was assumed that mixed waste would represent 0.5% of the sum of the RIM volume (309,700 bcy) and hazardous waste would represent 0.5% of overburden waste volume (1,511,000 bcy) for the full excavation of RIM with off-site disposal alternative. Adding in the daily cover amounts at 10% and applying the bulking factor to estimate the loose cubic yard volume and assuming that 0.5% could be hazardous results in estimated volume of mixed waste of 2,5504 lcy and of hazardous waste of 12,500 lcy. The added costs for handling, sampling/analysis, and treating mixed waste (transport and disposal costs are already included for RIM) for this alternative are estimated to range from $57,000 to $1,340,000 (Appendix K-10). The added costs for handling, sampling/analysis, shipping, treating, and disposing of hazardous waste for this alternative are estimated to range from $2.57 to $9.65 million (Appendix K-10). These cost ranges primarily result from variations in the fees charged by the off-site disposal facilities, as well as uncertainties associated with the nature of such wastes and the required method of treatment. Therefore, the additional costs that may be incurred if mixed and hazardous wastes are encountered during overburden relocation and RIM excavation for the Full Excavation with Off-Site Disposal Alternative, could range from $2.63 to $11.0 million (Appendix K-10). If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher.

6.2.5 Full Excavation of RIM with On-site Disposal Alternative

This section presents the detailed analysis of the full excavation of RIM with on-site disposal alternative. As previously described in Section 5.6, this alternative consists of the following components:

- Selection, investigation and approval of an on-site location for a new engineered disposal cell during remedial design;
- Design and construction of a new engineered disposal cell that meets appropriate requirements of UMTRCA, NRC, RCRA and the Missouri Solid Waste regulations;
- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station building to provide access to RIM located adjacent to the building and construction of an overpass over the Site access road;
- Excavation and stockpiling of overburden from OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from OU-1 Areas 1 and 2 that contains radionuclides above levels that would allow for unrestricted use as defined by the UMTRCA standards in 40 CFR §192.12 as modified by EPA's 1997 and 1998 OSWER guidance (EPA, 1997a and 1998);
- Loading, transport, and disposal of the RIM in a new on-site disposal cell;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 that contains radionuclides at levels greater than those that would be allowed for unrestricted use and transport of such soil to the new on-site disposal cell;
- Regrading of the remaining solid waste materials in Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the Missouri closure and post-closure care requirements for sanitary landfills over Areas 1 and 2;

- Closure of the new engineered landfill disposal cell;
- Design, installation and maintenance of storm water runoff controls for Areas 1 and 2 and the new disposal cell;
- Groundwater monitoring consistent with the requirements for sanitary landfills for Areas 1 and 2 and for an UMTRCA disposal unit for the new disposal cell;
- Landfill gas monitoring and control for Areas 1 and 2 and the new disposal cell, as necessary;
- Continuation of existing institutional controls and modification of the existing institutional controls as necessary to prevent land and resource uses that are inconsistent with a closed sanitary landfill site for Areas 1 and 2;
- Design and implementation of institutional controls for the new engineered disposal cell; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2 and the new engineered disposal cell.

Under this alternative, an estimated 310,000 bank cubic yards (bcy) of RIM and impacted soils would be excavated from Areas 1 and 2, and an additional approximately 2,900 bcy of impacted soil would be excavated from the Buffer Zone/Lot 2A2 and transported to the new on-site disposal cell. This volume of material (313,000 bcy) would increase upon excavation due to swelling, handling, and loading for transport to the on-site cell. The excavation areas would need to be covered daily to reduce odors, windblown debris, attraction to birds and vectors, and impacts to stormwater. Placement of daily cover over the excavation areas is estimated to increase the total volume by 10% (31,300) resulting in a total of 344,000 yds of material. Applying an assumed swell factor of 1.5 it is estimated that this will result in approximately 516,000 loose cubic yards (lcy) that would be transported to the new on-site disposal cell. It is assumed that during placement, this volume would be reduced by 1/3 (the inverse of the 50% swell factor) resulting in a placed volume of 346,000 bcy. Daily soil cover would have to be placed over the waste in the new cell (again estimated as 10% of the volume or 35,000 bcy) resulting in a total volume to be placed in the new cell of 381,000 lcy. It is assumed that compaction using modern equipment would be able to reduce this by a further 10% resulting in a total in-place waste volume of 343,000 bcy in the new cell.

Once the RIM above levels which would allow for unrestricted use has been removed from each area, the remaining solid waste materials in Areas 1 and 2 would be regraded to meet the final closure standards for sanitary landfills. A final sanitary landfill cover would then be constructed over Areas 1 and 2. This cover would not include the additional hybrid components included in the ROD-selected remedy to address the UMTRCA requirements, because the RIM above unrestricted use levels would have been removed under this alternative. An UMTRCA type cover would be applied to the new on-site disposal cell.

Because solid wastes would still be present in Areas 1 and 2, this alternative includes installation and maintenance of stormwater runon and runoff controls, groundwater and landfill gas monitoring, and institutional controls, as described for the ROD-selected remedy. Similar activities would also be required for the new on-site cell. Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site and around the new on-site cell met UMTRCA and State groundwater standards or other ARARs. Monitoring of surface or subsurface occurrences of landfill gas and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2 or the new on-site cell would be performed to ensure that migration of landfill gas above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls would ensure that land and resource uses are consistent with permanent solid waste disposal in Areas 1 and 2 and disposal of solid wastes and radioactive materials in the new on-site disposal cell.

6.2.5.1 Overall Protection of Human Health and the Environment

Conditions at the Site would be protective of human health and the environment after completion of construction of this alternative. This alternative would protect human health and the environment by limiting potential exposure to the Site contaminants through the removal and containment of RIM in a new engineered disposal cell that would meet UMTRCA, NRC, RCRA, and Missouri Solid Waste Regulation standards, as appropriate, and implementation of engineering methods and land use controls to address the remaining solid wastes in Areas 1 and 2.

6.2.5.2 Compliance with ARARs

The full excavation of RIM with on-site disposal would need to comply with ARARs. The ARARs currently being evaluated, in accordance with EPA's November 28, 2017 request for additional work under the AOC, are discussed below.

6.2.5.2.1 UMTRCA

Removal of any soil containing radionuclides from the Buffer Zone and Lot 2A2 would be done in a manner that meets the UMTRCA soil cleanup standards (40 CFR Part 192 Subpart B) as modified by the EPA guidance on the use of UMTRCA for cleanup at CERCLA sites (EPA, 1998 and 1997a). Although the UMTRCA standard is only intended to apply to land (which is defined to include any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building) and therefore is not considered to be an ARAR for Areas 1 and 2 (or, for that matter, the Buffer Zone), removal of RIM from Areas 1 and 2 as specified by EPA (EPA, 2015b and 2010a) would also be conducted in a manner that achieved the UMTRCA standard as modified by the EPA guidance.

It is also anticipated that the design, operation, closure, post-closure and monitoring of an-site disposal cell would also have to meet the UMTRCA performance standards for a disposal unit set forth in Subpart A of these regulations including the longevity, radon release, and groundwater protection standards (40 CFR 192.02), groundwater monitoring requirements (40 CFR 192.03) and corrective action requirements (40 CFR 192.04). The design, construction and closure of the on-site cell would also need to comply with the Subpart D standards for radon flux emissions as set forth in 40 CFR §192.31(k)(1) with regard to a permanent radon barrier. This section of the regulations requires that the final radon barrier construction to achieve compliance with, including attainment of, the limit on releases of radon-222 as set forth in 40 CFR §192.32(b)(1)(ii); specifically, the radon barrier shall "limit releases of radon-222 from uranium byproduct materials to the atmosphere so as to not exceed an average[70] release rate of 20 picocuries per square meter per second (pCi/m^2/s)." Calculations performed as part of the evaluation of the cover design (Appendix F) indicated that based on the 95% UCL for the total volume of material to be removed and placed in an on-site cell, the projected radon flux through the engineered cover over a new on-site cell would be 0.24 pCi/m^2/sec after one year and 6.8 pCi/m^2/sec at 1,000 years. Therefore, the engineered cell should meet the UMTRCA radon flux emission standard. The design, construction, operation, closure and monitoring of a new on-site cell would also need to meet Subpart D ground water protection standards and monitoring requirements (40 CFR 192.32) as relevant and appropriate to a disposal unit (as opposed to requirements for a surface impoundment) and the corrective action program requirements (40 CFR 192.33). The conceptual design of the on-site cell (Appendix M) used as the basis to evaluate this alternative is anticipated to meet these requirements.

6.2.5.2.2 NRC Regulations for Low-Level Waste

These regulations establish the procedures, criteria, and terms and conditions upon which the NRC issues licenses for land disposal of radioactive waste containing byproduct, source and special nuclear material. Per 10 CFR 61.1(b)(2), the regulations in this part do not apply to disposal of uranium or thorium tailings or wastes in quantities greater than 10,000 kilograms and containing more than 5 millicuries of radium-226. Therefore, these regulations are not applicable to the on-site disposal alternative. Because these regulations contain criteria for design, operation, monitoring, closure and post-closure of a radioactive material disposal cell, they may be potentially relevant and appropriate for design, operation and closure of a new on-site disposal cell. The performance objectives (Subpart C) and technical requirements (Subpart D) of these regulations may potentially be relevant and appropriate for an on-site cell. Because these

[70] "This average shall apply to the entire surface of each disposal area over periods of at least one year, but short compared to 100 years. Radon will come from both uranium byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from uranium byproduct materials to the atmosphere." 40 CFR §192.32(b)(1)(ii), footnote 2.

standards primarily contain generalized objectives, adherence to the more specific standards set forth in the UMTRCA regulations (40 CFR 192) and the NRC regulations for uranium mill wastes and tailings disposal (10 CFR 40 Appendix A) are expected to result in consistency with the NRC low-level waste disposal requirements.

6.2.5.2.3 NRC Criteria for Operation of Uranium Mills and Disposition of Tailings or Wastes

The NRC criteria relating to the operation of uranium mills and the disposition of tailings or wastes (10 CFR Part 40 Appendix A) apply to facilities licensed by the NRC and therefore would not be applicable to a new on-site disposal cell for OU-1. However, because these criteria provide standard for design, operation, closure and post-closure of a radioactive disposal unit, the technical criteria set forth in these regulations for the design, operation, closure, monitoring, and post-closure care of the new engineered on-site disposal cell are considered to be potentially relevant and appropriate for a new on-site disposal cell. The standards established by these regulations are essentially the same as those set forth in the UMTRCA standards (40 CFR 192) and therefore, compliance with the UMTRCA standards should result in compliance with these standards. Where additional specificity is provided by the NRC standards, such as the requirement for a maximum final grade of 5 horizontal to 1 vertical (5:1), the preliminary conceptual design of the on-site cell has been developed to address such standards.

6.2.5.2.4 RCRA Subtitle C

The RCRA Subtitle C requirements concerning identification of hazardous wastes (40 CFR Part 261), packaging, temporary storage, offsite transportation of hazardous wastes (40 CFR Parts 262 and 263), and treatment and disposal of hazardous wastes (40 CFR Part 268), are potentially applicable requirements in the event that hazardous wastes are encountered during implementation of any remedy at the Site. Similarly, the requirements of the Missouri Hazardous Waste Management Law (RSMo 260) and associated regulations (10 CSR 25-7) would apply in the event that hazardous wastes are encountered.

The RCRA Subtitle C and Missouri hazardous waste management regulations would also apply to the design, construction, operation and closure of a new on-site engineered disposal cell in the event that hazardous wastes would be disposed in this cell. However, the evaluations of the remedial alternatives presented in this FFS are predicated on the presumption that any hazardous or mixed waste that may be encountered during implementation of any of the remedial alternatives would be transported offsite for treatment and/or disposal. Therefore, the hazardous waste regulations related to design, operation, closure or post-closure of a hazardous waste landfill are not expected to be applicable to any of the remedial alternatives being evaluated in this FFS.

Although not applicable, the design criteria for a hazardous waste landfill (40 CFR Part 264 Subpart N), in particular those related to liner and cover system design and construction requirements, could be relevant and appropriate to the design of a new engineered on-site disposal cell included in the Full Excavation with On-Site Disposal Alternative. For purposes of this FFS, it has been assumed that these requirements will need to be met and therefore, the conceptual design of an on-site cell evaluated for this alternative includes a double-liner and leachate collection and detection systems equivalent to those required for a hazardous waste landfill.

6.2.5.2.5 Missouri Solid Waste Rules for Sanitary Landfills

Regrading, cover, and closure of the remaining solid waste at OU-1 Areas 1 and 2 after RIM removal would need to comply with the MDNR regulations described in Section 6.2.2.2.1 of this FFS. The only difference in site preparation for capping between the full excavation of RIM (with either on-site or off-site disposal) and the ROD-selected remedy would be that regrading Areas 1 and 2 after removal of the RIM under the full excavation of RIM alternatives would need to meet a minimum slope angle of 5% instead of the 2% permitted for the ROD-selected remedy. The increased surface slope would be necessary to account for the increased likelihood of differential settlement resulting from the greater extent of excavation and material disturbance caused by the RIM removal including excavation, stockpiling, and relocation of relatively younger waste contained in the above-grade portion of the North Quarry part of the Bridgeton Landfill that overlies the southern portion of Area 1. Because all RIM exceeding limits for unrestricted use will have been removed, the cover system for Areas 1 and 2 following RIM removal would follow Missouri rules for sanitary landfills, without the UMTRCA enhancements included in the ROD or UMTRCA cover systems.

The design, operation, closure, monitoring, and post-closure care of the new engineered cell would also need to comply with the Missouri solid waste regulations. Most of these requirements would be met through achievement of the requirements associated with the UMTRCA, NRC and RCRA Subtitle C regulations. Additional requirements associated solely with the solid waste regulations include:

- Requirements associated with airport safety and a demonstration that operation of the new landfill cell will not pose a bird hazard to aircraft (10 CSR 80-3.010(4)(8)1.A and 10 CSR 80-3.010(4)(8)1.8);
- Demonstration of the integrity of structural components if the new cell were to be located over existing waste materials (10 CSR 80-3.010(4)(8)6);
- Demonstration that the new cell liner will not be in contact with or be adversely affected by groundwater (10 CSR 80-3.010(4)(8)8);
- One-hundred-foot buffer zone requirement (10 CSR 80-3.010(5)(8)1);
- Calculation of settlement and bearing capacity to determine the effect of foundation material settlement on liner and leachate collection system (for locations where a new cell may be placed over existing waste materials) (10 CSR 80-3.010(5)(8)4.A);

- Screening and removal of unapproved wastes during excavation (disturbance) of Areas 1 and 2 (10 CSR 80-3.010(3)(B)2);
- Requirements for removal and segregation of any tires that may be encountered (10 CSR 80-3.010(3)(A)11);
- Requirements for leachate collection and limit on the amount of leachate that can accumulate on the liner (10 CSR 80-3.010(9)(A) and 10 CSR 80-3.010(9)(B)1.E);
- Groundwater monitoring, to the extent not addressed by other regulations (10 CSR 80-3.010(11)(A);
- Control of landfill gas (10 CSR 80-3.010(14)(A) and 10 CSR 80-3.010(14)(C)l);
- Control of vectors (10 CSR 80-3.010(15)(A)); and
- Cover requirements to minimize fire hazards, vectors, infiltration of water and control of gas (10 CSR 80-3.010(17)).

6.2.5.2.6 Safe Drinking Water Act

40 CFR Part 141 establishes primary drinking water regulations including maximum contaminant limits (MCLs) pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Public Law 93-523), and related regulations applicable to public water systems. These MCLs apply to public drinking water systems. Missouri regulations (10 CSR 60-4.010, et seq.) also establish MCLs for public drinking water systems. MCLs are considered relevant and appropriate to all potentially usable groundwater. As set forth in the NCP, non-zero maximum contaminant level goals (MCLGs) are also potentially relevant and appropriate to potentially usable groundwater. Regrading of the landfill surfaces and installation of an engineered landfill cover to promote runoff and minimize infiltration for Areas 1 and 2 and design of a liner, leachate collection system and engineered landfill cover for the new on-site disposal cell are included as part of this alternative. These measures should ensure that the Site does not result in groundwater quality exceeding the MCLs and non-zero MCLGs.

6.2.5.2.7 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against Ionizing Radiation (10 CFR Part 20) contain chemical-specific standards that address radiation protection. These regulations establish dose limits for individual members of the public and radiation workers, and define maximum permissible exposure limits for specific radionuclides in air and water at levels above background both inside and outside of controlled areas. These requirements are considered applicable during implementation of any remedial action. Specifically, these regulations would require perimeter air monitoring during implementation of the full excavation of RIM alternative. In addition, Site health and safety plans would address worker protection consistent with these requirements.

6.2.5.2.8 Missouri Well Construction Code

MDNR has promulgated regulations pertaining to the location and construction of water wells. The Well Construction Code (10 CSR 23-3.010) prohibits the placement of a well within 300 feet of a landfill. These rules would provide protection against the placement of wells on or near the Site. The regulations on monitoring well construction (10 CSR 23-4) would apply to the construction of new or replacement monitoring wells. The full excavation of RIM with on-site disposal alternative would meet these requirements through enforcement of the existing Institutional Controls[71], modification and amendment of the existing institutional controls for Areas 1 and 2 as necessary, development and implementation of new institutional controls for the on-site cell during remedial design, and adherence to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

6.2.5.2.9 Missouri Stormwater Regulations

The Missouri regulations governing stormwater management at construction sites are specified in 10 CSR 20-6.200 (Table 3-3). A disturbance of greater than 1 acre or the creation of a stormwater point source during construction of the remedy would trigger these requirements. The full excavation of RIM alternative would meet these requirements through implementation of a SWPPP, use of BMPs during construction, installation and maintenance of an engineered landfill cover to prevent stormwater from contacting the waste materials, and construction and maintenance of stormwater diversion and control structures to control runon and runoff and to reduce erosion potential as part of the design of the engineered landfill cover for Areas 1 and 2 and design of the new on-site disposal cell.

6.2.5.3 Long-Term Effectiveness and Permanence

Because the full excavation of RIM with on-site disposal alternative would result in removal of RIM containing radionuclides above unrestricted use levels from Areas 1 and 2 and placement of these materials in a secure engineered disposal cell, this alternative would provide permanent protection against exposures to radionuclides.

For purposes of the FFS evaluations, a potential cell located in the area of the current Bridgeton Landfill soil borrow/stockpile area has been evaluated. This location is outside of any designated floodplain (e.g., 100-year, 500-year or 500-year floodplain protected by levees – see Figure 2-9). Other potential locations that may be considered for an on-site cell (see Section

[71] In addition, the deed restrictions currently in place on Areas 1 and 2 and the Buffer Zone (and which are to be maintained in perpetuity) prohibit the placement of water wells for drinking water or agricultural purposes.

5.6.1), while outside the 100-year floodplain as directed by EPA, may be located near or possibly within the area of the 500-year floodplain protected by levees (e.g., if waste were to be removed from the northern portion of Area 2 and a new engineered disposal cell were to be constructed in that area). The proximity (approximately 1.5 miles) of the Site to the Missouri River presents some uncertainty with regard to meeting the UMTRCA longevity criteria. The West Lake Landfill, including Areas 1 and 2, is located within the geomorphic floodplain of the Missouri River, indicating that within geologic time frames, the river at one time was located in the vicinity of what is now the West Lake Landfill. Given the long-term risk posed by the RIM, it is possible that the river could meander back into this area; however, the ability of the river to expand near or to the Site area is currently controlled by the historic channelization of the River and the presence of the Earth City levee. In the event that a new engineered waste disposal cell located in an area that may be within the floodplain is further considered, additional evaluations would be required to demonstrate the stability of such a cell to withstand flood levels.

Under this alternative RIM containing radionuclides at levels above those that would allow for unrestricted use would be removed from Areas 1 and 2 and placed in an engineered cell that was designed to include a double liner and leachate collection system and an engineered covered that includes both CCL and GCL and/or geosynthetic liner (GSL) to limit precipitation infiltration and radon emissions as well as having sufficient thickness to shield against gamma radiation. Areas 1 and 2 would still contain other solid wastes and would still remain a landfill subject to the applicable requirements for closed solid waste landfills. Therefore, a new landfill cover would need to be installed over the remaining solid wastes after removal of the RIM above cleanup levels. Groundwater monitoring would need to be performed around Areas 1 and 2 consistent with the applicable or relevant and appropriate requirements for a solid waste landfill and around the new engineered cell consistent with UMTRCA, NRC, RCRA and the solid waste regulation requirements. Institutional controls would be required to restrict intrusion into or disruption of the engineered components of the new disposal cell and to prevent unacceptable land uses from occurring on the area of the new disposal cell. Institutional controls would also be required both for Areas 1 and 2 to ensure that future land uses at the Site would be compatible with the presence of a solid waste landfill and to prevent intrusion into the waste materials, disruption of the landfill cover, monitoring points, or other aspects of the solid waste landfill containment system.

6.2.5.3.1 Magnitude of Residual Risk

The calculated lifetime risks to future groundskeeper from radiological materials that would be placed in the new engineered disposal cell after implementation of the full excavation of RIM with on-site disposal alternative are as follows:

- 2×10^{-7} for year 1, 1.9×10^{-6} for year 1,000, and 5.4×10^{-6} for year 9,000.

Risks to residents were even lower (see Appendix H). These calculated risks are mainly attributable to radon emissions from the radionuclide occurrences in the material that would be placed in the on-site cell. The calculated risk levels are within or below EPA's target risk range of 1×10^{-6} to 1×10^{-4} and the magnitude of the radiological carcinogenic risk from the RIM in the on-site cell is acceptable. These risks do not specifically include potential exposures from non-radiological landfill waste in either Areas 1 or 2 or the on-site cell after construction is complete; however, those wastes would be covered by a cap which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

Additionally, the on-site cell and Areas 1 and 2 would be capped and access to and future use of the capped waste disposal areas would be limited by Site access restrictions and institutional controls. Direct contact with chemical constituents or radionuclides in the waste materials under the caps, or ingestion, inhalation, or dermal contact with such materials, is not expected to occur. Because no complete exposure pathway would exist for such materials after construction of the landfill covers, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks.

After soils containing radionuclide concentrations above the cleanup levels are removed from the Buffer Zone/Lot 2A2 property, residual risks posed by the remaining radionuclide-impacted soils on these properties, if any, are expected to be indistinguishable from variations in background levels.

6.2.5.3.2 Adequacy and Reliability of Controls

The new engineered on-site cell would be designed and constructed to meet appropriate requirements of UMTRCA, NRC, RCRA Subtitle C and the Missouri Solid Waste Regulations. It would include low permeability cover to minimize infiltration of precipitation and a double liner and leachate collection systems to contain and control leachate migration. The conceptual design of the engineered cover includes sufficient thickness to reduce gamma radiation and radon flux to levels that would comply with ARARs and meet risk-based standards, based on the projected ingrowth of radium-226 from 1,000 years of thorium-230 decay using the 95% UCL for both isotopes. Therefore, the engineered cover should provide adequate control of radon emission and gamma radiation. Reliability of the cover is enhanced through inclusion of a GCL and/or GSL in addition to a CCL to create the low permeability layer, inclusion of a biointrusion layer above the low permeability layer to protect that layer from burrowing animals or erosion, creation and maintenance of a vegetative (grass) cover, the possible addition of a rock mulch to the upper portion of the vegetative layer to reduce the potential for erosion in the event of loss of vegetation, the overall thickness of the cover system, and performance of routine inspections, maintenance and repairs, if any are needed.

The components of the engineered cell would be constructed from a combination of both natural and man-made materials. Evaluation of potential future radon emissions through the cover system (Appendix F) was based on consideration of only the natural materials (e.g., the CCL) and did not consider the presence of the man-made components of the cover system (e.g., GCL and/or GSL). Therefore, the design of the engineered cell is expected to be reliable upon completion of construction and into the future. Construction of the on-site cell is expected to be performed in accordance with strict quality assurance/quality control requirements and subject to independent inspection and testing by the contractor, the design engineer, other independent engineer, and the regulatory agencies to ensure that it is constructed in accordance with the design specifications.

The engineered measures and institutional controls that would be implemented for Areas 1 and 2 under the full excavation of RIM alternative with on-site disposal alternative (landfill cover, groundwater and landfill gas monitoring, and institutional controls) are considered to be adequate and reliable. OM&M requirements for the full excavation of RIM with on-site disposal alternative for Areas 1 and 2 would be the same as those previously discussed for the full excavation with off-site disposal (see Section 6.2.4.3.2). No difficulties or uncertainties or potential need to replace significant components are envisioned for the long-term OM&M functions for Areas 1 and 2 under the full excavation of RIM with on-site disposal alternative.

Because the full excavation of RIM with on-site disposal alternative entails removal of all RIM above the criteria that would allow for unrestricted use relative to radionuclide occurrences from Areas 1 and 2, the remedial actions included in this alternative are expected to be a final action for Areas 1 and 2. Therefore, it is assumed that no components of the remedy for Areas 1 and 2 would need to be replaced in the future. The landfill cap of Areas 1 and 2 would need to be maintained but because it would be composed of natural materials (*e.g.*, soil) it should not need to be replaced. However, in the unlikely case that components of the remedy for Areas 1 and 2 require replacement in the future, because all of the radionuclides would have been removed from these areas, unacceptable risks are not expected to occur. Moreover, given that the components of the final covers at Areas 1 and 2 would be constructed from natural materials with properties that limit migration potential of any residual radionuclides below unrestricted levels or solid waste constituents, there is a high degree of confidence that the engineered controls would prevent or otherwise address potential problems.

6.2.5.3.3 Climate Changes and Potential Impacts of a Tornado

The on-site cell would include an engineered cover meeting the UMTRCA design and performance (longevity) standards as shown conceptually on Figure 5-4. Because municipal solid waste would still remain in Areas 1 and 2, a new engineered landfill cover would be installed over these areas. Because radionuclides above unrestricted use levels would be removed from these areas, the engineered landfill cover to be installed over Areas 1 and 2 under this alternative would not include the 2-foot-thick rock/rubble biointrusion layer. Instead, the engineered cover would consist of a standard landfill cover for a Subtitle D MSW landfill without a liner system, which would consist of a 2-foot-thick low-permeability layer and a 1-foot-thick vegetative layer. The engineered landfill covers over the on-site cell and Areas 1 and 2 would be classified as an in-situ containment system (EPA, 2014a).

Because the UMTRCA type landfill cover to be installed over the on-site cell is similar to the landfill cover to be installed under all of the other alternatives except for the full excavation with off-site disposal, the analysis of the potential effects of climate change or impacts of a tornado are essentially the same as those previously described for the ROD-selected remedy and the UMTRCA cover alternative. These effects were previously discussed in Section 6.2.2.3.3 for the ROD-selected remedy and therefore are only summarized below.

Similar to the capping alternatives, the vegetative layer of the landfill cover to be installed over the on-site cell and Areas 1 and 2 under the on-site disposal alternative could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation and increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potential increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence.

The low permeability layer (CCL and/or GCL) could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include the desiccation of the CCL or bentonite material in the GCL or slope areas, which could increase the permeability of the low permeability layer resulting in an increased potential for infiltration of precipitation. However, the vegetative layer would likely show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer and thereby provide advance notice of a potential impacts. Accordingly, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. For these reasons, potential degradation of the CCL/GCL due to extreme temperatures or drought is not expected to result in release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and possibly the biointrusion layer, which, if left untended, could result in erosion of the underlying low permeability layer. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given that the landfill cover over Areas 1 and 2 included in this alternative would not include the 2-foot-thick rock layer above the low permeability layer, stormwater erosion under a severe storm event could potentially erode down through the entire landfill cover in these areas, resulting in temporary exposure of waste materials. This could result in exposure of the waste material or the release of contamination. However, because it is presumed that all RIM above unrestricted use levels would be removed as a part of the full excavation of RIM alternatives, such impacts would not result in release of radionuclides above risk-based levels. Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including the erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs (if any are needed). Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. Any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair, and replacement of cover material in response to any damage that may occur.

The full excavation of RIM alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, FEMA has determined that Areas 1 and 2 are located outside of the area of the 500-year floodplain that is protected by levees. In addition, the area to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River, are protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park.

Similar to the ROD-selected remedy as discussed in Section 6.2.2.3.3, the full excavation of RIM with on-site disposal alternative, upon completion, is not vulnerable to impacts from a tornado. Specifically, based on a review of the impacts of tornados at other sites, a tornado is not expected to damage the vegetative layer. However, even if a tornado were to impact the vegetative cover, such an impact would not be significant because it could be easily identified and, due to the design and thickness of the engineered cover, would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy aboveground infrastructure such as signage, fencing, or environmental monitoring equipment. Such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the full excavation of RIM alternative is not considered to be vulnerable to potential impacts from a tornado.

Although the full excavation of RIM with on-site disposal alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could be considered during remedial design to provide a degree of adaptation for climate change. For example, although the conceptual design of the on-site cell is based on a maximum 5:1 slope, the final design could include shallower slope angles that would reduce the potential for stormwater erosion. Similarly, although this alternative includes regrading of the surfaces of Areas 1 and 2 to a minimum grade of 5% to allow for possible increased decomposition that may occur as a result of exposing a large volume of waste to atmospheric air (oxygen), regrading of the surface of Areas 1 and 2 to a 2% slope instead of a minimum 5% slope could be considered as a potential adaptation measure for possible climate change. Reducing the slope of the landfill surface to 2% would reduce the velocity of runoff across the surface of Areas 1 and 2 and thereby reduce erosion and soil loss potential under extreme precipitation events. Potential increased settlement of the waste material and cover system that may occur if there is increased decomposition of the waste could be addressed through routine cover maintenance and repair activities. Installation of runoff collection and diversion systems along the base of the above-grade portion of the North Quarry portion of the Bridgeton Landfill adjacent to Area 1 and along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2 could be installed to divert runoff from these areas around Areas 1 and 2 to reduce the potential for impacts from heavy precipitation events. Use of grass seed mixtures that are more tolerant of long-term changes in precipitation or temperature and/or soil addition to increase water storage capacity could be evaluated as part of the design. Similarly, inclusion of a geotextile at the base of the vegetative layer and/or biointrusion layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low permeability layer. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls to increase the overall resilience of these features to heavy precipitation events. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures would be included as part of the ongoing inspection and maintenance program.

6.2.5.3.4 Potential Impacts of a Subsurface Heating Event

If the on-site cell were to be constructed in the current Bridgeton Landfill soil borrow/stockpile area, it would be physically separated by native soil and rock from other landfill units at the Site. Therefore, there would be no potential for a subsurface heating event in the Bridgeton Landfill to migrate to or otherwise impact the on-site cell. If the on-site cell were to be located on top of one of the existing OU-2 landfill units, such as the Closed Demolition Landfill or Inactive Sanitary Landfill, a potential exists for a reaction to impact the cell. If the cell were to be located in the northern portion of Area 2, and presuming all of the waste were removed prior to construction of the cell, it would be physically separated from the other waste disposal units and therefore not subject to impacts from a subsurface heating event in the Bridgeton Landfill.

To the extent the materials in Areas 1 and 2 could support the occurrence of an independent subsurface heating event, the evaluation of risks for the on-site cell would align with those discussed above, as would the mitigation actions.

Because it is presumed that all radionuclides above unrestricted use levels would be removed from the Areas 1 and 2 under the full excavation of RIM with on-site disposal alternative, radionuclide-related impacts would not be expected to occur if a subsurface heating event were to occur in Areas 1 or 2. Odor emissions, ground settlement, disruption of an engineered cover, and other potential impacts associated with a heating event could potentially still occur under the full excavation of RIM alternative. These would be addressed as part of OM&M activities including activities such as placement of additional soil to fill areas of subsidence, repair and/or enhancements to the landfill cover system, and efforts to manage, control and reduce odor emissions.

6.2.5.3.5 Effects of an Isolation Barrier

Because it is presumed that all of the radionuclides above unrestricted levels would be removed from Areas 1 and 2 under the full excavation of RIM with on-site disposal alternative, there would be no need for installation of an isolation barrier system between the North Quarry and Area 1. If an isolation barrier system were installed prior to implementation of a full excavation of RIM alternative, large portions of the barrier system may need to be removed to gain access to RIM in the vicinity of a barrier.

6.2.5.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6 as part of the evaluation of long-term effectiveness of the ROD-selected remedy, a screening level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. The full excavation of RIM alternative with on-site disposal action does not include treatment as a primary component.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. Consequently, ex-situ treatment techniques are considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix in portions of Areas 1 and 2 make in-situ treatment techniques equally impracticable. The remedy for the Buffer Zone/Crossroads Property also would not reduce toxicity, mobility, or volume through treatment because it consists of removing radiologically-impacted soil from the Buffer Zone/Crossroads Property and shipping it off-site for disposal.

An on-site technology that may potentially be applicable to the full excavation of RIM alternative is physical separation of impacted soil from the solid wastes by using solids separation techniques such as hand-picking for large bulky items and various fixed, vibrating, or rotating screens, among others (see discussion in Section 4.3.5.2). Physical separation would not decrease the mobility or toxicity of the radiologically-impacted materials, but has the potential to separate existing RIM from non-radiologically-impacted materials thereby reducing the volume of material that would need to be disposed in the new on-site cell. Use of radiological segregation techniques such as a segmented gate system, may also reduce the volume of material that would need to be disposed in the on-site cell; however, as this alternative includes identification and relocation of all RIM defined as material containing combined radium and combined thorium above 7.9 pCi/g, radiological segregation is not expected to be effective. Review of published literature regarding the use of radiological segregation indicates that this technology has not been demonstrated effective at levels down to 7.9 pCi/g. Furthermore, radiological segregation relies on gamma emissions to identify radiological material. Thorium-230, which does not produce a measurable gamma signature, is the primary radionuclide of concern at West Lake Landfill. Occurrences of thorium-230 at levels above 7.9 pCi/g has been identified at the site without co-occurrence of radium-226 or other gamma emitters. Therefore, radiological segregation is not expected to be effective at identification of RIM from non-RIM solid waste.

As previously discussed, any solids separation or radiological segregation techniques would need to be pilot tested at full-scale using materials from Areas 1 and 2 during remedial design to ascertain the potential effectiveness, implementability, and cost of this technology. Of particular interest in conducting pilot-testing with material from Areas 1 and 2 would be obtaining an estimate of the degree of RIM volume reduction that could be achieved, assessing the moisture content of the filled material, determining the fraction of soil that would be contained in or adhered to the segregated refuse, and determining the residual levels of radioactivity that would be present in the non-soil refuse after screening out the soil fraction. Assuming that solids separation combined with radiological segregation could prove to be an effective and implementable technology (that is, it could effectively separate the radiologically-impacted soil from the other landfilled waste materials such that the other landfilled wastes would contain radionuclide activities below the levels that would allow for unrestricted use), it has the potential to reduce the volume of radiologically-impacted material that would need to be transported to an and disposed in an on-site disposal cell. However, little is known about the potential application of a soils separation technology to this situation, and it is possible that pilot testing could demonstrate that physical separation would not be effective at separating RIM from non-radiologically-impacted materials. At this stage of analysis, neither the estimated costs nor the estimated schedules in this FFS include any allowance for solids separation pilot testing or implementation; however, the discussion of costs does include an approximate estimate of the time and cost that may be incurred to conduct a full-scale pilot test of these technologies.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's Land Disposal Restrictions (LDR) program and Universal Treatment Standards (UTS)) and in accordance with the permits and standard operating procedures of the receiving facility. After arriving at an off-site disposal facility and undergoing a waste receipt analysis, RCRA soil/debris and RCRA soil/debris with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on its physical characteristics, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste and radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

For the full excavation of RIM with on-site disposal alternative, any hazardous waste or mixed waste would be shipped to the off-site disposal facility by truck. If the volume is small, the material may be placed in drums, metal boxes or other containers and shipped by truck, although if the volume is sufficient to fill an IM container, it may be shipped by rail. Any material that is identified as hazardous would be handled and shipped as discrete material and not mixed with other material. Any material shipped off-site would be subjected to a radiation survey and classification in accordance with DOT requirements and subject to uniform hazardous waste manifest and specific placards and markings on the semi-trucks and rail cars identifying the material as hazardous waste (also as radioactive in the case of mixed waste).

Beyond the shipping aspect, the hazardous component of any mixed waste would present additional issues with respect to waste segregation, sampling/analysis, and ultimate disposition at the off-site disposal facility. During excavation, any suspected hazardous or mixed waste would be segregated from the waste containing only overburden material or RIM, stockpiled in a separate area, sampled and analyzed for toxicity characteristic leaching procedure (TCLP) parameters, and covered with a tarp or other cover material until analytical results were available. Sampling procedures and analytical methods would be addressed in a Remedial Action Sampling and Analysis Plan to be developed during the remedial design phase.

Based on analytical results, segregated materials would be assigned a waste profile of RCRA soil, RCRA soil with radionuclide material, RCRA debris, or RCRA debris with radionuclide material. The RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would be packaged and shipped to the off-site disposal facility in containers with appropriate marking/placarding under a unique manifest. In order to comply with the RCRA waste storage limitations, stockpiled RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would not be stored on site beyond the RCRA specified maximum accumulation periods prior to shipment to the off-site disposal facility.

In the event that hazardous waste that is not radioactive is encountered, there are numerous facilities to which such material could be shipped for treatment and/or disposal. In the event that hazardous waste that also contains radionuclides is encountered, the four off-site disposal facilities identified and discussed in Section 4.3.5.4 are all permitted to accept RCRA wastes and mixed wastes (Section 3.1.4.3) subject to their WAC (Appendix C). After arriving at the selected off-site disposal facility and undergoing a waste receipt analysis, RCRA waste/soil and RCRA waste/soil with radionuclide material would be treated as necessary, and/or stabilized prior to placement in a disposal cell. Depending on the physical characteristics of the debris, RCRA debris and RCRA debris containing radionuclides, the material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell.

6.2.5.5 Short-Term Effectiveness

The full excavation of RIM with on-site disposal alternative poses significant potential short-term risks, similar to those previously described for the full excavation with off-site disposal (see Section 6.2.4.5). EPA has identified and discussed the following short-term risks associated with waste excavation: waste handling, sorting, and stockpiling; water management; noise, odor and windblown trash; worker health and safety (PPE, gamma exposure, physical stress, physical hazards, workplace monitoring); contaminant migration/spreading (fugitive dust and airborne migration, fugitive dust control and water application, leachate generation, equipment decontamination water, and water from open excavations); and waste hauling and transportation/truck decontamination issues (transfer facilities, increased local traffic, waste handling on public roads, interstate transport by rail, DOT requirements, safety issues).

6.2.5.5.1 Protection of the Community During Remedial Actions

The projected incremental carcinogenic risks that may be posed to off-site residents by this alternative are expected to be approximately 8.1×10^{-5}, which is within EPA's acceptable risk range (see Appendix H). No non-carcinogenic risks are expected to occur.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each FFS alternative. For the full excavation of RIM with on-site disposal alternative, the projected incidence of transportation accidents associated with construction of the on-site cell, relocation of RIM to the on-site cell, regrading of Areas 1 and 2, and importing of materials for construction of the landfill cover over Areas 1 and 2 is 3.0, meaning that approximately 3 accidents are projected to occur if this option were implemented (Appendix H).

Disturbing the waste material during implementation of the full excavation of RIM may expose the community to radioactive waste, methane and radon gas, and other contaminants, and also may cause a release of undesirable odors. Excavation of existing waste materials would undoubtedly result in odor emissions during the period of time that existing wastes may be handled or exposed. Mitigation of odors through engineering means is limited.

The full excavation of RIM with on-site disposal alternative would contribute significant carbon dioxide equivalent emissions as a result of ongoing vehicle operations associated with remedial work. Specifically, approximately 80,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere due to: construction of the new on-site disposal cell; excavation, transport and placement of RIM in the new disposal cell; regrading of Areas 1 and 2; construction of the landfill covers of Areas 1 and 2 and the UMTRCA cover over the on-site disposal cell; and the importation of materials used to construct new disposal cell and the multilayer landfill cover of Areas 1 and 2 (Appendix I, Table I-8).

Because RIM in Areas 1 and 2 would be excavated under this alternative, overburden containing putrescible wastes would be stockpiled and stored, while RIM would be loaded and transported to the new cell. Under this alternative, a large volume of waste material (approximately 1.9 million in-place cubic yards) would need to be handled, including a substantial amount of the above-grade material in the North Quarry portion of the Bridgeton Landfill, which is relatively younger waste, and therefore less decomposed. During these activities, the nuisance attraction to and congregation by birds at and above the affected areas would be problematic unless effectively controlled. The long duration of the construction activities associated with this alternative (see Section 6.2.5.5.6 below) increases the potential for attraction of birds. The FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007). The main concern would be the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. Mitigation measures (such as excavation best management practices, which include application of daily soil cover and/or tarping of exposed waste, visual and auditory frightening devices, or use of wire or monofilament grids positioned over exposed refuse to prevent bird access) could be implemented to attempt to minimize bird attraction to and congregation at and above the disturbed areas.

Excavation of waste materials from Areas 1 and 2 would require removal of the existing landfill cover and overburden from Areas 1 and 2 and from portions of adjacent areas of OU-2. Excavation of overburden and RIM would create depressions in the landfill area during the period of time required to remove the RIM and regrade and cover the remaining landfill wastes. Precipitation that falls on the landfill while such depressions are open would potentially flow into and accumulate in the depressions. Any accumulation of precipitation[72] in depressions created during waste excavation could result in increased infiltration of precipitation runoff through the underlying waste materials, which could result in increased leaching of volatile organic compounds (VOCs) or other soluble contaminants from the waste materials.

This alternative could be adversely impacted by severe weather impacts. Due to the extended duration required for implementation of this alternative, one or more severe weather events may occur during implementation of the full excavation of RIM alternative. Such an event(s) could result in direct delays to excavation work, and also indirect delays if such an event results in diversion of resources (*e.g.*, equipment) from waste excavation activities to mitigation of impacts of a severe weather event. Severe weather events could potentially greatly increase the volume of contact stormwater that would need to be contained and managed which may further limit waste excavation activities and increase the amount of time required to implement this alternative. In addition, severe weather events could increase the potential for loss of stormwater

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[72] Accumulation could be significant during a heavy rainstorm insofar as the maximum historical 24-hour rainfall for the St. Louis area ranges from a low of 3.7 inches in November to a high of 8.8 inches in August (NOAA, 2011).

containment through failure of best management practices for controlling stormwater impacts. Such failures may include soil/waste scouring and suspended phase transport resulting in an increased potential for release and off-site transport of stormwater that has been in contact with waste material or soil containing radionuclides.

Stormwater controls would be implemented in accordance with the Missouri Storm Water regulations 10 CSR 20-6.200 to protect the community. During construction, consideration would be given to minimizing the areas of exposed waste during waste excavation in Areas 1 and 2 and waste placement in the new cell. Temporary diversion berms would be constructed above the open excavation areas and any previously excavated (and temporarily covered) surfaces and in the new disposal cell in order to divert precipitation runoff away from areas of exposed waste to prevent the runoff from contacting uncovered waste materials. Precipitation that would contact uncovered waste materials would flow into the low point of the excavation or disposal cell and be pumped out into temporary storage tanks using portable gas-driven pumps. Samples would be collected from the tanks and sent to a laboratory for analysis. The stored water would be directly discharged or treated and disposed appropriately based on the analytical results.

6.2.5.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.5.2 as part of the evaluation of short-term impacts associated with the ROD-selected remedy, a screening level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.5.5.3 Protection of Workers During Remedial Actions

The full excavation of RIM with on-site disposal alternative would entail significant excavation, handling, loading and transport of RIM at the Site and therefore would pose both significantly increased radiological exposure risks as well as construction safety risks to on-site workers. The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the full excavation of RIM alternative, the projected incidence of industrial accidents is 28 over the life of the project. The projected carcinogenic risk to the maximally exposed individual (radiation field technician) is 3.68×10^{-3}, and the projected hazard index is 26.9. The projected radiation dose to a remediation worker is 1,820 mrem/yr (Appendix H).

Workers involved in the waste excavation, loading and relocation activities may be subject to potential short-term risks associated with excavation, handling and placement of the waste materials, including exposure to contaminated waste; excavation/trenching instability; stormwater runoff entering areas where waste is exposed, resulting in the exposure to contact storm water; odor emissions; and other aesthetic issues (*e.g.*, windblown trash) arising from exposed waste. Worker exposures would be addressed through development and implementation of a site safety plan, use of personal protective equipment, and performance of personnel and environmental monitoring during implementation of remedial action. Workers would be protected during construction by adhering to OSHA practices. However, as this alternative entails large amounts of excavation, handling, and transportation of RIM, OSHA work practices and personal protective equipment may not provide full protection against exposure to external gamma radiation.

Excavation would require construction workers and equipment that would initially disturb the overburden soil and underlying waste materials. Dust control measures would be required to limit worker exposure to fugitive dust during construction. As discussed in Section 4.4.1.2, the separation of radiologically-impacted soil from solid wastes and construction/ demolition debris may (if feasible) may be a potential means of reducing the overall volume of material and resultant cost of off-site transport and disposal. However, this action would increase short-term exposures and risks to remediation workers because the screens or other equipment used to segregate large items and debris from the soil could become fouled with plastic, wood, and other debris that potentially would need to be physically removed by workers. Such activities would require workers to be in close proximity to the RIM, thereby increasing their short-term exposure risks. The risk assessment conducted for this FFS does not account for such increased physical separation/segregation exposures to workers.

Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers including the projected non-carcinogenic risks identified above. Protective clothing alone would not reduce the carcinogenic risk or projected radiation dose these risks result from exposure to gamma radiation. The only way to address these risks is to limit the amount of time (exposure duration and frequency) that workers are exposed to gamma radiation. This could be done by measuring and tracking worker exposures and shifting workers to other tasks with less potential for gamma exposure to reduce the overall level of exposure to radiation. However, managing worker exposures, especially for those involved in the RIM excavation, transportation and re-disposal operations, who are expected to be the maximally exposed individuals, could present challenges for implementation of this alternative and therefore represents a short-term risk for this alternative.

6.2.5.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from this alternative. As noted in the original and updated BRA (Auxier & Associates, 2000 and 2017b), some of the ecosystems present at the Site are the result of existing institutional controls and other limitations on land use within or adjacent to OU-1 that have allowed field succession to take place. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Excavation of RIM, regrading of Areas 1 and 2, and construction of the engineered landfill cover would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on these area as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance. The areas being considered for an on-site disposal cell, such as the soil borrow/stockpile area, the Closed Demolition Landfill or the Inactive Sanitary Landfill have previously been and continue to be disturbed and therefore do not contain habitat or ecosystems. The portion of Area 2 that could be considered for an on-site disposal cell would have to be disturbed regardless in order to remove RIM from this area.

6.2.5.5.5 Ability to Monitor Effectiveness

Monitoring of the radon emissions from the new disposal cell would be performed after completion of construction of the UMTRCA cover over the cell to verify the protectiveness and compliance with ARARS (e.g., UMTRCA radon emission standard) of the constructed cover. During and after construction, regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2 and the on-site disposal cell to assess the effectiveness of this alternative.

6.2.5.5.6 Time Until Remedial Action Objectives Are Achieved

The RAO related to the Lot 2A2 Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas. The RAOs related to Areas 1 and 2 and the Buffer Zone would be met once the RIM excavation and construction of the new landfill cover over Areas 1 and 2 were completed and the Buffer Zone is either covered as part of the landfill regrading work or any soil containing radionuclides above unrestricted use levels are removed from this area. Excavation and on-site disposal of RIM makes achievement of these RAOs post-excavation more certain because the full excavation of RIM alternative is predicated on the assumption that all RIM above unrestricted use levels would be removed from Areas 1 and 2 and placed in a new engineered disposal cell design to meet UMTRCA, NRC, RCRA Subtitle C and Solid Waste Regulations standards, thereby reducing the magnitude of potential exposures to radionuclides, potential future radon emissions, and potential leaching of radionuclide constituents.

Initiation of this alternative would require significant planning due to design of a new on-site disposal cell and the logistics associated with identifying, excavating, handling, classifying and loading the materials for transport to the new disposal cell. Preparation of the remedial design should be completed within approximately 15 months of authorization to proceed with the RD. RD could take significantly longer if full-scale pilot testing of solids separation equipment is performed. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 13.5 years after approval of the RD (Appendix J). Therefore, the remedial action objectives should be achieved within 14.8 years of approval to proceed with the RD. This schedule estimate assumes that the buyout of the asphalt company lease and potential permitting for and subsequent relocation of the solid waste transfer station occurs during the remedial design phase; otherwise, the schedule would be longer.

The projected construction schedule and the cost estimate for the full excavation of RIM alternative are highly dependent on the waste material swell factor; that is, the amount the in-place waste volume expands as it is excavated, handled and loaded for transport the on-site disposal cell. For purposes of this FFS, a swell factor of 1.5 has been assumed. A swell factor greater than 1.5 would result in an increase to the overall construction schedule and the estimated costs. The projected construction schedule and the cost estimate for the full excavation of RIM alternative also are highly dependent on the rate at which overburden waste can be removed and RIM can be excavated, transported to and placed within the new cell.

6.2.5.6 Implementability

This alternative would involve construction, operation and closure of a new on-site disposal cell, excavation and staging of non-RIM overburden waste, excavation of RIM from Areas 1 and 2 and disposal of the RIM in a new on-site disposal cell, repair and restoration of the disturbed portions of the OU-2 landfill units and associated control systems adjacent to Areas 1 and 2, grading of the surfaces and installation of upgraded landfill covers over Areas 1 and 2, long-term monitoring and maintenance of the engineered covers, and long-term monitoring of landfill gas and of groundwater and surface water quality around Areas 1 and 2 and the new disposal cell.

Although the full excavation of RIM alternative as defined by EPA (2015b and 2010a) is presumed to result in removal of RIM from Areas 1 and 2 such that the remaining materials would allow for unrestricted use relative to the presence of radionuclides, there is uncertainty as to whether all of the RIM above cleanup levels could be removed from Area 1 or 2. There are several areas where RIM is located at depths below 15 feet (which is the range of a typical excavator), and as deep as 94 feet bgs. In addition, some of the RIM in OU-1 Area 1 is located adjacent to or beneath the above-grade portion of the North Quarry part of the Bridgeton Landfill or adjacent to the solid waste transfer station, and some of the RIM in OU-1 Area 2 is located very close to the adjacent Closed Demolition Landfill or the Inactive Sanitary Landfill, which are not known to contain radionuclides and are therefore part of OU-2. The proximity of these adjacent landfills greatly increases the level of difficulty and the amount of overburden material that would have to be moved to access and remove some of the RIM. These conditions would increase the potential for failure of the adjacent landfill units during implementation of the OU-2 remedy and the potential that all of the RIM above cleanup levels may not be able to be removed from Areas 1 and 2.

Excavation of RIM would require removal of substantial amounts of overburden and material from the sidewalls of the excavations in order to maintain stability of the excavation areas. Overburden removal would entail removing and temporarily relocating a large amount of the above-grade portion of the North Quarry part of the Bridgeton Landfill in order to access the underlying RIM in OU-1 Area 1. The North Quarry portion of the Bridgeton Landfill has substantially newer waste than that contained in Areas 1 and 2 since waste was placed in the North Quarry up through 2004. Based upon the age and state of decomposition, this waste will present a relatively higher risk of odor and bird attraction. Removal of this overlying area will require modification of the existing landfill gas and leachate collection systems for the North Quarry portion of the Bridgeton Landfill. Open excavation into this area also presents a risk of oxygen intrusion into the Bridgeton Landfill. Control systems will have to be modified and appropriate cover implemented to minimize the risk of oxygen intrusion given the subsurface fire risk presented by oxygen intrusion.

The total amount of non-RIM waste required to be removed is estimated to be approximately 1,550,000 bcy, which, based on an expansion factor of 1.5, would result in the need to handle, stockpile and replace 2,325,000 lcy of waste. Management of such a large amount of exposed waste in both the excavation areas and the stockpiles (including management of stockpiles, stormwater runon and runoff, odor emissions, attraction to birds and other vectors, and litter control) would be a significant undertaking over the extended duration of performance of this remedial alternative. The amount of space available for stockpiling the overburden material is limited, and therefore overburden material from Area 1 would need to be transported to Area 2 for temporary stockpiling while waiting for final placement and capping. Similarly, the total volume of RIM that would be excavated under this alternative is estimated to be 310,000 bcy, equivalent to approximately 516,000 lcy including daily cover material. Due to the double-handling (at a minimum) of the overburden material plus the RIM handling, it is anticipated that approximately 6,500,000 lcy of waste would be handled under this alternative. Following re-disposal of the waste in Area 1, the portion of the leachate collection system and gas control systems that had been removed from the North Quarry portion of the Bridgeton Landfill would need to be replaced.

An additional complication arises from the proximity of the Bridgeton Transfer Station. In order to access the RIM in the southwest portion of Area 1, the solid waste transfer station would need to be relocated. Removal of waste material would extend up to and along the base of the transfer station such that the integrity of the transfer station building foundation and above-grade structure would be compromised. The only available space for relocation of the transfer station is the area currently occupied by Simpson Asphalt Company, which holds a long-term (99-year) lease on this area. This lease would have to be bought out and the asphalt company would need to be relocated before the transfer station could be relocated to this area. The estimated construction schedule (Appendix J) and costs (Appendix K-5) for this alternative are predicated on the solid waste transfer station being relocated prior the start of RIM excavation and relocation.

In order to minimize potential vehicle interactions between normal traffic to and from the re-located solid waste transfer station and the construction operations associated with this alternative, a dedicated road system would be required between Areas 1 and 2 and the new disposal cell. Use of a dedicated system of haul roads would allow haul trucks to efficiently move between Areas 1 and 2 and eliminate the potential for trackout of RIM that may be released during transport and re-location by non-construction related traffic (i.e., it would eliminate joint use of some of the same roads by haul trucks and other construction equipment and refuse trucks or other vehicles that access the Site unrelated to the construction activities). Such a road system would include a temporary overpass over the Site access road to allow for uninterrupted movement of construction traffic between Areas 1 and 2 and uninterrupted traffic of refuse trucks to/from the relocated solid waste transfer station. An overpass is considered the most efficient and safest means for transfer of overburden waste from Area 1 to stockpile locations in Area 2 and then back to Area 1 and to prevent trackout of any RIM that may be spilled or otherwise released along the haul routes. In addition, if the new disposal cell were to be located in the area of the current soil borrow stockpile area, RIM removed from Area 2 would need to be transferred over the Site access road to the new on-site disposal cell. Conversely, if the new cell were located on the Closed Demolition Landfill, Inactive Sanitary Landfill, or the north portion of Area 2, RIM removed from Area 1 would need to be transported over the Site access road to the new disposal cell. Installation of an overpass would eliminate the potential for RIM material to be tracked across the Site access road and potentially tracked off-site. An overpass would also eliminate the need for traffic control and potential for accidents that would be associated with an intersection of the solid waste transfer station access road and the temporary construction traffic road between Area 1 and Area 2.

While excavation with subsequent transportation and on-site disposal have been implemented at other sites containing radioactively-impacted materials, materials from these other sites have not included significant amounts of landfill solid wastes and debris, and it is expected that these landfill wastes could complicate the implementation of any RIM removal. Significant technical and administrative implementability issues are also associated with excavating the RIM and loading and relocation to an on-site cell if this alternative were to be implemented. These include the following:

- Reduced excavation production rates and increased volume of RIM ultimately subject to excavation and disposal resulting from application of daily cover over an extended excavation schedule;

- Increased potential over an extended period of time for bird strikes to aircraft as a result of excavation of putrescible or organic solid waste overburden waste from the North Quarry portion of the Bridgeton Landfill and Areas 1 and 2 and excavation of RIM-contaminated waste from Areas 1 and 2, all of which are located within flight paths of Lambert–St. Louis International Airport;

- Increased risk of oxygen intrusion into the North Quarry portion of the Bridgeton Landfill resulting from removal of a portion of the North Quarry waste overlying Area 1;

- Ability to remove all of the RIM due to the proximity of some of the deeper RIM in OU-1 Area 1 beneath and adjacent to the above-grade portion of the North Quarry portion of the Bridgeton Landfill and in OU-1 Area 2 adjacent to other landfill units (*e.g.*, Closed Demolition Landfill and Inactive Sanitary Landfill); and

- Impacts to other Site operations and traffic on surrounding roads from additional truck traffic used to haul wastes to the on-site disposal cell and to haul earthen materials to the Site for construction of the new disposal cell, and for daily cover, stockpile covers, and construction of the final covers.

Design, construction and operation of a new disposal cell and design and construction of post-RIM-excavation landfill covers over Areas 1 and 2, with subsequent monitoring and maintenance, are not expected to pose any implementability challenges. Materials and services necessary for construction and operation of a disposal cell and for regrading and construction of the final landfill covers over Areas 1 and 2 after RIM removal are available, and the technologies have been proven through application at other landfills.

The actions included for the Buffer Zone/Lot 2A2—that is, the testing and excavation of surface soil—are regularly and easily implementable.

Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of an onsite cell and the covers placed over Areas 1 and 2 and are easily implemented.

6.2.5.6.1 Ability to Construct and Operate the Technology

In general, excavation and disposal are standard technologies. However, there are unique circumstances associated with excavation of RIM in Areas 1 and 2, insofar as Areas 1 and 2 are located within an overall larger closed/inactive landfill site, which would complicate implementation of standard excavation technologies.

There are questions regarding the ability to remove all of the RIM from Area 1 and Area 2 due to the depth of some of the RIM and/or the proximity of OU-1 Areas 1 and 2 to the OU-2 landfill units such as the North Quarry portion of the Bridgeton Landfill, closed construction and demolition waste landfill (the C&D landfill) and the OU-2 inactive solid waste landfill. RIM is not present in these other landfill units, but it would be necessary to excavate into these OU-2 units in order to access some of the RIM in OU-1. Although sheet piling as a Site-wide replacement for excavation sidewall sloping was evaluated as part of the SFS and again for this FFS (Appendix D-1) and determined not to save costs or time compared to sloping the sidewalls, small areas of sheet piling where the OU-1 RIM is closest to the transfer station or areas adjacent to OU-2 landfill units may prevent or minimize damage to the transfer station foundation (if it were not relocated) or encroachment of excavation slopes into the OU-2 units and therefore prove economical for the full excavation of RIM alternative. Such targeted use of sheet piling could be further evaluated during remedial design.

Upon completion of removal of the RIM from OU-1, disturbed portions of the adjacent landfill units in OU-2 would need to be repaired and restored to a condition that meets or exceeds existing closure conditions prior to implementation of this alternative and subject to the requirements of any additional remedial actions required for either of these areas as part of implementation of the OU-2 remedy.

RIM excavation and relocation to a new on-site disposal cell is also expected to present implementability concerns, challenges, and risks, specifically those associated with the following:

- Excavation and handling of contaminated materials;
- Safety risks associated with encountering methane gas during excavation;
- Safety risks associated with potential for oxygen intrusion into the waste mass of the landfill, especially in conjunction with any removal of portions of the Bridgeton Landfill that overly portions of Area 1;
- Management of fugitive dust and potential odors;
- Mitigation of bird hazards;
- Management and treatment of stormwater exposed to RIM and solid wastes during excavation; and
- Identifying, segregating, and disposing off-site of any hazardous wastes, polychlorinated biphenyls (PCBs) or RACM that may be encountered during RIM excavation.

If hazardous wastes, PCBs, or RACM are encountered during excavation of RIM, these materials would need to be segregated from the other waste materials, characterized, and transported to an off-site disposal facility in containers separate from the other RIM. Additional health and safety procedures would be required during excavation of these materials. These materials would require separate handling at the off-site disposal facility and could require treatment prior to disposal. Depending on the characteristics of any hazardous waste encountered during excavation, the hazardous waste could need to be transported to a different off-site facility for treatment and disposal in accordance with RCRA.

Directing and controlling the RIM excavation process using radiological scanning and sampling techniques would significantly impact overburden and RIM excavation production rates. Based on experience in excavation of radiologically-impacted waste at other sites, a reduction in efficiency is expected for overburden excavation and a greater reduction is expected for RIM excavation. Because thorium-230 cannot be detected using field survey instruments, excavation activities would have to rely on collection and laboratory analyses of samples for guidance. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities and initial confirmation that all of the RIM had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that all RIM has been removed from a particular area would also be subjected to off-site laboratory analyses and data validation.

While potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses and by moving excavation activities to other areas while waiting on the results of verification of confirmation sample analyses, even with these measures it is likely that some short-term delays to the construction work on the order of hours to days will likely occur as a result of waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedule developed for this alternative.

Daily soil cover and tarps would need to be placed over open excavation areas and stockpiled overburden to minimize dust, odor, and the attraction of birds and other wildlife. The proximity of Areas 1 and 2 to Lambert-St. Louis International Airport poses a potential risk to aviation operations. The St. Louis Airport Authority and the U.S. Department of Agriculture have identified as a problem the potential for increased bird activity in conjunction with waste excavation at the Site and the resultant increased risk of aviation bird strikes. Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed overburden and wastes), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be evaluated for use at Areas 1 and 2. The size of open excavations may limit the constructability of wire or monofilament grids. Careful evaluation of material properties would be necessary during remedial design to assure that the appropriate strength and elasticity of materials are considered, that the materials are available, and that grids can be reasonably constructed.

Effective stormwater controls could be readily implemented using conventional construction equipment and materials. Temporary berms to direct stormwater away from open excavations would need to be constructed, and precipitation accumulation in depressions created by the excavation activities would need to be pumped out and managed. Direct precipitation or runoff that may contact waste material could become contaminated with soils or wastes containing thorium or radium. These elements would be entrained in colloidal material that would readily settle in low areas or in the tanks used to collect and store stormwater prior to treatment and discharge. At the end of excavation activities, accumulated sediment in any low areas or the tanks would also be removed and, depending upon the activity levels, either placed in Area 1 or 2 or transported to the off-site disposal facility.

Truck hauling of RIM to a new on-site disposal cell is technically implementable. Regrading the landfills and placement of final cover is implementable and has been performed at other landfills, including CERCLA sites. Environmental monitoring is routinely performed at most sites and is not expected to present any feasibility challenges.

6.2.5.6.2 Reliability of the Technology

Excavation and placement of radioactively-impacted material in an engineered disposal cell is a reliable technology, and has been implemented at a number of other sites including other CERCLA sites, FUSRAP sites, and DOE Land Management sites, most notably, the Weldon Springs facility. However, none of these FUSRAP sites involved such large-scale excavations of radiological materials commingled with municipal solid waste and disposed in a landfill setting such as what is included under this alternative for OU-1. The reliability associated with disposal in a new on-site disposal cell would be dependent on the integrity of the liner and cover systems being maintained, as well as the effectiveness of the various monitoring programs.

Engineered disposal cells and landfill cover systems such as those that would be implemented over Areas 1 and 2 after RIM removal that are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance have been demonstrated to be reliable at: (1) minimizing percolation and infiltration of precipitation; (2) minimizing leachate generation; (3) minimizing impacts to groundwater quality; (4) minimizing impacts to surface water quality and quantity; (5) minimizing erosion of cover material; and (6) minimizing uncontrolled releases of landfill gas. Landfill cover systems have been demonstrated to be reliable methods for isolating waste materials. Similarly, access restriction measures have been demonstrated to be reliable mechanisms to prevent unauthorized access to a site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed RIM and waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated, reliable technologies under proper operating and excavating conditions. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. In addition, the FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are well-established technologies that are implemented at most landfill sites. For this alternative, gravity settling of suspended solids potentially containing radionuclides is a well-established and reliable technology.

6.2.5.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

It is possible that all of the RIM may not be able to be removed during implementation of the full excavation with on-site disposal alternative. In accordance with the Supplemental Standards provision of UMTRCA (40 CFR §192.21), a decision could be made by EPA to allow some RIM to remain in Area 1 or 2, such as RIM that is located adjacent to the transfer station, until future changes provide access to such material. EPA could determine that RIM that is deeply buried beneath large volumes of waste or that is located adjacent to buildings (*e.g.,* adjacent to the solid waste transfer station) such that removal could impair/ undermine the integrity of those structures, would be better left in Area 1 or 2. If this were to occur after completion of the full excavation of RIM alternative, regrading of the landfill, and construction of a new engineered landfill cover, performance of additional remedial action in the future to remove such materials would be very difficult and costly. The design of the cover system over Area 1 or 2 may also need to be modified depending upon the expected duration that such materials may remain in these areas.

The only anticipated additional remedial actions that may need to be taken for the full excavation of RIM with on-site disposal alternative would be maintenance activities needed to sustain the cover systems over the new disposal cell and Areas 1 and 2, repair of areas of differential settlement or to address erosion, or possible implementation of a contingent landfill gas control systems. Differential settlement or compaction of the underlying remaining waste materials after RIM excavation in Areas 1 and 2 or placement of RIM in a new cell could necessitate placement of additional soil over all or portions of new cell or Areas 1 or 2 to maintain the required final grades. Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term monitoring and maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would involve placement of additional fill, regrading, and revegetation of the repaired area.

Under this alternative, part of the landfill gas system currently being operated in the North Quarry portion of the Bridgeton Landfill would likely have to be removed in conjunction with the waste excavation activities and replaced upon completion of the excavation and regarding activities. In the event that monitoring of subsurface landfill gas detects the presence of gas levels above regulatory thresholds along the perimeter of Areas 1 and 2, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system. Installation of a contingent gas system could be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be applied to additional excavated area in the event that additional waste volume is encountered.

Stormwater management measures, other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures, are not anticipated to be necessary to support implementation of the full excavation of RIM alternative.

6.2.5.6.4 Ability to Monitor Effectiveness of Remedy

The effectiveness of the engineered disposal cell would be evaluated through monitoring of air, stormwater and groundwater combined with inspection of the surface and monitoring equipment and components. Demonstrating the effectiveness of the cover systems constructed over Areas 1 and 2 after RIM removal above unrestricted use levels would be accomplished by implementing inspection, maintenance and monitoring programs for the cover surfaces, landfill gas system, groundwater, and surface water programs as previously described in Section 5.5.6. These types of monitoring programs have been proven at demonstrating cover effectiveness and are easily implemented.

6.2.5.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the full excavation of RIM alternative with on-site disposal would require approvals from other agencies, including the following:

- Approval from the FAA to conduct waste excavation and waste placement activities within 10,000 feet of an active airport runway. FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, "Hazardous Wildlife Attractants On or Near Airports," recommends "against locating a MSWLF [municipal solid waste landfill] within the separation distances identified in Sections 1-2 through 1-4. The separation distances should be measured from the closest point of the airport's AOA [airport operations area] to the closest planned MSWLF cell." AC 150/5200-33B, p. 4. The separation distances referenced are 5,000 feet from the end of a runway for airports serving piston-powered (propeller) aircraft; 10,000 feet for airports serving turbine-powered (jet) aircraft; and 5 miles of protection from hazardous wildlife movement for approach, departure and circling airspace. The FAA strongly recommends against allowing a waste disposal operation within 10,000 feet of a jet aircraft runway if the material contains putrescible waste and so has the potential to attract wildlife that could threaten air traffic. The excavation of RIM material containing putrescible waste within 10,000 feet of the westernmost runway (11/29, formerly known as 12W/30W) at Lambert-St. Louis International Airport, as would occur during excavation of the RIM in Areas 1 and 2, is limited by the need to mitigate potential bird activity during excavation to address the requirements of the FAA Advisory Circular and to comply with the same prohibitions in the Missouri solid waste regulations. It may be necessary to work directly with the FAA and MDNR to identify specific bird mitigation measures during implementation.

- Approval of St. Louis Airport Authority (STLAA) relative to obtaining a release for the Negative Easement and Declaration of Restrictive Covenants Agreement (Appendix A-2). Excavation of RIM from Areas 1 and 2 and placement of such material in a new disposal cell poses a potential to increase the bird populations at the Site if mitigation procedures are not employed or prove ineffective. An increase in bird populations presents a greater potential for aircraft bird strikes. The STLAA and USDA have identified this as a concern relative to construction and operation of a new on-site disposal cell that was included in the full excavation of RIM with on-site disposal alternative evaluated in the SFS. Based on the STLAA's position stated in the STLAA's September 20, 2010 letter to EPA (Appendix A-5), STLAA acceptance of RIM waste excavation would not be likely if bird activity were to increase. It may be necessary to work directly with the FAA and the STLAA to address these concerns, either by amending the FAA ROD, amending the Negative Easement, requiring specific bird mitigation measures during implementation, or making other changes to secure STLAA's cooperation. By letters dated August 11, 2014 and August 11, 2017 (Appendix A), the Airport again submitted comments to EPA, emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives.

6.2.5.6.6 Coordination with Other Agencies

Coordination with many entities would be necessary to implement the full excavation of RIM alternative (although not all of them are considered "agencies"). Coordination with the Site owner and operator and owners or occupants of the various parcels that comprise the West Lake Landfill Site would be necessary because of the following:

- Termination of the asphalt company lease and removal of the asphalt plant followed by relocation of the Bridgeton solid waste transfer facility and construction of an overpass between Areas 1 and 2 over the Site access road would need to occur prior to the start of RIM excavation.

- Access to operations conducted on other portions of the Site would need to be maintained.

- Areas 1 and 2 are within the existing Site footprint, and the use of areas on the West Lake Landfill Site outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction.

- Implementation of this alternative would require excavation of portions of landfill units located outside of OU-1. Upon completion of removal of the RIM, disturbed portions of the adjacent landfill units would need to be repaired and restored, and regrading and installation of a replacement landfill cover over areas outside of OU-1 would need to be performed. Coordination would also be required relative to integration of the slopes and grading for adjacent landfill areas, as well as routing and design of stormwater diversion and conveyance structures between OU-1 and other landfill areas. Finally, modification and ultimate restoration will be necessary for the landfill gas and leachate collection systems for the North Quarry portion of the Bridgeton Landfill.

- Use of other areas of the West Lake Landfill Site that may be necessary for stockpiling of overburden and staging or routing of equipment used to haul the excavated RIM to the on-site disposal cell.

- Implementation of any additional institutional controls or modifications of any of the existing institutional controls that EPA may require would need to be approved and accepted by the individual entities that own the various parcels that compose the Site.

For the duration of excavation and waste relocation to a new disposal cell, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the current on-site solid waste transfer station and other Site tenants.

Future groundwater monitoring activities could require obtaining and maintaining access to off-site properties if off-site groundwater monitoring were required as part of the remedy.

The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the FAA and STLAA. The effectiveness of proposed bird nuisance mitigation measures would be of interest to the FAA and STLAA. Consequently, the FAA and STLAA would need to be involved in the remedial planning process.

Coordination with other agencies, including the Earth City Flood Control District, MSD, and MDOT, as well as adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities, both during and after completion of construction;

- Coordinate with MSD regarding the permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from AAA Trailer for testing and, if necessary, remediation of the Lot 2A2 and possibly for implementation of remedial actions that may need to be performed along the property boundary (e.g. regrading, fencing, etc. in Area 2).

As discussed at the beginning of this section (6.2.5.6), in order to access RIM in Area 1, the Bridgeton Transfer Station building would need to be relocated. The only suitable area for relocation of the solid waste transfer station is the area currently under lease and occupied by Simpson Asphalt Company. The asphalt company lease would need to be bought out and their equipment removed from the Site before the transfer station could be relocated. Relocation of the transfer station would normally be subject to permitting by the City of Bridgeton and St. Louis County; however, because relocation of the transfer station would be performed as part of a Superfund remedial action and the transfer station would remain on site, additional permitting is not anticipated to be required. However, it is likely that public meetings and hearings may be necessary, which would require coordination with the City of Bridgeton and St. Louis County and could impact the timing for the start of construction of a full excavation of RIM alternative.

6.2.5.6.7 Availability of Off-site Treatment, Storage, and Disposal Services and Capacity

Unless hazardous wastes are encountered during overburden removal or RIM excavation activities, it is not anticipated that any waste materials would need to be sent off-site under this alternative. In the event that hazardous waste that does not contain radionuclides is encountered, there are numerous facilities to which such materials could be sent for treatment and/or disposal. In the event that hazardous waste that contains radionuclides were encountered, the four off-site disposal facilities previously identified for disposal of RIM under the off-site disposal alternatives (See Section 4.3.5.4) are permitted to accept mixed waste material. Off-site treatment, storage, and disposal may be required in the event that hazardous wastes are encountered in the overburden or RIM excavated from Areas 1 and 2.

The identified off-site disposal facilities are also permitted to: (1) accept liquid wastes, should any stormwater that may accumulate in excavations during RIM excavation become contaminated and require disposal off-site; (2) accept mixed wastes, if mixed wastes are encountered during excavation; and (3) treat soil and/or debris that contains hazardous waste or mixed waste.

As discussed in Section 3.1.4.1, the CERCLA Off-Site Rule requires that waste materials removed from a CERCLA site only be placed in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during remedial design and would need to be regularly evaluated and updated during remedy implementation.

Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater. Initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.5.6.8 Availability of Necessary Equipment and Specialists

Materials, equipment and personnel required for construction of a new on-site disposal cell and excavation and transport of RIM to such a cell are readily available. Trained health physics technicians and specialized equipment required to monitor personnel, monitor environmental conditions, and assist in directing the RIM excavation sequencing are also available.

All of the materials, equipment and personnel needed to construct the covers over Areas 1 and 2 after RIM removal are readily available and the technologies have been generally proven through application at other landfills. The implementability and potential cost of the covers would be influenced by the availability and location of clean cover materials and/or off-site borrow sources at the time this alternative would be implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006) and during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI, 2008). Geosynthetic materials such as GCL, flexible membrane liners, and other geosynthetic materials are commercially available from several sources. Information obtained from the vendors at these times indicated that rock, clay and clean fill material were readily available from sources located near the Site. If these local sources of cover materials become exhausted prior to or during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

The necessary materials, equipment and personnel required for assessment and removal of RIM that may be present at the Buffer Zone/Crossroads Property to unrestricted use levels, and to implement the institutional controls and monitoring components of this alternative are also readily available.

6.2.5.6.9 Availability of Prospective Technologies

The full excavation of RIM with on-site disposal alternative is based on proven, established, and commonly used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.5.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the full excavation of RIM with on-site disposal alternative are included in Appendix K-5 and summarized on Table 6-1. Conceptual design of a new on-site disposal cell and conceptual design of the excavation, backfill, and bottom and top of final cover grading plans for Areas 1 and 2, as well as stormwater control features used as the basis for the full excavation of RIM with on-site disposal alternative capital cost estimate, are provided in Appendix M. The estimated cost to conduct the full excavation of RIM with on-site disposal alternative remedy (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $591,000,000 (see Appendix K-5).

These costs do not include costs to conduct full-scale pilot testing of solids separation equipment, which is beyond the scope of the FFS and is something that could be evaluated further during remedial design. If a full-scale test of physical separation and radiological segregation were to be performed, it is anticipated that such a test would add approximately $1,000,000 to the cost of this alternative and require an additional nine months for design, obtaining approvals, procurement, mobilization and implementation, laboratory testing, and evaluation and reporting.

The estimated annual OM&M costs range from $182,100 to $444,100 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring and years when landfill cover repairs may occur). The cost estimates provided in this FFS are feasibility-level cost estimates which were developed to a level of accuracy such that the actual costs incurred to implement this alternative are expected to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the full excavation of RIM with on-site disposal alternative are projected to be $391 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $568 million. The total non-discounted costs for the full excavation of RIM alternative over 30 years are projected to be $596 million. Given the long life of the radionuclides present at OU-1, the costs for the Full Excavation with On-Site Disposal Alternative were also evaluated for 200- and 1,000-year periods (without consideration of any constraints on annual expenditures). The total nondiscounted costs of the on-site disposal alternative are projected to be $631 million over a 200-year period. The total present-worth costs of the on-site disposal alternative are projected to be $391 million based on a 7% discount rate or $585 million based on a 0.7% discount rate over a 200-year period. The total non-discounted and present worth costs of the on-site disposal alternative are projected to be $788 million over a 1,000-year period. The present worth costs over a 1,000-year period are projected to be $391 million based on a 7% discount rate or $592 million based on a 0.7% discount rate.

Similar to the Full Excavation with Off-Site Disposal Alternative, the total additional costs that may be incurred for off-site transport and disposal if hazardous/mixed wastes are encountered during overburden relocation and RIM excavation could range from $2.63 to $11.0 million (see Appendix K-10). Alternatively, because the conceptual design of the on-site cell evaluated in this FFS incorporates the design requirements for a Subtitle C landfill, any mixed or hazardous waste that may be encountered during the full excavation could be disposed in the on-site cell resulting in no additional costs.

6.2.6 Partial Excavation of Shallow RIM with Activities Above 52.9 pCi/g

This section presents the detailed analysis of a partial excavation alternative consisting of removal of RIM with combined radium and/or combined thorium activities greater than 52.9 pCi/g that is located within 16 feet of the 2005 topographic (ground) surface and subsequent regrading and capping of the remaining waste (hereafter referred to as the “52.9 Partial Excavation Alternative”). As previously described in Section 5.7, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station building to provide access to RIM located adjacent to the building and construction of an overpass over the Site access road;
- Excavation and stockpiling of overburden from OU-1 Areas 1 and 2 in order to access the RIM;
- Excavation of RIM from the OU-1 Areas 1 and 2 that contains combined radium or combined thorium activities greater than 52.9 pCi/g that is located within 16 feet of the 2005 topographic surface;
- Loading, transport, and disposal of the RIM and impacted soil at an off-site disposal facility;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 that contains radionuclides at levels greater than those that would allow for unrestricted use and, depending upon activity levels, placement of such soil in Area 1 or 2, or alternatively transport of such soil that contains combined radium or combined thorium levels greater than 52.9 pCi/g to an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the UMTRCA design, performance, and longevity standards, as well as Missouri landfill closure regulations, over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for UMTRCA and sanitary landfills;

- Landfill gas and radon monitoring and control, as necessary;
- Institutional controls (currently in place) to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radionuclides; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Under this alternative, an estimated 93,000 bcy of RIM would be excavated from Areas 1 and 2 for off-site disposal. The volume of material would increase upon excavation due to swelling, handling, and loading for transport to an off-site disposal facility. Applying the swell factor of 1.5 and accounting for daily cover, it is estimated that approximately 140,000 lcy would be transported to and disposed off-site. Under this alternative an additional approximately 2,900 bcy of impacted soil would be excavated from the Buffer Zone/Lot 2A2 Property and, depending upon activity levels, would either be placed in Area 1 or 2 or transported to the off-site disposal facility.

Once all of the material containing combined radium or combined thorium activities greater than 52.9 pCi/g that is located within 16 feet of the 2005 ground (topographic surface) has been removed from Areas 1 and 2, the remaining solid waste materials in Areas 1 and 2 would be regraded to achieve a minimum surface slope of 5% and maximum slopes of 25% or less in accordance with Missouri's closure standards for sanitary landfills. Because waste containing radionuclides above unrestricted use standards would still remain in Areas 1 and 2, this cover would be designed to meet the requirements of the UMTRCA performance standards (see prior discussions in Section 5.4).

This alternative also includes installation and maintenance of surface water runon and runoff controls, groundwater and landfill gas monitoring, and institutional controls for Areas 1 and 2 and the Buffer Zone. Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site met State standards or other ARARs or risk-based levels. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the perimeter of Areas 1 or 2. Landfill gas and groundwater monitoring as described in Sections 5.3.1.6 and 5.3.1.10, respectively, are also included as part of the 52.9 Partial Excavation Alternative.

Existing institutional controls would be maintained and enforced, and any additional controls or modifications to the existing controls that EPA determines are necessary would also be implemented. These institutional controls are necessary to ensure that residential uses do not occur at the Site, and that commercial and industrial uses or ancillary uses that could result in unacceptable risks do not occur on Areas 1 and 2 or the Buffer Zone. In addition to prohibiting land uses that could result in potential exposure to waste materials or contaminants at the Site, these institutional controls would also limit or prohibit land uses or activities that could disrupt the integrity, performance, or longevity of the new landfill cover or other components of the remedy.

Long-term inspections and maintenance activities of the engineered components similar to those described for the ROD-selected remedy (Section 5.3.1.10) and enforcement of the institutional controls (Section 5.3.2.1) would also be required.

6.2.6.1 Overall Protection of Human Health and the Environment

The 52.9 Partial Excavation Alternative would protect human health and the environment through (1) removal and off-site disposal of a large portion (50% or more) of the RIM; and (2) engineered containment, long-term surveillance and maintenance, and institutional controls on land and resource use. The UMTRCA cover would reduce potential risks from exposure to external gamma radiation or radon gas emissions, and eliminate potential risks associated with inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, and wind dispersal of fugitive dust.

The presence of an engineered cover would prevent users of the Site from exposure to external gamma radiation, primarily through shielding and increasing the distance to the radiation source (*i.e.*, the cover materials would be of sufficient thickness and design to attenuate gamma radiation). The depth of cover required for gamma radiation shielding is on the order of 2 feet (60 cm). The total thickness of the final cover for the 52.9 Partial Excavation Alternative would be a minimum of 5 feet (2 feet of clay soil, 2 feet of biointrusion rock/rubble and drainage layer, and 1 foot of vegetative soil).

The cover materials would also be of sufficient thickness and design to retard or divert the vertical upward migration of radon. The engineered cover would act as a diffusion barrier, thereby allowing time for the decay of the relatively short-lived radon-222 gas (the half-life for radon-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon is continually produced from the radium source, but need only be detained in the cover materials for a few days to decay to its non-radiological progeny, thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a landfill gas control system. Calculations presented in Appendix F indicate that a clay layer thickness of 2 feet, combined with a 2-foot-thick rock/rubble layer and a 1-foot-thick vegetative layer, would provide sufficient radon attenuation to meet the radon emissions ARAR of 20 pCi/m^2s. As discussed in Appendix F, these calculations were based on the increased levels of radium expected to be present at the Site after 1,000 years of in-growth of radium from decay of thorium.

The potential for direct contact with waste materials is eliminated by partial removal of RIM and by placing a barrier (multi-layer landfill cover including biointrusion layer) between the remaining RIM/waste materials and any potential receptors. There is no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place.

The multi-layer cover would also be designed to minimize infiltration of surface water through the wastes, thereby reducing the potential for leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier (e.g., a compacted clay layer meeting the specified permeability requirements). These are all conventional functions for landfill cover technologies and are widely used by government and industry to address similar circumstances where contaminated materials must be encapsulated to protect against future potential contact. Long-term maintenance of the cover and monitoring of the groundwater would ensure that the 52.9 Partial Excavation Alternative functions as intended.

Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site meets state standards or other applicable ARARs. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2 would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls would ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions would reflect the presence of radionuclides at the Site.

6.2.6.2 Compliance with ARARs

Insofar as the 52.9 Partial Excavation Alternative includes excavation and off-site disposal of a portion of the RIM, some RIM would remain on site. Therefore, regrading of the remaining solid wastes and installation of a new engineered cover over Areas 1 and 2 would need to meet the relevant and appropriate requirements of the UMTRCA performance standards as set forth in 40 CFR 192 Subpart A. Because the site would still contain solid wastes, the relevant and appropriate requirements of the Missouri solid waste rules for sanitary landfills, in particular the final closure standards for sanitary landfills, would also be relevant and appropriate to this alternative. Upon completion of RIM excavation, the remaining RIM and solid waste in Areas 1 and 2 would be regraded to achieve minimum 5% and maximum 25% slopes and an engineered cover that would meet the performance standards of UMTRCA and the cover requirements for a solid waste landfill without a liner would be installed. Sections 6.2.3.2.1 and 6.2.3.2.3 contain full discussions of the MDNR solid waste regulations and the UMTRCA standards.

The 52.9 Partial Excavation Alternative would also need to comply with the applicable or relevant and appropriate requirements of CERCLA Off-site Rule, WAC for Off-site Disposal, Off-site Transportation Requirements, NESHAPs, the Safe Drinking Water Act, NRC Standards for Protection Against Radiation, the Missouri Well Construction Code, and the Missouri Storm Water Regulations. Sections 6.2.3.2.2, 6.2.3.2.4 through 6.2.3.2.7, and 6.2.4.2.2 to 6.2.4.2.4 contain full discussions of these regulatory requirements. These requirements would be met or achieved using the same methods as previously described in Sections 6.2.4.2.3 through 6.2.4.2.8 with respect to the full excavation of RIM alternative.

6.2.6.3 Long-Term Effectiveness and Permanence

These criteria refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. The 52.9 Partial Excavation Alternative would reduce risk through removal of a portion of the RIM and provide engineered containment in conjunction with long-term monitoring, maintenance, and land use control designed to be effective over the long term for the remaining RIM. Removal of a large portion of the RIM, combined with installation of an engineered landfill cover, would essentially eliminate the potential for: gamma exposure; inhalation of radon gas or dust containing radionuclides or other constituents; dermal contact with impacted materials; incidental ingestion of soil containing radionuclides or other chemicals; or leaching of radionuclides or chemicals to the underlying groundwater. Maintaining the integrity of the engineered cover would protect the underlying RIM from erosion and intrusion. An UMTRCA-compliant cover would provide a reliable method to control exposure of the RIM to surface receptors and mitigate potential migration of the covered materials.

Long-term site management plans and institutional controls would be made as robust and durable as possible. Long-term groundwater monitoring would be effective in verifying that the remedy is performing as required and groundwater is protected. The landfill cover would also passively prevent potential contaminant migration and human exposures for an indefinite period in the unlikely event that institutional controls were compromised.

By removing any contaminated soil from the Buffer Zone/Lot 2A2 back on to Area 1 or 2—or, if the activity levels are high enough, shipping it to the off-site disposal facility in conjunction with shipping of the RIM with activity levels above 52.9 pCi/g—this alternative would provide long-term effectiveness and permanence relative to the Buffer Zone/Lot 2A2.

6.2.6.3.1 Magnitude of Residual Risks

The calculated lifetime risks following the exposure scenarios in the risk assessment after a portion of the RIM had been removed from Areas 1 and 2, an engineered landfill cover has been installed, and the remainder of this remedial alternative has been implemented (Appendix H) are as follows:

- Area 1: 3.0×10^{-7} for year 1, 2.3×10^{-6} for year 1,000, and $5.4 \text{ x } 10^{-6}$ for year 9,000.
- Area 2: 3.3×10^{-7} for year 1, 2.0×10^{-6} for year 1,000, and $4.3 \text{ x } 10^{-6}$ for year 9,000.

The calculated risk levels are within or below EPA's target risk range of 1×10^{-6} to 1×10^{-4}, and the magnitude of residual risk in Areas 1 and 2 is acceptable. These risk levels are attributable to gamma radiation and radon emissions from any radionuclide occurrences that would remain in Areas 1 and 2 after removal of RIM containing combined radium and/or combined thorium activities greater than 52.9 pCi/g, but take into consideration the installation of the new engineered cover and access restrictions and institutional controls.

They do not specifically include potential exposures from non-radiological landfill wastes after construction is complete. However, those wastes would also be covered by caps which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

Direct contact with the remaining RIM under the engineered cover on Areas 1 and 2, and exposure by ingestion, inhalation, or dermal contact with such materials, is not expected to occur. These are the primary exposure pathways for any non-radiological COPCs which may be mixed with the RIM and landfill wastes that would remain in Areas 1 and 2 after partial excavation. Because no complete exposure pathway would exist for such materials after completion of the partial excavation and cap construction in Areas 1 and 2, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks.

After soils containing radionuclide concentrations above unrestricted use levels are removed from the Buffer Zone/Lot 2A2, residual risks posed by the remaining radionuclide-impacted material on these properties, if any, should be indistinguishable from variations in background levels.

6.2.6.3.2 Adequacy and Reliability of Controls

The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. Cover construction is based on and relies on the use of natural materials that would be expected to remain in place and meet performance criteria for at least 200 years, as required by the UMTRCA performance standards. Post-closure inspection and maintenance of the cover as required by the solid waste regulation ARARs, and as routinely performed at thousands of landfills across the country, also would ensure long-term reliability of the engineered cover.

The surfaces of Areas 1 and 2 are not currently graded to promote drainage of stormwater, but instead, are generally flat with several surface depressions which act to increase precipitation accumulation and infiltration through the waste mass. In addition, no engineered landfill cover exists over these areas. Even with these limitations, infiltration of precipitation has not resulted in discernible leaching of radionuclides or other chemicals to groundwater. Removal of a portion of the RIM, regrading Areas 1 and 2 to promote drainage, and installation of the engineered landfill cover included as part of the 52.9 Partial Excavation Alternative would significantly reduce infiltration of precipitation and potential for leaching, thereby providing further protection against potential impacts to groundwater.

Long-term OM&M would include routine cover and stormwater ditch inspection and service, if necessary, to mitigate erosion, and if such a system is necessary, OM&M of a landfill gas collection and treatment system. Long-term monitoring would also be implemented to assess compliance with environmental performance standards. The performance of these engineering controls would also be re-evaluated during statutory 5-year reviews.

The current Covenants and Restrictions for Areas 1 and 2 would be adequate to protect human health. The permanence of these restrictions is assumed to be adequate for the foreseeable future, as both EPA and MDNR approval are required to remove or modify the restrictions. The adequacy of the restrictions would be continually evaluated during the statutory-required 5-year reviews.

6.2.6.3.3 Climate Change and Potential Impacts of a Tornado

Because RIM and municipal solid waste would still remain in Areas 1 and 2 after implementation of the 52.9 Partial Excavation Alternative, a new engineered landfill cover would be installed over these areas. Because radionuclides above unrestricted use levels would remain in Areas 1 and 2, this engineered landfill cover would include a 2-foot-thick low-permeability layer, a 2-foot-thick rock/rubble biointrusion layer, and a 1-foot thick vegetative layer as previously described for the UMTRCA cover alternative (Sections 5.4 and 6.2.3). This engineered landfill cover would be classified as an in-situ containment system (EPA, 2014a).

Because the engineered landfill cover to be installed over Areas 1 and 2 under the 52.9 Partial Excavation Alternative is the same as the UMTRCA cover to be installed under the UMTRCA cover alternative and is also substantially similar to the landfill cover to be installed under the ROD-selected remedy, the analysis of the potential effects of climate change or impacts of a tornado are essentially the same for all of these alternatives. These effects were previously discussed in Section 6.2.2.3.3 for the ROD-selected remedy and Section 6.2.3.3.3 for the UMTRCA cover alternative and therefore will not be repeated again here. The results of those evaluations (as discussed in Sections 6.2.2.3.3 and 6.2.3.3.3) relevant to the landfill cover system for the 52.9 Partial Excavation Alternative are summarized below.

Similar to the ROD-selected remedy, the vegetative layer of the UMTRCA cover to be installed under the 52.9 Partial Excavation Alternative could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.,* grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potential increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence. In addition, the design of the engineered cover may include a rock mulch in the upper portion of the vegetative layer in order to protect against soil erosion by wind or water in the event of loss of the vegetation.

The CCL and GCL layers could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low permeability materials (CCL or GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Such impacts are not considered to be significant because the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. In addition, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards and are projected to remain below these standards in the future (see prior discussion in Section 2.3.1 and also in Appendix E). Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality or radon emissions are not expected to be significant. More importantly, the vegetative layer would show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL/GCL. Therefore, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities such as temporary irrigation to maintain the grass cover, overseeding with grasses that required less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Furthermore, such impacts are not expected to result in release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer, which, if left untended, could result in erosion of the underlying biointrusion layer and potentially the low-permeability layer. The design of an UMTRCA cover is anticipated to include a rock mulch to reduce the potential for erosion of the vegetative layer and thus increase the longevity of the cover system. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot-thick rock layer in the base of the cover system, stormwater erosion, even under the most severe storm event, is not anticipated to result in erosion down through the entire landfill cover. Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points thereby causing delays in implementation of repairs if any are needed. Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. However, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regarding, repair, and replacement of cover material in response to any damage that may occur.

The 52.9 Partial Excavation Alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, FEMA has determined that, with the exception of the easternmost portions of Areas 1 and 2, which do not contain waste materials, Areas 1 and 2 are located outside of the 500-year floodplain. In addition, the area to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River, are protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park.

As previously discussed in Section 6.2.2.3.3 in connection with the ROD-selected remedy, an evaluation of potential impacts associated with a tornado was previously performed and submitted to EPA (EMSI, 2013f). Similar to the ROD-selected remedy, the 52.9 Partial Excavation Alternative is not vulnerable to impacts from a tornado. Specifically, a tornado is not expected to damage the vegetative layer of the cover system (see prior discussion in Section 6.2.2.3.3) and even if it did, such an impact is not considered to be significant because it could be easily identified. Due to the design and thickness of the engineered cover, such an impact would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy aboveground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the 52.9 Partial Excavation Alternative is not considered to be vulnerable to impacts from a tornado.

Although the 52.9 Partial Excavation Alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could be considered during remedial design to provide a degree of adaptation for climate change. For example, regrading of the surface of Areas 1 and 2 to a 2% slope instead of a 5% slope could be considered to reduce the velocity of runoff across the surface of Areas and 1 and 2 and thereby reduce erosion and soil loss potential under extreme precipitation events. Installation of runoff collection and diversion systems along the base of the above-grade portion of the North Quarry part of the Bridgeton Landfill adjacent to Area 1 and along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2 could be included in order to divert runoff from these areas around Areas 1 and 2 to reduce the potential for impacts from heavy precipitation events. Use of grass seed mixtures that are more tolerant of long-term changes in precipitation or temperature, and/or soil addition to increase water storage capacity could be evaluated as part of the design. Similarly, inclusion of a geotextile at the base of the vegetative layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low-permeability layer. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls to increase the overall resilience of these features to heavy precipitation events. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures would be included as part of the ongoing inspection and maintenance program.

6.2.6.3.4 Potential Impacts of a Subsurface Heating Event

Because radionuclides above unrestricted use levels would still remain at the Site under the 52.9 Partial Excavation Alternative, radionuclide-related impacts similar to those described in Section 6.2.2.3.4 for the ROD-selected remedy could potentially occur if an SSE or SSR were to occur in Areas 1 or 2. Specifically, a localized, temporary increase in radon emissions from the ground surface could occur.

In the event that a subsurface heating event were to occur in Area 1 or Area 2, such an event is not expected to impact the long-term effectiveness of this alternative. As discussed for the ROD-selected remedy, there would only be a temporary potential increase in radon emissions, which are not expected to pose unacceptable risks. Destruction or modification of the waste material by increased temperatures could result in a reduction in volume which could cause subsidence and/or differential settlement of the waste mass. In turn, subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time could result in displacement or disruption of an engineered cover system thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

- Installation and operation of a heat extraction barrier or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions, after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2, the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills such as those located in the deeper quarry landfill, which provides a significant insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

6.2.6.3.5 Effects of an Isolation Barrier

Installation of a heat extraction barrier consisting of various heat extraction points, regardless of location, would not have a significant impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability or cost of the 52.9 Partial Excavation Alternative.

Installation of heat extraction wells could result in bringing RIM to the ground surface which if not properly managed could result in a potential for an airborne release. However, most drilling at the Site has been performed using Sonic drilling techniques, which generate little to no cutting material, thereby reducing the potential risk. Installation of heat extraction wells after installation of a new cover system would require repair of the cover system around such penetrations which could lead to additional maintenance or further repairs in the future; however, such activities are routinely performed at solid waste landfills and are not expected to significantly impact the OM&M costs. Installation of a physical barrier, such as a vertical wall of inert material, would require excavation and regrading of the above-grade portion of the North Quarry part of the Bridgeton Landfill wastes located over the southern portion of Area 1. If such a barrier were to be installed prior to implementation of the 52.9 Partial Excavation Alternative, portions of the barrier would need to be removed in conjunction with removal of RIM in the southwestern portion of Area 1. In addition, the design of the engineered cover included in this alternative would need to account for any changes in the surface grades, the stormwater drainage system, and the presence of any above-grade features (*e.g.,* heat extraction points, temperature monitoring probes, or additional gas extraction wells) that may be installed in conjunction with a barrier. In contrast, if a physical barrier were installed after RIM removal and construction of the engineered cover included in the 52.9 Partial Excavation Alternative, that portion of the engineered landfill cover that extended over the construction area of an isolation barrier and the associated revised landfill grades would need to be removed as part of construction of an isolation barrier. The alignment of a potential isolation barrier may also need to be revised to reflect the removal of some of the RIM from the southwestern portion of Area 1, assuming that the barrier is designed before the RIM removal and regrading occurs.

Because only Area 1 is located contiguous to the Bridgeton Landfill, an isolation barrier would only be installed near Area 1. Area 2 is physically separated by native material (soil and rock) present beneath the leachate treatment facility and Site access road from the Bridgeton Landfill. Therefore, any potential impacts to or from a potential isolation barrier from or to the ROD-selected remedy would only affect Area 1.

6.2.6.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6 as part of the evaluation of long-term effectiveness of the ROD-selected remedy, a screening-level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

6.2.6.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Although a portion of the RIM would be removed, the 52.9 Partial Excavation Alternative is primarily a containment remedy and therefore generally would not reduce the toxicity, mobility, or volume of the waste material through treatment.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be fully neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. Consequently, ex-situ treatment techniques are considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix in portions of Areas 1 and 2 make in-situ treatment techniques equally impracticable. The remedy for the Buffer Zone/Crossroads Property also would not reduce toxicity, mobility, or volume through treatment because it consists of moving radiologically-impacted soil from the Buffer Zone/Crossroads Property to Area 1 or 2, where it would either be shipped off-site for disposal or consolidated with the RIM in Areas 1 and 2.

An on-site technology that may potentially be applicable to this alternative is ex-situ physical separation of impacted soil from the solid wastes by using solids separation techniques such as hand picking for large bulky items and various fixed, vibrating, or rotating screens, among others (see prior discussion in Sections 4.3.5.2 and 4.4.1.2). Physical separation would not decrease the mobility or toxicity of the radiologically-impacted materials, but has the potential to separate existing RIM from non-radiologically-impacted materials. As previously discussed, any solids separation techniques would need to be pilot tested at full-scale using materials from Areas 1 and 2 during remedial design to ascertain the potential effectiveness, implementability, and cost of this technology. Of particular interest in conducting pilot testing with material from Areas 1 and 2 would be obtaining an estimate of the degree of RIM volume reduction that could be achieved, assessing the moisture content of the filled material, determining the fraction of soil that would be contained in or adhered to the segregated refuse, and determining the residual levels of radioactivity that would be present in the non-soil refuse after screening out the soil fraction. Assuming that solids separation could prove to be an effective and implementable technology (that is, it could effectively separate the radiologically-impacted soil from the other landfilled waste materials such that the other landfilled wastes would contain radionuclide activities below the levels that would allow for unrestricted use), it has the potential to reduce the volume of radiologically-impacted material that would need to be transported to and disposed at an off-site disposal facility. However, little is known about the potential application of a soils separation technology in this scenario, and it is possible that pilot testing could demonstrate that physical separation would not be effective at separating RIM from non-radiologically-impacted materials, in which case the non-radiologically-impacted materials would need to also be shipped off site for disposal. At this stage of analysis, neither the estimated costs nor the estimated schedules for this FFS include any allowance for solids separation pilot testing or implementation.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's LDR program and UTS) and in accordance with the permits and standard operating procedures of the receiving facility. After arriving at an off-site disposal facility and undergoing a waste receipt analysis, RCRA soil/debris and RCRA soil/debris with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on its physical characteristics, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste and radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

Section 6.2.2.4 contains a full discussion of the procedures, protocols and concerns associated with the off-site shipment of hazardous wastes or mixed wastes.

6.2.6.5 Short-Term Effectiveness

This alternative poses significant potential short-term risks as described below. During a public meeting held as part of the ROD-selected remedy process, EPA identified and discussed the following short-term risk issues for waste excavation: waste handling, sorting and stockpiling; water management; noise, odor and windblown trash; worker health and safety (PPE, gamma exposure, physical stress, physical hazards, workplace monitoring); contaminant migration/spreading (fugitive dust and airborne migration, fugitive dust control and water application, leachate generation, equipment decontamination water, and water from open excavations); and waste hauling and transportation issues/truck decontamination (transfer facilities, increased local traffic, waste handling on public roads, interstate transport by rail, DOT requirements, safety issues).

6.2.6.5.1 Protection of the Community During Remedial Actions

The projected carcinogenic risks that may be posed to off-site residents by this alternative would be less than 9.7×10^{-7}, which is below EPA's accepted risk levels (Appendix H). No non-carcinogenic risks are expected to occur.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each FFS alternative. For the 52.9 Partial Excavation Alternative, the projected incidence of transportation accidents associated with shipping of RIM for off-site disposal and importing of materials for construction of the multi-layer landfill cover is 7.6, meaning that approximately 8 transportation-related accidents are projected to occur if this alternative were implemented. This risk is associated with transportation of excavated RIM from the Site to the rail transloading facility, hauling by rail, and transport of the RIM from the destination rail offloading facility to the disposal site, plus truck traffic associated with delivery of construction materials to be used for construction of the new engineered landfill cover on Areas 1 and 2.

Disturbing the waste material may expose the community to radioactive waste, methane and radon gas, dust, and particulates, and may cause an undesirable release of odors. Excavation of existing waste materials would undoubtedly result in odor emissions during the period of time that existing wastes may be handled or exposed. Mitigation of odors through engineering means is limited.

The 52.9 Partial Excavation Alternative would contribute significant carbon dioxide equivalent emissions to the atmosphere as a result of vehicle operations associated with the remedial work. In particular, approximately 36,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere as a result of: landfill regrading and cover construction in Areas 1 and 2; the excavation, loading, and transport of the RIM to an off-site disposal facility; and the importation of materials used to construct the multilayer landfill cover for Areas 1 and 2 (Appendix I, Table I-5).

Because RIM in Areas 1 and 2 would be excavated under this alternative, overburden would be stockpiled and stored, and RIM would be staged and loaded for off-site disposal. During these activities, the nuisance attraction to and congregation by birds at and above the affected areas could be problematic unless effectively controlled. The main concern would be the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. For the 52.9 Partial Excavation Alternative, an enclosed waste staging and loading structure would be constructed to minimize the outdoor handling of waste and associated attraction of birds or other vectors. Additional mitigation measures such as excavation best management practices, which include application of daily soil cover and/or placement of tarps over areas of exposed waste, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, could be implemented to minimize bird attraction to and congregation at and above the disturbed areas.

Excavation of waste materials from Areas 1 and 2 would require removal of the existing landfill cover and overburden from Areas 1 and 2 and portions of adjacent areas of OU-2. Excavation of overburden and RIM would create depressions in the landfill area during the period required to remove the RIM and regrade and cover the remaining landfill wastes. Precipitation that falls on the landfill while such depressions are open would potentially flow into and accumulate in the depressions. Any increased accumulation of precipitation[73] in depressions created during waste excavation could result in increased infiltration of precipitation runoff through the underlying waste materials, which could result in leaching of VOCs or other soluble contaminants from the waste materials.

This alternative could be adversely affected by severe weather impacts. Due to the extended duration required for implementation of this alternative, the potential exists for one or more severe weather event to occur during implementation of this partial excavation alternative. Such an event(s) could delay construction due to direct delays to the excavation work from such an event and also indirectly if such an event results in diversion of resources (*e.g.*, equipment) from waste excavation activities to mitigation of impacts of a severe weather event. Severe weather events could potentially greatly increase the volume of contact stormwater that would need to be contained and managed which may further limit waste excavation activities and increase the amount of time required to implement this alternative. In addition, severe weather events could increase the potential for loss of stormwater containment through failure of best management practices for controlling stormwater impacts. Failures such as soil/waste scouring and suspended phase transport may result in an increased potential for release and off-site transport of stormwater that has been in contact with waste material or soil containing radionuclides.

Because Areas 1 and 2 would be excavated and RIM loaded into transport containers, storm water controls would be implemented in accordance with the Missouri Storm Water regulations 10 CSR 20-6.200 to protect the community. During construction, consideration would be given to minimizing the areas of excavation that would be open and exposed to waste materials at any given time. Temporary diversion berms using daily cover material would also be constructed above the open excavation areas on the previously excavated (and temporarily covered) surface of any excavation depressions in order to divert precipitation runoff around the open excavation and thereby prevent the runoff from contacting uncovered waste materials. Precipitation that would contact uncovered waste materials would flow into the low point of the excavation and be pumped out into temporary storage tanks using portable gas-driven pumps. Samples from each tank would be collected and sent to a laboratory for analysis. The stored water would be directly discharged or treated and disposed appropriately based on the analytical results.

6.2.6.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.5.2 as part of the evaluation of short-term impacts associated with the ROD-selected remedy, a screening-level analysis did not identify any

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[73] Accumulation could be significant during a heavy rainstorm as the maximum historical 24-hour rainfall for the St. Louis area ranges from a low of 3.7 inches in November to a high of 8.8 inches in August (NOAA, 2011).

environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.6.5.3 Protection of Workers During Remedial Actions

This alternative would entail significant excavation, handling, loading, and transport of RIM at the Site, and therefore would pose both significantly increased radiological exposure risks as well as construction safety risks to on-site workers.

Workers involved in the excavation activities would be subject to potential short-term risks. Possible short-term impacts associated with excavation and regrading of the RIM include the following potential risks: exposure of workers to contaminated waste; excavation/trenching instability; stormwater runoff entering areas where waste is exposed, resulting in the exposure of workers to contact storm water; and odor emissions or other aesthetic issues arising from exposed waste. Worker exposures would be addressed through development and implementation of a Site safety plan, use of personal protective equipment, and performance of personnel and environmental monitoring during implementation of remedial action. Workers would be protected during construction by adhering to OSHA practices; however, as this alternative entails large amounts of excavation, handling, and transportation of radiologically-impacted materials, OSHA work practices and personal protective equipment may not provide full protection against exposure to external gamma radiation.

The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the 52.9 Partial Excavation Alternative, the projected incidence of industrial accidents is 11.1 over the life of the project. The projected carcinogenic risk to the maximally exposed individual is 2.2×10^{-3} and the projected hazard index is 27.1. The projected radiation dose to a remediation worker is 6,940 mrem/yr (Appendix H).

Excavation would require construction workers and equipment that would disturb the overburden soil and underlying waste materials. Dust control measures would be required to limit worker exposure to fugitive dust during construction.

Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers, including the projected non-carcinogenic risks identified above. Protective clothing alone would not reduce the carcinogenic risk or projected radiation dose these risks result from exposure to gamma radiation. The only way to address these risks is to limit the amount of time (exposure duration and frequency) that workers are exposed to gamma radiation. This could be done by measuring and tracking worker exposures and shifting workers to other tasks with less potential for gamma exposure to reduce the overall level of exposure to radiation. However, even this option may not be sufficient for workers involved with RIM sorting and handling prior to loading. For example, it is anticipated that the disposal facility would provide qualified individuals to supervise loading of RIM into transport containers to ensure that each container meets the WAC for the disposal facility. The disposal facility may not be able to provide sufficient workers to allow for substitution to minimize gamma exposures. Implementation of the remedial action would not be performed in a manner that would result in an unacceptable risk to any worker or anyone else. However, managing worker exposures, especially for those involved in the RIM sorting and loading operations, who are expected to be the maximally exposed individuals, could present challenges for implementation of this alternative and therefore represents a short-term risk for this alternative.

6.2.6.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from this alternative. As noted in the BRA (Auxier, 2000) and the updated BRA (Auxier, 2017a), some of the ecosystems present at the landfill are the result of existing institutional controls and other limitations on land use within or adjacent to OU-1 that have allowed field succession to take place. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Excavation of RIM, regrading of Areas 1 and 2, and construction of the engineered landfill cover under the 52.9 Partial Excavation Alternative would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.6.5.5 Ability to Monitor Effectiveness

Measurement of gamma radiation and radon flux through the newly constructed landfill cover would be conducted on Areas 1 and 2 after construction is complete. Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2. Measurements of subsurface occurrences of landfill gas and radon levels would be conducted along the property boundaries adjacent to Areas 1 and 2 to verify that off-site gas migration above regulatory thresholds does not occur.

6.2.6.5.6 Time Until Remedial Action Objectives Are Achieved

The RAOs of (1) preventing direct contact with contaminated media; (2) preventing exposure by inhalation and external radiation; (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; and (5) controlling radon and landfill gas emissions from Areas 1 and 2 would be met once construction of the new engineered landfill cover over Areas 1 and 2 is completed. The RAO related to the Lot 2A2 Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas.

Initiation of this alternative would require significant planning and permitting due to the limited number of off-site disposal facilities capable of taking this material and the extensive logistics associated with identifying, handling, classifying, and loading the materials for transport to the selected off-site facility. Preparation of the remedial design should be completed within approximately 15 months of authorization to proceed with the RD. The RD could take significantly longer if full-scale pilot testing of solids separation equipment were to be performed. The RAOs would be achieved upon completion of construction which is estimated to be finished within approximately 3.7 years after approval of the RD. Therefore, the remedial action objectives should be achieved within approximately 5 years of approval to proceed with the RD (Appendix J). This schedule estimate assumes that the buyout of the asphalt company lease and relocation of the solid waste transfer station occur during the remedial design phase. If this is not the case, the schedule would be longer.

The projected construction schedule and the cost estimate for the 52.9 Partial Excavation Alternative are highly dependent on the waste material swell factor; that is, the amount the in-place waste volume expands as it is excavated, handled and loaded for transport to an off-site disposal facility. For purposes of this FFS, a swell factor of 1.5 has been assumed. A swell factor greater than 1.5 would result in an increase to the overall construction schedule and the estimated costs. The projected construction schedule and the cost estimate for the 52.9 Partial Excavation Alternative also are highly dependent on the number of rail cars that could be loaded and shipped per day. The schedule and cost estimate developed in this FFS for this alternative are based on an assumption that a sufficient number of IM containers and rail cars can be made available, loaded, switched out and replaced every day. If the actual rate is less than the projected rates of RIM excavation used to develop the construction schedules, the time required to complete construction and consequently the costs for 52.9 Partial Excavation Alternative would increase.

6.2.6.6 Implementability

This alternative would involve excavation and off-site disposal of a portion of the RIM in Areas 1 and 2, repair and restoration of the disturbed portions of the OU-2 landfill units adjacent to Areas 1 and 2, grading of the surfaces and installation of upgraded landfill covers over Areas 1 and 2, long-term monitoring and maintenance of the covers, and long-term monitoring of landfill gas and groundwater and surface water quality.

Excavation of RIM would require removal of substantial amounts of overburden and material from the sidewalls of the excavations in order to maintain stability of the excavation areas. Overburden removal would entail removing and temporarily relocating part of the above-grade portion of the North Quarry portion of the Bridgeton Landfill in order to access the underlying RIM in Area 1 of OU-1. The total amount of non-RIM waste required to be removed under this alternative is estimated to be approximately 190,000 bcy, which, based on an expansion factor of 1.5, would result in the need to handle, stockpile, and replace 285,000 lcy of waste. Management of exposed waste in both the excavation areas and the stockpiles—including management of stockpiles, stormwater runon and runoff, odor emissions, attraction to birds and other vectors, and litter control—would be a significant undertaking. The amount of space available for stockpiling the overburden material is limited, and therefore overburden material from Area 1 would likely need to be transported to Area 2 for temporary stockpiling while waiting for final placement and capping. Similarly, the total volume of RIM that would be excavated under this alternative is estimated to be 83,900 bcy, equivalent to 126,000 lcy although due to the inclusion of daily cover material would require the shipment of 138,000 lcy. Due to the double-handling (at a minimum) of the overburden material plus the RIM handling, it is anticipated that approximately 910,000 lcy of waste would be handled under this alternative.

An additional complication arises from the proximity of the Bridgeton Transfer Station. In order to access the RIM in the southwest portion of Area 1, the solid waste transfer station would need to be relocated, as removal of waste material would extend up to and along the base of the solid waste transfer station such that the integrity of the solid waste transfer station building foundation and above-grade structure would be compromised. The only available space for relocation of the transfer station is the area currently occupied by Simpson Asphalt Company, which holds a long-term (99-year) lease on this area. This lease would have to be bought out and the asphalt company would need to be relocated before the transfer station could be relocated to this area.

It is anticipated that a new structure would be constructed to shelter the RIM staging and loading operations in order to minimize stormwater contact, odor emissions and bird attraction. It is anticipated that such a structure would be constructed along the north side of the Site access road in the area that is currently being used to store new, reclaimed, and surplus equipment and materials associated with ongoing operation, maintenance, and closure activities for the Bridgeton Landfill. These materials would need to be relocated to another portion of the Site prior to construction of such a structure.

In order to minimize potential vehicle interactions between normal traffic to and from the solid waste transfer station and the construction operations associated with this alternative, a temporary overpass would likely need to be constructed over the Site access road to allow for uninterrupted movement of construction traffic between Areas 1 and 2. An overpass is considered the most efficient and safest means for transfer of overburden waste from Area 1 to stockpile locations in Area 2 and then back to Area 1. In addition, as discussed above, a single RIM staging and loading building would be constructed and operated as part of this alternative. RIM removed from Area 1 would need to be transferred over the Site access road. Installation of an overpass would eliminate the potential for RIM to be tracked across the Site access road and potentially tracked off site.

While excavation with subsequent off-site transportation and disposal have been implemented at other sites containing radioactively-impacted materials, materials from these other sites have not included significant amounts of landfill solid wastes. Significant technical and administrative implementability issues are associated with excavating the RIM and loading it into IM containers for transportation if this alternative were to be implemented. These include the following:

- Reduced excavation production rates and increased volume of RIM subject to excavation resulting from application of daily cover over an extended excavation schedule;
- Ability to locate and obtain a lease to an off-site rail spur for use as a truck-to-rail transfer facility, or alternatively the ability to construct an on-site rail spur and rail loading facility;
- Increased potential for bird strikes to aircraft as a result of excavation of putrescible or organic solid waste overburden waste from the North Quarry portion of the Bridgeton Landfill and Areas 1 and 2, and excavation of RIM-contaminated waste from Areas 1 and 2, all of which are located within flight paths of Lambert–St. Louis International Airport;
- Impacts to other Site operations and traffic on surrounding roads from additional truck traffic used to haul wastes to an off-site truck-to-rail transfer facility and to haul earthen materials to the Site for daily cover, stockpile covers, and construction of the final cover.

Design and construction of post-RIM-excavation landfill covers over Areas 1 and 2, with subsequent monitoring and maintenance, are not expected to pose any implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 after RIM removal are available and the technologies have been proven through application at other landfills. Design and construction of landfill covers over Areas 1 and 2 after RIM removal are not expected to pose any significant implementability challenges.

The actions included for the Buffer Zone/Lot 2A2—that is, testing and excavation of surface soil—are regularly and easily implementable.

Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of the engineered landfill cover that would be placed over Areas 1 and 2 and are easily implemented.

6.2.6.6.1 Ability to Construct and Operate the Technology

In general, excavation and off-site disposal are standard technologies. However, there are unique circumstances associated with excavation of RIM in Areas 1 and 2, insofar as they are located within a larger closed/inactive landfill site, which would complicate implementation of standard excavation technologies.

RIM excavation and placement in IM containers and hauling of the containers by truck for subsequent transfer to rail is also expected to present implementability concerns, challenges, and risks, specifically those associated with the following:

- Excavation and handling of contaminated materials;
- Safety risks associated with encountering methane gas during excavation;
- Management of fugitive dust and potential odors;
- Mitigation of bird hazards;
- Management and treatment of stormwater exposed to RIM during excavation; and
- Identifying, segregating, and disposing off-site any hazardous wastes, PCBs, or RACM that may be encountered during RIM excavation.

If hazardous wastes, PCBs, or RACM are encountered during excavation of RIM, these materials would need to be segregated from the other waste materials, characterized, and transported to an off-site disposal facility in containers separate from the other RIM. Additional health and safety procedures would be required during excavation of these materials. These materials would require separate handling at the off-site disposal facility and could require treatment prior to disposal. Depending on the characteristics of any hazardous waste encountered during excavation, the hazardous waste could need to be transported to a different off-site facility for treatment and disposal in accordance with RCRA.

Directing and controlling the RIM excavation process using radiological scanning and sampling techniques would significantly impact overburden and RIM excavation production rates. Based on experience in excavation of radiologically-impacted waste at other sites, a reduction in efficiency is expected for overburden excavation and a greater reduction is expected for RIM excavation. Because thorium-230 cannot be detected using field survey instruments, excavation guidance would have to rely on collection and laboratory analyses of samples. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities and initial confirmation that all RIM had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that all RIM has been removed from a particular area would also be subjected to off-site laboratory analyses and data validation. Potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses, as well as moving excavation activities to other areas while waiting on the results of verification of confirmation sample analyses. However, even with these measures, it is likely that some short-term delays to the construction work on the order of hours to days will likely occur due to waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedule developed for this alternative.

Daily soil cover and tarps would need to be placed over open excavation areas and stockpiled overburden to minimize dust, odor, and the attraction of birds and other wildlife. The proximity of Areas 1 and 2 to Lambert-St. Louis International Airport poses a potential risk to aviation operations. The St. Louis Airport Authority and the U.S. Department of Agriculture have identified as a problem the potential for increased bird activity in conjunction with waste excavation at the Site and the resultant increased risk of bird strikes to aircraft. Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed overburden and wastes), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be evaluated for use at Areas 1 and 2. The size of open excavations may limit the constructability of wire or monofilament grids. Careful evaluation of material properties would be necessary during remedial design to assure that the appropriate strength and elasticity of materials are considered, that the materials are available, and that grids can be reasonably constructed.

Effective stormwater controls could be readily implemented using conventional construction equipment and materials. Temporary berms to direct stormwater away from open excavations would need to be constructed, and precipitation accumulation in depressions created by the excavation activities would need to be pumped out and managed. Direct precipitation or runoff that may contact waste material could become contaminated with soils or wastes containing thorium or radium. These elements would be entrained in colloidal material that would readily settle in low areas or in the tanks used to collect and store stormwater prior to treatment and discharge. At the end of excavation activities, after all RIM above cleanup levels would have been removed, accumulated sediment in any low areas or the tanks would also be removed and, depending upon activity levels, either placed in Area 1 or 2 or transported to the off-site disposal facility.

Excavated RIM exposed to precipitation would be subject to the paint filter liquids test (PFLT) as necessary to determine if free liquids exist prior to being loaded for off-site disposal. If the excavated material to be hauled off site does not pass the PFLT, a dewatering area would need to be staged and collected water treated and/or disposed, potentially through off-site disposal. The current costs and schedules do not address any dewatering activities. Should such activities be necessary, a suitable area would have to be identified within the Site.

Truck hauling of IM containers of RIM to a truck-to-rail transloading facility and transferring the RIM to railcars is technically implementable. Loading RIM directly into railcars on-site if a rail spur could be extended onto the West Lake Landfill property is theoretically implementable.

However, it is not known whether extension of a spur onto the property is feasible. If construction of an on-site rail spur were to be considered, an engineering study and development of a detailed design would be necessary to determine the feasibility and implementability. As discussed in detail in Sections 6.2.4.6.5 and 6.2.4.6.6 above, construction of an on-site rail spur would also require coordination with a number of local and state regulatory authorities as well as private landowners.

An initial comparison of the US Ecology Grand View facility WAC to estimated activity levels in the OU-1 RIM under the 52.9 Partial Excavation Alternative is presented on Table 6-3. Although a representative of the turnkey contractor would be on site during RIM excavation to coordinate loading of containers, there is a potential that one or more shipping containers could contain activity levels that exceed the WAC and may have to be unloaded and re-distributed prior to shipment or, in the worst case, returned to the Site by the disposal facility and/or sent to a different disposal facility. These additional activities could result in additional worker exposures, additional time to complete the project, and potentially additional costs.

Regrading the remaining landfills and placement of final cover is implementable and has been performed at other landfills, including CERCLA sites. Environmental monitoring is routinely performed at most sites and is not expected to present any feasibility challenges.

6.2.6.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material is a reliable technology that has been performed at number of facilities including other CERCLA sites, FUSRAP sites, and DOE Land Management sites. It should be noted, however, that none of these sites involved such large-scale excavations (*i.e.,* hundreds of thousands of yards) of radiological materials commingled with municipal solid waste and disposed in a landfill setting such as envisioned under this alternative. The reliability associated with disposal in an off-site facility would be dependent on the integrity of the liner and cover systems at the off-site facility being maintained, as well as the effectiveness of the various off-site facility monitoring programs.

Landfill cover systems such as those that would be implemented over Areas 1 and 2 after partial removal of RIM, and which are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance, have been demonstrated to be reliable at: (1) minimizing percolation and infiltration of precipitation; (2) minimizing leachate generation; (3) minimizing impacts to groundwater quality; (4) minimizing impacts to surface water quality and quantity; (5) minimizing erosion of cover material; and (6) minimizing uncontrolled releases of landfill gas. Landfill cover systems have been demonstrated to be reliable methods for isolating waste materials. Similarly, access restriction measures have been demonstrated to be reliable mechanisms to prevent unauthorized access to a site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed RIM and waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated reliable technologies under proper operating and excavating conditions. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. In addition, the FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are well-established technologies that are implemented at most landfill sites. For this alternative, gravity settling of suspended solids potentially containing radionuclides is a well-established and reliable technology.

6.2.6.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

Because all of the RIM would not be removed during implementation of this partial excavation alternative, it is possible that EPA could later require removal of additional RIM. If such a decision were to occur after construction completion of this alternative, performance of any such additional remedial action in the future would be very difficult and costly. Such actions would require removal of the newly constructed engineered landfill cover and re-excavation of materials previously removed and replaced as part of this partial excavation alternative.

Other than the possibility of additional excavation in the future, the only potential additional remedial actions that may need to be taken for the 52.9 Partial Excavation Alternative would be maintenance activities to sustain the cover system, repair areas of differential settlement or erosion, or possible implementation of a contingent landfill gas control system. Regrading and contouring the existing waste materials to achieve final grades would require re-compaction of the regraded waste materials in order to minimize the potential for compaction or differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill cover may result in differential compaction of the waste materials, depending upon the nature, age, and amount of prior degradation of the waste materials. Runoff of stormwater can result in formation of erosional rills. Depressions caused by differential settlement of the wastes or erosional features can easily be (and commonly are) addressed at landfill sites through placement of additional soil material to fill such features.

In the event that monitoring of subsurface landfill gas and radon detects the presence of gas levels above regulatory thresholds along the perimeter of the Site, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system, and/or possible use of a carbon adsorption system to remove radon from the extracted gas stream. Installation of a contingent gas system could be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would be straightforward, primarily entailing placement of additional fill, regrading, and revegetation of the repaired area.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarps), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated to be readily implementable at landfill sites.

Stormwater management measures other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures are not anticipated.

6.2.6.6.4 Ability to Monitor Effectiveness of Remedy

Demonstrating the effectiveness of the cover systems constructed over Areas 1 and 2 after partial excavation of RIM would be accomplished by implementing monitoring programs for the cover surface, landfill gas system, groundwater and surface water programs, as previously described in Section 5.5.6. These types of monitoring programs have been proven at demonstrating cover effectiveness and are easily implemented.

6.2.6.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the 52.9 Partial Excavation Alternative would require approvals from other agencies, including the following:

- Approval from the FAA to conduct waste excavation activities within 10,000 feet of an active airport runway. FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, "Hazardous Wildlife Attractants On or Near Airports," recommends "against locating a MSWLF [municipal solid waste landfill] within the separation distances identified in Sections 1-2 through 1-4. The separation distances should be measured from the closest point of the airport's AOA [airport operations area] to the closest planned MSWLF cell." AC 150/5200-33B, p. 4. The separation distances referenced are 5,000 feet from the end of a runway for airports serving piston-powered (propeller) aircraft; 10,000 feet for airports serving turbine-powered (jet) aircraft; and 5 miles of protection from hazardous wildlife movement for approach, departure and circling airspace. The FAA strongly recommends against allowing a waste disposal operation within 10,000 feet of a jet aircraft runway if the material contains putrescible waste and so has the potential to attract wildlife that could threaten air traffic. The excavation of RIM containing putrescible waste within 10,000 feet of the westernmost runway (11/29, formerly known as 12W/30W) at Lambert-St. Louis International Airport, as would occur during excavation of the RIM in Areas 1 and 2, is limited by the need to mitigate potential bird activity during excavation to address the requirements of the FAA Advisory Circular and to comply with the same prohibitions in the Missouri solid waste regulations. It may be necessary to work directly with the FAA and MDNR to identify specific bird mitigation measures during implementation.

- Approval of St. Louis Airport Authority (STLAA) relative to obtaining a release for the Negative Easement and Declaration of Restrictive Covenants Agreement. Excavation of RIM from Areas 1 and 2 poses a potential to increase the bird populations at the Site if mitigation procedures are not employed or prove ineffective. An increase in bird populations presents a greater potential for aircraft bird strikes. The STLAA and USDA have identified this as a concern relative to construction and operation of a new on-site disposal cell that was included in the full excavation of RIM with on-site disposal alternative evaluated in the SFS. Based on the STLAA's position stated in the STLAA's September 20, 2010 letter to EPA, STLAA acceptance of RIM waste excavation would not be likely if bird activity were to increase. It may be necessary to work directly with the FAA and the STLAA to address these concerns, either by amending the FAA ROD, amending the Negative Easement, requiring specific bird mitigation measures during implementation, or making other changes to secure STLAA's cooperation. By letters dated August 11, 2014 and August 11, 2017 (Appendix A), the Airport again submitted comments to EPA, emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives.

- Location of an off-site truck-to-rail loading facility. At the discussion held in September 2010, the STLAA indicated that they would not allow the use of the existing SLAPS truck-to-rail transloading facility for loading waste from the West Lake Landfill into railcars (Appendix A-4). The SLAPS rail spur is reportedly owned by the U.S. Army Corps of Engineers and the land on which the rail spur is built is owned by the City of St. Louis. It is not clear that the STLAA could prevent use of the SLAPS rail spur for loading and shipping via contractual means; however, as the STLAA is the owner of the property, their concurrence must be considered. Therefore, it appears unlikely that the SLAPS rail spur would be available for implementation of a remedial action for West Lake Landfill. No other nearby off-site truck-to-rail loading facilities have been identified. Discussions with US Ecology have indicated that as part of the transportation and disposal activities, US Ecology would locate and lease an existing rail spur in the area or otherwise construct a rail spur somewhere in the area that could serve as a transloading facility.

- Compliance with EPA's OSR. The EPA Region where the off-site disposal facility is located would need to be contacted every 60 days during the period of off-site waste shipments to obtain a compliance determination as to whether the disposal facility currently meets the criteria under the OSR to accept CERCLA waste. If, during RIM excavation, the contracted off-site disposal facility was to be out of compliance for a period of time, excavation and transportation would need to cease until the facility becomes compliant or RIM would need to be transported to another facility that is determined to be in compliance with the OSR. Besides schedule delays, temporary stoppage of construction would present significant technical implementability concerns regarding open excavation areas.

- Rocky Mountain Low Level Radioactive Waste Compact Consent. If RIM were to be disposed at the Clean Harbors Deer Trail, CO facility, an application would have to be submitted to and accepted by the Rocky Mountain Low Level Radioactive Waste Compact. Disposal at the US Ecology Grand View, ID, US Ecology Wayne, MI, and Energy*Solutions* Clive, UT facilities would not be subject to a Waste Compact consent.

6.2.6.6.6 Coordination with Other Agencies

Although not all would be considered "agencies," coordination with many entities would be necessary to implement the 52.9 Partial Excavation Alternative. Coordination with the landfill owner and operator and owners or occupants of the various parcels that comprise the West Lake Landfill Site would be necessary because of the following:

- Termination of the asphalt company lease and removal of the asphalt plant followed by relocation of the Bridgeton solid waste transfer facility and construction of an overpass between Areas 1 and 2 over the Site access road would need to occur prior to the start of RIM excavation;

- Access to operations conducted on other portions the Site would need to be maintained.

- Areas 1 and 2 are within a larger existing Site footprint, and use of areas on the Site outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction.

- Implementation of this alternative would require excavation of portions of landfill units located outside of OU-1. Upon completion of removal of the RIM, disturbed portions of the adjacent landfill units would need to be repaired and restored, and regrading and installation of a replacement landfill cover over areas outside of OU-1 would need to be performed. Coordination would also be required relative to integration of the slopes and grading for adjacent landfill areas, as well as routing and design of stormwater diversion and conveyance structures between OU-1 and other landfill areas.

- Use of other areas of the West Lake Landfill Site that may be necessary for stockpiling of overburden and staging or routing of trucks or rail cars used to haul the excavated RIM off site.

- Implementation of any additional institutional controls or modifications to existing institutional controls that EPA may require would need to be approved and accepted by the individual entities that own the various parcels that comprise the Site.

For the duration of excavation, off-site transport, and import of cover materials, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the current on-site solid waste transfer station and other Site tenants.

If a truck-to-rail transloading facility at an off-site rail spur location were to be used, a suitable location would need to be identified and a lease secured with the land/rail spur owner for the duration of the RIM loading and transport operations. As noted above, it does not appear that the existing SLAPS truck-to-rail transloading facility would be available, so costs for establishing a new facility would need to be considered[74].

If a rail spur were to be extended onto the West Lake Landfill Site:

- Land located across St. Charles Rock Road would either need to be purchased or long-term leases would be needed with landowners;

- State and local government, private landowner, facility occupant, and community approval would need to be obtained in order to construct a rail spur across private property located to the east of St. Charles Rock Road, across St. Charles Rock Road, and along the access roads which serve the existing solid waste transfer station and asphalt plant operations located at the Site;

- Appropriate safety measures for the crossing at St. Charles Rock Road would have to be installed, consistent with requirements of state and local governments;

- The long-term lease of the asphalt plant for land south of the solid waste transfer station, would need to be bought out or otherwise acquired; and

- Because of the high traffic volume on St. Charles Rock Road during the day, dropping off empty and picking-up loaded railcars would likely be possible only during late night and early morning hours.

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[74] The unit cost estimates provided by US Ecology for purposes of this FFS include costs to secure an off-site rail spur for a truck-to-rail transloading facility.

Provision of and switching of gondola railcars either at a truck-to-rail transloading facility spur or an on-site rail spur would need to be coordinated with the railroad company that would be hauling the railcars to the off-site disposal facility.

Future groundwater monitoring activities could require obtaining and maintaining access to off-site properties if off-site groundwater monitoring were required as part of the remedy.

The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the FAA and St. Louis Airport Authority. The effectiveness of proposed bird nuisance mitigation measures would be of interest to the FAA and STLAA. Consequently, the FAA and STLAA would need to be involved in the remedial planning process.

Coordination with other agencies, including the Earth City Flood Control District, MSD, and MDOT, as well as the adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities, both during and after completion of construction;

- Coordinate with MSD regarding permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from AAA Trailer for testing and if necessary remediation of the Crossroads Property, and possibly for implementation of remedial actions that may need to be performed along the property boundary (e.g., regrading, fencing, etc. in Area 2).

As discussed at the beginning of this section (6.2.5.6), in order to access RIM in Area 1, the solid waste transfer station facility would need to be relocated. The only suitable area for relocation of the transfer station is currently under lease and occupied by Simpson Asphalt Company. The asphalt company lease would need to be bought out and their equipment removed from the Site before the transfer station could be relocated. Relocation of the transfer station would normally be subject to permitting by the City of Bridgeton and St. Louis County; however, because relocation of the transfer station would be performed as part of a Superfund remedial action and the transfer station would remain on-site, additional permitting is not anticipated to be required. However, it is likely that public meetings and hearings may be necessary, which would require coordination with the City of Bridgeton and St. Louis County and could impact the timing for the start of construction of a 52.9 Partial Excavation Alternative.

6.2.6.6.7 Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity

As discussed in Section 4.3.5.4, four off-site disposal facilities that could accept excavated RIM from the West Lake Landfill OU-1 have been identified. At least three of these facilities (located in Idaho, Utah, and Colorado) have accepted radiologically-impacted soil from projects or sites in the United States, although none of them have previously accepted radiologically-impacted soil mixed with solid waste. All four of the identified facilities have available capacity to accept the estimated volume of RIM from the Site. The volumetric rate of acceptance for all facilities would be limited by the number of IM containers and railcars that could be provided and loaded at or near the Site, as well as the number that could be unloaded at or near the disposal facility. Off-site treatment, storage and disposal may be required in the event that hazardous wastes or RACM are encountered in the overburden or RIM excavated from Areas 1 and 2.

The identified facilities are also permitted to: (1) accept liquid wastes, should any stormwater that may accumulate in excavations during RIM excavation become contaminated and require disposal off-site; (2) accept mixed wastes if mixed wastes are encountered during excavation; and (3) treat soil and/or debris that contains hazardous waste or mixed waste.

As discussed in Section 3.1.4.1, the CERCLA OSR requires that waste materials removed from a CERCLA site be placed only in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during remedial design and would need to be regularly evaluated and updated during remedy implementation.

Offsite treatment and discharge of any leachate that may be encountered or stormwater that may contact waste materials during the landfill re-contouring activities could also be required. Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater. Initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.6.6.8 Availability of Necessary Equipment and Specialists

Materials, equipment and personnel required for excavation and transport of RIM to an off-site disposal facility are readily available. Trained health physics technicians and specialized equipment required to monitor personnel, monitor environmental conditions, and assist in directing the RIM excavation sequencing are also available.

As discussed above, there are a limited number of disposal facilities that can accept these types of wastes, and most of these have stringent waste acceptance criteria which may limit the ability of some of the facilities to receive the wastes.

Availability of rail service, particularly the number of rail cars that can be made available and switched daily by the railroad, would also affect the production rate of RIM excavation and disposal and therefore the cost.

All the materials, equipment, and personnel necessary to remove the designated portion of the RIM and to regrade and construct the engineered landfill cover over Areas 1 and 2 after the designated portion of the RIM (*i.e.*, greater than 52.9 pCi/g) has been removed are readily available. The necessary technologies have been generally proven through application at other landfills. The implementability and potential cost of the covers would be influenced by the availability and location of clean cover materials and/or off-site borrow sources at the time this alternative would be implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006) and during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI, 2008) regarding availability, and the availability of some of the materials was verified in conjunction with construction of the NCC. Information obtained from the vendors at these times indicated that rock, clay, and clean cover material were readily available from sources located near the Site. If these local sources of cover materials become exhausted prior to or during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

The necessary materials, equipment, and personnel required for assessment and removal of RIM that may be present at the Buffer Zone/Lot 2A2 above unrestricted use levels, and to implement the institutional controls and monitoring components of this alternative are also readily available.

6.2.6.6.9 Availability of Prospective Technologies

The 52.9 Partial Excavation Alternative is based on proven, established, and commonly-used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.6.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the 52.9 Partial Excavation Alternative are included in Appendix K-6 and summarized on Table 6-1. Conceptual excavation, backfill, and bottom and top of final cover grading plans, as well as stormwater control features used as the basis for the 52.9 Partial Excavation Alternative capital cost estimate are provided in Appendix M. The estimated cost to conduct the 52.9 Partial Excavation Alternative (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $274,000,000 based in part on unit costs provided by US Ecology. These costs do not include costs to conduct full-scale pilot testing of solids separation equipment. The estimated annual OM&M costs range from $176,000 to $389,000 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring and years when landfill cover repairs and 5-year reviews may occur). The cost estimates provided in this FFS are feasibility-level cost estimates which were developed to a level of accuracy such that the actual costs incurred to implement this alternative are expected to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the 52.9 Partial Excavation Alternative are projected to be $236 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $275 million. The total non-discounted costs for the 52.9 Partial Excavation Alternative over 30 years are projected to be $280 million.

Given the long life of the radionuclides present at OU-1, the costs for the 52.9 Partial Excavation Alternative were also evaluated for 200- and 1,000-year periods (without consideration of any constraints on annual expenditures). The total non-discounted costs of the 52.9 Partial Excavation Alternative are projected to be $312 million over a 200-year period. The total present-worth costs of the 52.9 Partial Excavation Alternative are projected to be $237 million based on a 7% discount rate or $290 million based on a 0.7% discount rate over a 200-year period. The total non-discounted costs of the 52.9 Partial Excavation Alternative are projected to be $464 million over a 1,000-year period. The present-worth costs over a 1,000-year period are projected to be $237 million based on a 7% discount rate or $297 million based on a 0.7% discount rate.

For purposes of demonstrating how much shipping of mixed/hazardous waste could influence costs, it was assumed that mixed waste would represent 0.5% of the sum of the volumes of RIM (83,900 bcy) and overburden wastes (190,000 bcy). Accounting for the addition of daily cover (10% increase in volume) and the bulking of the waste that would occur upon excavation (50% increase in volume) and assuming that 0.5% of these materials would be mixed/hazardous wastes results in estimated volumes of mixed and hazardous waste of 692 lcy and 1,570 lcy, respectively, for the 52.9 Partial Excavation Alternative. The added costs for handling, sampling/analysis, and treating mixed waste (RIM that is also a hazardous waste) for this alternative are estimated to range from $16,000 to $363,000 (Appendix K-10). The additional cost for handling, sampling/ analysis, shipping, treating, and disposal of hazardous waste from excavation of overburden material is estimated to be $323,000 to $1,210,000 (Appendix K-10). These ranges of costs primarily result from variations in the fees charged by the off-site disposal facilities and uncertainties associated with the nature of such wastes and the required method of treatment. Therefore, the additional costs that may be incurred if mixed and hazardous wastes are encountered during overburden relocation and RIM excavation for the 52.9 pCi/g Partial Excavation Alternative, could range from $339,000 to $1.58 million (Appendix K-10). If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher.

6.2.7 Partial Excavation of RIM with Activities Above 1,000 pCi/g

This section presents the detailed analysis of a partial excavation alternative consisting of removal of RIM with combined radium and/or combined thorium activities greater than 1,000 pCi/g and subsequent regrading and capping of the remaining waste (hereafter referred to as the "1,000 Partial Excavation Alternative"). As previously described in Section 5.8, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station building to provide access to RIM located adjacent to the building and construction of an overpass over the Site access road;
- Excavation and stockpiling of overburden from OU-1 Areas 1 and 2, including the portion of the North Quarry area of the Bridgeton Landfill that overlays Area 1, in order to access the RIM;
- Excavation of RIM from the OU-1 Areas 1 and 2 that contains combined radium or combined thorium activities greater than 1,000 pCi/g;
- Loading, transport, and disposal of the RIM at an off-site disposal facility;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Crossroads Property;
- Excavation of any soil from the Buffer Zone and/or Crossroads Property that contains radionuclides at levels greater than those that would allow for unrestricted use, and placement of such soil in Area 1 or 2;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of a landfill cover meeting the UMTRCA design, performance, and longevity standards over Areas 1 and 2;
- Design, installation and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for sanitary landfills;
- Landfill gas and radon monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radionuclides; and

- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Under this alternative, an estimated 38,700 bcy of RIM would be excavated from Areas 1 and 2 for off-site disposal. The volume of material would increase upon excavation due to swelling, handling, and loading for transport to an off-site disposal facility. Applying the swell factor of 1.5 and accounting for daily cover, it is estimated that approximately 63,900 lcy would be transported to and disposed off site. An additional approximately 2,900 bcy of impacted soil would be excavated from the Buffer Zone/Lot 2A2 and placed in either Area 1 or 2 under this alternative.

Once all of the material containing combined radium or combined thorium activities greater than 1,000 pCi/g has been removed from Areas 1 and 2, the remaining solid waste materials in Areas 1 and 2 would be regraded to achieve a minimum surface slope of 5% and maximum slopes of 25% or less in accordance with Missouri's final closure standards for sanitary landfills. Because waste containing radionuclides above unrestricted use standards would still remain in Areas 1 and 2, this cover would be designed to meet the requirements of the UMTRCA performance standards (see prior discussions in Section 5.4).

This alternative also includes installation and maintenance of surface water runon and runoff controls, groundwater and landfill gas monitoring, and institutional controls for Areas 1 and 2 and the Buffer Zone. Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site met State standards or other ARARs. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the perimeter of Areas 1 or 2. Landfill gas and groundwater monitoring as described in Sections 5.3.1.6 and 5.3.1.10, respectively, are also included as part of the 1,000 Partial Excavation Alternative.

Existing institutional controls would be maintained and enforced as previously described in Section 5.3.2.1 for the ROD-selected remedy to ensure that land and resource uses are consistent with permanent waste disposal. These institutional controls are necessary to ensure that residential uses do not occur at the landfill and that commercial and industrial uses or ancillary uses that could result in unacceptable risks do not occur on Areas 1 and 2 or the Buffer Zone. In addition to prohibiting land uses that could result in potential exposure to waste materials or contaminants at the Site, these institutional controls would also limit or prohibit land uses or activities that could disrupt the integrity, performance or longevity of the new landfill cover or other components of the remedy. Any modifications to the existing institutional controls or any additional controls that EPA may determine are necessary would be implemented as part of remedial design.

Long-term inspections and maintenance activities of the engineered components, similar to that described for the ROD-selected remedy (Section 5.3.1.10), and enforcement of the institutional controls (Section 5.3.2.1) would also be required.

6.2.7.1 Overall Protection of Human Health and the Environment

The 1,000 Partial Excavation Alternative would protect human health and the environment through (1) removal and off-site disposal of RIM above industrial use risk-based levels which also possess the highest activity levels found at the Site, and (2) engineered containment, long-term surveillance and maintenance, and institutional controls on land and resource use. The UMTRCA cover would reduce potential risks from exposure to external gamma radiation or radon gas emissions and eliminate potential risks associated with inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, and wind dispersal of fugitive dust.

The presence of an engineered cover would prevent users of the Site from exposure to external gamma radiation primarily through shielding and increasing the distance to the radiation source (i.e., the cover materials would be of sufficient thickness and design to attenuate gamma radiation). The depth of cover required for gamma radiation shielding is 3 feet. The total thickness of the final cover for the 1,000 Partial Excavation Alternative would be a minimum of 5 feet (2 feet of clay soil, 2 feet of biointrusion rock/rubble and drainage layer, and 1 foot of vegetative soil).

The cover materials would also be of sufficient thickness and design to retard or divert the vertical upward migration of radon. The engineered cover would act as a diffusion barrier, allowing time for the decay of the relatively short-lived radon-222 gas (the half-life for radon-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon is continually produced from the radium source, but need only be detained in the cover materials for a few days to decay to its non-radiological progeny, thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a landfill gas control system. Calculations presented in Appendix F indicate that a clay layer thickness of 2 feet, combined with a 2-foot-thick rock/rubble layer and a 1-foot-thick vegetative layer, would provide sufficient radon attenuation to meet the radon emissions ARAR of 20 pCi/m^2s. As discussed in Appendix F, these calculations were based on the increased levels of radium expected to be present at the Site after 1,000 years of ingrowth of radium from decay of thorium.

The potential for direct contact with waste materials is eliminated by partial removal of RIM and by placing a barrier (multi-layer landfill cover including biointrusion layer) between the remaining RIM/waste materials and any potential receptors. Likewise, there is no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place.

The multi-layer cover would also be designed to minimize infiltration of surface water through the wastes, thereby reducing the potential for leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier (e.g., a compacted clay layer meeting the specified permeability requirements). These are all conventional functions for landfill cover technologies and are widely used by government and industry to address similar circumstances where contaminated materials must be encapsulated to protect against future potential contact. Long-term maintenance of the cover and monitoring of the groundwater would ensure that the 1,000 Partial Excavation Alternative functions as intended.

Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site meets state standards or other ARARs. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2, would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls would ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions would reflect the presence of radionuclides at the Site.

6.2.7.2 Compliance with ARARs

Insofar as the 1,000 Partial Excavation Alternative includes excavation and off-site disposal of only a portion of the RIM, some RIM would remain on site. Therefore, regrading of the remaining solid wastes and installation of a new engineered cover over Areas 1 and 2 would need to meet the relevant and appropriate requirements of the UMTRCA performance standards as set forth in 40 CFR 192 Subpart A. Because the site would still contain solid wastes, the relevant and appropriate requirements of the Missouri solid waste rules for sanitary landfills, in particular the final closure standards for sanitary landfills, would also be relevant and appropriate to this alternative. Upon completion of RIM excavation, the remaining RIM and solid waste in Areas 1 and 2 would be regraded to achieve minimum 5% and maximum 25% slopes, and an engineered cover that would meet the performance standards of UMTRCA and also be consistent with the cover requirements for a solid waste landfill without a liner would be installed. Sections 6.2.3.2.1 and 6.2.3.2.2 contain full discussions of the MDNR solid waste regulations and the UMTRCA standards. The design of the landfill cover would meet these requirements.

The 1,000 Partial Excavation Alternative would also need to comply with the applicable or relevant and appropriate requirements of CERCLA Off-site Rule, WAC for Off-site Disposal, Off-site Transportation Requirements, NESHAPs, the Safe Drinking Water Act, NRC Standards for Protection Against Radiation, the Missouri Well Construction Code, and the Missouri Storm Water Regulations. Sections 6.2.3.2.2, 6.2.3.2.4 through 6.2.3.2.7, and 6.2.4.2.2 to 6.2.4.2.4 contain full discussions of these regulatory requirements. These requirements would be met or achieved using the same methods as previously described in Sections 6.2.4.2.3 through 6.2.4.2.8 with respect to the full excavation of RIM alternative.

6.2.7.3 Long-Term Effectiveness and Permanence

These criteria refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. The 1,000 Partial Excavation Alternative would reduce risk through removal of a portion of the RIM and provide engineered containment in conjunction with monitoring, maintenance, and land use control designed to be effective over the long term for the remaining RIM. Removal of a portion of the RIM, combined with installation of an engineered landfill cover, would essentially eliminate the potential for: gamma exposure, inhalation of radon gas or dust containing radionuclides or other constituents; dermal contact with impacted materials; incidental ingestion of soil containing radionuclides or other chemicals; and leaching of radionuclides or chemicals to the underlying groundwater. Maintaining the integrity of the engineered cover would protect the underlying RIM from erosion and intrusion. An UMTRCA-compliant cover would provide a reliable method to control exposure of the RIM to surface receptors and mitigate potential migration of the covered materials.

Long-term site management plans and institutional controls would be made as robust and durable as possible. Long-term groundwater monitoring would be effective in verifying a remedy is performing as required and groundwater is protected. The landfill cover would also passively prevent potential contaminant migration and human exposures for an indefinite period in the unlikely event of a loss of institutional controls.

By removing any contaminated soil from the Buffer Zone/Lot 2A2 to either Areas 1 or 2, the remedy would provide long-term effectiveness and permanence relative to the Buffer Zone/ Lot 2A2.

6.2.7.3.1 Magnitude of Residual Risk

The calculated lifetime risks following the exposure scenarios in the risk assessment after removal from Areas 1 and 2 of RIM with combined radium and/or combined thorium activities greater than 1,000 pCi/g, an engineered landfill cover has been installed, and the remainder of this remedial alternative has been implemented (Appendix H) are as follows:

- Area 1: 8.6×10^{-8} for year 1, 2.7×10^{-7} for year 1,000, and 4.9×10^{-7} for year 9,000.

- Area 2: 1.4×10^{-8} for year 1, 1.5×10^{-7} for year 1,000, and 3.7×10^{-7} for year 9,000.

These calculated risk levels are below EPA's target risk range of 1×10^{-6} to 1×10^{-4}, and the magnitude of residual risk in Areas 1 and 2 is acceptable. These calculated risk levels are attributable to gamma radiation and radon emissions from any radionuclide occurrences that would remain in Areas 1 and 2 after removal of RIM containing combined radium and/or combined thorium activities greater than 1,000 pCi/g and the new engineered cover had been installed, and are also reflective of access restrictions and institutional controls. They do not specifically include potential exposures from non-radiological landfill wastes after construction is complete; however, those wastes would also be covered by caps which would prevent exposures. Additional information regarding the risk assessment calculations is presented in Appendix H.

Direct contact with the remaining RIM under the engineered cover on Areas 1 and 2, and exposure by ingestion, inhalation, or dermal contact with such materials, is not expected to occur. These are the primary exposure pathways for any non-radiological COPCs which may be mixed with the RIM and landfill wastes that would remain in Areas 1 and 2 after partial excavation. Because no complete exposure pathway would exist for such materials after completion of the partial excavation and cap construction in Areas 1 and 2, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks.

After soils containing radionuclide concentrations above unrestricted use levels are removed from the Buffer Zone/Lot 2A2, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.7.3.2 Adequacy and Reliability of Controls

The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. Cover construction is based on and relies upon the use of natural materials that would be expected to remain in place and meet performance criteria for at least 200 years, as required by the UMTRCA performance standards. Post-closure inspection and maintenance of the cover – as required by the solid waste regulation ARARs, and as routinely performed at thousands of landfills across the country – also would ensure long-term reliability of the engineered cover.

The surfaces of Areas 1 and 2 are not currently graded to promote drainage of stormwater, but instead are generally flat with several surface depressions which act to increase precipitation accumulation and infiltration through the waste mass. In addition, no engineered landfill cover exists over these areas. Even with these limitations, infiltration of precipitation has not resulted in discernible leaching of radionuclides or other chemicals to groundwater. Removal of a portion of the RIM, regrading Areas 1 and 2 to promote drainage, and installation of the engineered landfill cover included as part of the 1,000 Partial Excavation Alternative would significantly reduce infiltration of precipitation and potential for leaching, thereby providing further protection against potential impacts to groundwater.

Long-term OM&M would include routine cover and stormwater ditch inspection and service to mitigate erosion, and OM&M of a landfill gas collection and treatment system if such a system is needed. Long-term monitoring would also be implemented to assess compliance with environmental performance standards. The performance of these engineering controls would also be re-evaluated during statutory 5-year reviews.

The current Covenants and Restrictions for Areas 1 and 2 would be adequate to provide protection to human health. The permanence of these restrictions is assumed to be adequate for the foreseeable future, as both EPA and MDNR approval are required to remove or modify the restrictions. The adequacy of the restrictions would be continually evaluated during the statutorily-required 5-year reviews.

6.2.7.3.3 Climate Changes and Potential Impacts of a Tornado

Because RIM and municipal solid waste would still remain in Areas 1 and 2 after the 1,000 Partial Excavation Alternative is implemented, a new engineered landfill cover would be installed over these areas. Because radionuclides above unrestricted use levels would remain in Areas 1 and 2, the engineered landfill cover that would be installed under this alternative would include the 2-foot-thick low permeability layer, 2-foot-thick rock/rubble biointrusion layer, and 1-foot-thick vegetative layer as previously described for the UMTRCA cover alternative (Sections 5.4 and 6.2.3). This engineered landfill cover would be classified as an in-situ containment system (EPA, 2014a).

Because of the similarity between the engineered landfill cover to be installed over Areas 1 and 2 under the 1,000 Partial Excavation Alternative with the landfill cover to be installed under the UMTRCA cover alternative, the analysis of the potential effects of climate change or impacts of a tornado are essentially the same for both alternatives. These effects were previously discussed in Section 6.2.3.3.3 for the UMTRCA cover alternative and therefore will not be fully repeated here. The results of those evaluations (as discussed in Section 6.2.3.3.3) with regard to the landfill cover system for the 1,000 Partial Excavation Alternative are summarized below.

As discussed in connection with the capping remedies, the vegetative layer of the UMTRCA cover to be installed under the 1,000 Partial Excavation Alternative could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health and vitality of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potential increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence. In addition, the design of the engineered cover may include a rock mulch in the upper portion of the vegetative layer in order to protect against soil erosion by wind or water in the event of loss of the vegetation.

The CCL and GCL layers could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low permeability materials (CCL or GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Such impacts are not considered to be significant because the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. In addition, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards and are projected to remain below these standards in the future (see prior discussion in Section 2.3.1 and also in RI Addendum Section 7.1.1.1). Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality or radon emissions are not expected to be significant. More importantly, the vegetative layer would show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL/GCL. Therefore, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities such as temporary irrigation to maintain the grass cover, overseeding with grasses that required less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Further, such impacts are not expected to result in the release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying biointrusion layer and potentially the low-permeability layer. The design of an UMTRCA cover is anticipated to include a rock mulch to reduce the potential for erosion of the vegetative layer and thus increase the longevity of the cover system. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot-thick rock layer in the base of the cover system, stormwater erosion—even under the most severe storm event—is not anticipated to result in erosion down through the entire landfill cover. Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including: erosion of drainage channels; damage to or bypassing of let-down and erosion control structures and features; or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs if any are needed. Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. However, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair and replacement of cover material in response to any damage that may occur.

The 1,000 Partial Excavation Alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, FEMA has determined that with the exception of the easternmost portions of Areas 1 and 2, which do not contain waste materials, Areas 1 and 2 are located outside of the 500-year floodplain. In addition, the areas to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park) that potentially could be subject to flooding by the Missouri River are protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park.

As previously discussed in Section 6.2.2.3.3 in connection with the ROD-selected remedy, an evaluation of potential impacts associated with a tornado was previously performed and submitted to EPA (EMSI, 2013f). Similar to the ROD-selected remedy, the 1,000 Partial Excavation Alternative is not vulnerable to impacts from a tornado. Specifically, a tornado is not expected to damage the vegetative layer of a cover system. Even if it did, such an impact is not considered to be significant because it could be easily identified and, due to the design and thickness of the engineered cover, would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy aboveground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the 1,000 Partial Excavation Alternative is not considered to be vulnerable to impacts from a tornado.

Although the 1,000 Partial Excavation Alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could be considered during remedial design to provide a degree of adaptation for climate change. For example, regrading of the surface of Areas 1 and 2 to a 2% slope instead of a 5% slope could be considered to reduce the velocity of runoff across the surface of Areas and 1 and 2 and thereby reduce erosion and soil loss potential under extreme precipitation events. Installation of a runoff collection and diversion system along the base of the above-grade portion of the North Quarry portion of the Bridgeton Landfill adjacent to Area 1, and along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2 could be included to divert runoff from these areas around Areas 1 and 2 and thereby reduce the potential for impacts from heavy precipitation events. Use of grass seed mixtures that are more tolerant of long-term changes in precipitation or temperature and/or soil addition to increase water storage capacity could be evaluated as part of the design. Similarly, inclusion of a geotextile at the base of the vegetative layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low permeability layer. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls to increase the overall resilience of these features to heavy precipitation events. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures should be included as part of the ongoing inspection and maintenance program.

6.2.7.3.4 Potential Impacts of a Subsurface Heating Event

Because radionuclides above unrestricted use levels would still remain at the Site under the 1,000 Partial Excavation Alternative, radionuclide-related impacts similar to those described in Section 6.2.2.3.4 for the ROD-selected remedy could potentially occur if an SSE or SSR were to occur in Areas 1 or 2. Specifically, a localized, temporary increase in radon emissions from the ground surface could occur.

In the event that a subsurface heating event were to occur in Area 1 or Area 2, such an event is not expected to impact the long-term effectiveness of this alternative. As discussed above, there would only be a temporary potential increase in radon emissions which are not expected to pose unacceptable risks. Destruction or modification of the waste material by increased temperatures could result in a reduction in volume, which could cause subsidence and/or differential settlement of the waste mass. Subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time, could result in displacement or disruption of an engineered cover system, thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

- Installation and operation of a heat extraction barrier or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system, followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions, after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2, the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills such as those located in the deeper quarry landfill, which provides a significant insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

6.2.7.3.5 Effects of an Isolation Barrier

Installation of a heat extraction barrier consisting of various heat extraction points would not have a significant impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability, or cost of the 1,000 Partial Excavation Alternative, regardless of barrier location. Installation of heat extraction wells could result in bringing RIM to the ground surface which, if not properly managed, could result in a potential for an airborne release. However, most drilling at the Site has been performed using Sonic drilling techniques that generate little to no cutting material, thereby reducing this potential risk. Installation of heat extraction wells after installation of a new cover system would require repair of the cover system around such penetrations which could lead to additional maintenance or further repairs in the future; however, such activities are routinely performed at solid waste landfills and are not expected to significantly impact the OM&M costs. Installation of a physical barrier, such as a vertical wall of inert material, would require excavation and regrading of the above-grade areas of the North Quarry portion of the Bridgeton Landfill wastes located over the southern portion of Area 1. If such a barrier were to be installed prior to implementation of the 1,000 Partial Excavation Alternative, portions of the barrier would need to be removed in conjunction with removal of RIM in the southwestern portion of Area 1. In addition, the design of the engineered cover included in this alternative would need to account for any changes in the surface grades, stormwater drainage system and the presence of any above-grade features (*e.g.*, heat extraction points, temperature monitoring probes, or additional gas extraction wells) that may be installed in conjunction with a barrier. In contrast, if a physical barrier were installed after RIM removal and construction of the engineered cover included in the 1,000 Partial Excavation Alternative, that portion of the engineered landfill cover that extended over the area of an isolation barrier and the associated revised landfill grades would need to be removed as part of the construction of an isolation barrier. The alignment of a potential isolation barrier may also need to be revised to reflect the removal of some of the RIM from the southwestern portion of Area 1, assuming it is designed before the RIM removal and regrading occurs.

6.2.7.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6 as part of the evaluation of long-term effectiveness of the ROD-selected remedy, a screening-level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

6.2.7.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. Although a portion of the RIM would be removed, the 1,000 Partial Excavation Alternative is overall a containment remedy, and therefore generally would not reduce the toxicity, mobility, or volume of the waste material through treatment.

As discussed in Section 4, radionuclides are naturally-occurring elements which cannot be neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout portions of the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. Consequently, ex-situ treatment techniques are considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix in portions of areas 1 and 2 make in-situ treatment techniques equally impracticable. The remedy for the Buffer Zone/Lot 2A2 also would not reduce toxicity, mobility, or volume through treatment because it consists of moving radiologically-impacted soil from the Buffer Zone/Lot 2A2 to Area 1 or 2, where it would either be shipped off-site for disposal or consolidated with the RIM in Areas 1 and 2.

An on-site technology that may potentially be applicable to this alternative is ex-situ physical separation of impacted soil from the solid wastes by using solids separation techniques such as hand picking for large bulky items and various fixed, vibrating, or rotating screens, among others (see prior discussion in Section 4.3.5.2). Physical separation would not decrease the mobility or toxicity of the radiologically-impacted materials, but has the potential to separate existing RIM from non-radiologically-impacted materials. As previously discussed, any solids separation techniques would need to be pilot tested at full-scale using materials from Areas 1 and 2 during remedial design to ascertain the potential effectiveness, implementability, and cost of this technology. Of particular interest in conducting pilot testing with material from Areas 1 and 2 would be obtaining an estimate of the degree of RIM volume reduction that could be achieved, assessing the moisture content of the filled material, determining the fraction of soil that would be contained in or adhered to the segregated refuse, and determining the residual levels of radioactivity that would be present in the non-soil refuse after screening out the soil fraction. Assuming that solids separation could prove to be an effective and implementable technology (that is, it could effectively separate the radiologically-impacted soil from the other landfilled waste materials such that the other landfilled wastes would contain radionuclide activities below the levels that would allow for unrestricted use), it has the potential to reduce the volume of radiologically-impacted material that would need to be transported to and disposed at an off-site disposal facility. However, little is known about the potential application of a soils separation technology to this situation, and it is possible that pilot testing could demonstrate that physical separation would not be effective at separating RIM from non-radiologically-impacted materials, in which case the non-radiologically-impacted materials would need to also be shipped off-site for disposal. At this stage of analysis, neither the estimated costs nor the estimated schedules for this FFS include any allowance for solids separation pilot testing or implementation.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off site and would be treated at the disposal facility in accordance with the hazardous waste regulations (*e.g.*, EPA's LDR program and UTS) and in accordance with the permits and standard operating procedures of the receiving facility. After arriving at an off-site disposal facility and undergoing a waste receipt analysis, RCRA soil/debris and RCRA soil/debris with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on its physical characteristics, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste and radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies, but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

Section 6.2.3.4 contains a full discussion of the procedures, protocols and concerns associated with the off-site shipment of hazardous wastes or mixed wastes.

6.2.7.5 Short-Term Effectiveness

This alternative poses significant potential short-term risks, as described below. During a public meeting held as part of the ROD-selected remedy selection process, EPA identified and discussed the following short-term risk issues for waste excavation: waste handling, sorting, and stockpiling; water management; noise, odor and windblown trash; worker health and safety (PPE, gamma exposure, physical stress, physical hazards, workplace monitoring); contaminant migration/spreading (fugitive dust and airborne migration, fugitive dust control and water application, leachate generation, equipment decontamination water, and water from open excavations); and waste hauling and transportation issues/truck decontamination (transfer facilities, increased local traffic, waste handling on public roads, interstate transport by rail, DOT requirements, safety issues).

6.2.7.5.1 Protection of the Community During Remedial Actions

The projected carcinogenic risks that may be posed to off-site residents by this alternative are estimated to be 2.5×10^{-6} (see Appendix H). No non-carcinogenic risks are expected to occur.

The risk assessment (Appendix H) includes an estimate of the projected incidence of transportation accidents associated with each FFS alternative. For the 1,000 Partial Excavation Alternative, the projected incidence of transportation accidents associated with shipping of RIM for off-site disposal and importing of materials for construction of the multi-layer landfill cover is 16.2, meaning that approximately 16 transportation-related accidents are projected to occur if this alternative were implemented. The risk of an increased number of transportation-related accidents is associated with the transport of excavated RIM from the Site, and in particular: (1)

transport from the Site to the rail transloading facility; (2) hauling by rail of the RIM to the disposal site; (3) transport of the RIM from the destination rail offloading facility to the disposal site; and (4) truck traffic associated with delivery of construction materials to be used for construction of the new engineered landfill cover on Areas 1 and 2.

Disturbing the waste material may expose the community to radioactive waste, methane and radon gas, dust, and particulates. Excavation of existing waste materials would also undoubtedly result in undesirable odor emissions during the period of time that existing wastes may be handled or exposed. Mitigation of odors through engineering means is limited.

The 1,000 Partial Excavation Alternative would contribute significant carbon dioxide equivalent emissions to the atmosphere due to ongoing vehicle operations associated with remedial work. In particular, approximately 48,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere as a result of the excavation, loading, and transport of the RIM to an off-site disposal facility, landfill regrading and cover construction work in Areas 1 and 2, and the importation of materials used to construct the multi-layer landfill cover for Areas 1 and 2 (Appendix I, Table I-6).

Because RIM in Areas 1 and 2 would be excavated under this alternative, overburden would be stockpiled and stored, and RIM would be staged and loaded for off-site disposal. Under this alternative, a large volume of waste material (approximately 1.13 million loose cubic yards) would need to be handled. This include a large part of the above-grade material in the North Quarry portion of the Bridgeton Landfill, which is relatively younger, and therefore less decomposed waste. During these activities, the nuisance attraction to and congregation by birds at and above the affected areas could be problematic unless effectively controlled. The long duration of the construction activities associated with this alternative (see Section 6.2.7.5.6 below) increases the potential for attraction of birds. The main concern would be the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport. For the 1,000 Partial Excavation Alternative, an enclosed waste staging and loading structure would be constructed to minimize the outdoor handling of waste and associated attraction of birds or other vectors. Additional mitigation measures such as excavation best management practices, which include application of daily soil cover and/or placement of tarps over areas of exposed waste, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, could be implemented to minimize bird attraction to and congregation at and above the disturbed areas.

Excavation of waste materials from Areas 1 and 2 would require removal of the existing landfill cover and overburden from Areas 1 and 2 and portions of adjacent areas of OU-2. Excavation of overburden and RIM would create depressions in the landfill area during the period of time required to remove the RIM and regrade and cover the remaining landfill wastes. Precipitation that falls on the Site while such depressions are open would potentially flow into and accumulate in the depressions. Any accumulation of precipitation in depressions created during waste excavation could result in increased infiltration of precipitation runoff through the underlying waste materials, which could result in increased leaching of VOCs or other soluble contaminants from the waste materials. Such leaching potentially could contaminate the underlying groundwater if not adequately controlled.

This alternative could be adversely impacted by severe weather impacts. Due to the extended duration required for implementation of this alternative, the potential exists for one or more severe weather events to occur during implementation of this partial excavation alternative. Such an event(s) could directly delay excavation work, and also indirectly if such an event results in diversion of resources (*e.g.*, equipment) from waste excavation activities to mitigation of impacts of a severe weather event. Severe weather events could potentially greatly increase the volume of contact stormwater that would need to be contained and managed which may further limit waste excavation activities and increase the amount of time required to implement this alternative. In addition, severe weather events could increase the potential for loss of stormwater containment through failure of best management practices for controlling stormwater impacts. Such failures could include soil/waste scouring and suspended phase transport resulting in an increased potential for release and offsite transport of stormwater that has been in contact with waste material or soil containing radionuclides.

Because Areas 1 and 2 would be excavated and RIM loaded into transport containers, stormwater controls would be implemented in accordance with the Missouri Storm Water regulations 10 CSR 20-6.200 to protect the community. During construction, consideration would be given to minimizing the areas of excavation that would be open and exposed to waste materials at any given time. Temporary diversion berms using daily cover material would also be constructed above the open excavation areas on the previously excavated (and temporarily covered) surface of any excavation depressions in order to divert precipitation runoff around the open excavation to prevent the runoff from contacting uncovered waste materials. Precipitation that contacts uncovered waste materials would flow into the low point of the excavation and be pumped out into temporary storage tanks using portable gas-driven pumps. Samples from each tank would be collected and sent to a laboratory for analysis. The stored water would be either directly discharged or treated and disposed appropriately based on the analytical results.

6.2.7.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.5.2 as part of the evaluation of short-term impacts associated with the ROD-selected remedy, a screening-level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.7.5.3 Protection of Workers During Remedial Actions

The 1,000 Partial Excavation Alternative would entail significant excavation, handling, loading and transport of RIM at the Site and therefore would pose both significantly increased radiological exposure risks as well as construction safety risks to on-site workers.

Workers involved in excavation and regrading of the RIM would be subject to potential short-term risks, including: exposure of workers to contaminated waste; excavation/trenching instability; stormwater runoff entering areas where waste is exposed, resulting in the exposure of workers to contact stormwater; and odor emissions or other aesthetic issues arising from exposed waste. Worker exposures would be addressed through development and implementation of a site safety plan, use of personal protective equipment, and performance of personnel and environmental monitoring during implementation of remedial action. Workers would be protected during construction by adhering to OSHA practices; however, as this alternative entails extensive excavation, handling, and transportation of radiologically-impacted materials, OSHA work practices and personal protective equipment may not provide full protection against exposure to external gamma radiation.

The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the 1,000 Partial Excavation Alternative, the projected incidence of industrial accidents is 15.6 over the life of the project. The projected carcinogenic risk to the reasonably maximally exposed individual, a radiation technician, is 1.06×10^{-2}, which exceeds EPA's generally accepted risk range of 10^{-4} to 10^{-6}. The projected hazard index for worker exposures to chemicals is 27.2. The projected radiation dose to a remediation worker is 13,400 mrem/yr (Appendix H).

Excavation would necessarily entail disturbance of the overburden soil and underlying waste materials by construction workers and equipment. Dust control measures would be required in order to limit worker exposure to fugitive dust during construction.

Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers including the projected non-carcinogenic risks identified above. Protective clothing alone would not reduce the carcinogenic risk or projected radiation dose these risks result from exposure to gamma radiation. The only way to address these risks is to limit the amount of time (exposure duration and frequency) that workers are exposed to gamma radiation. This could be done by measuring and tracking worker exposures and shifting workers to other tasks with less potential for gamma exposure to reduce the overall level of exposure to radiation. However, even this option may not be sufficient for workers involved with RIM sorting and handling prior to loading. For example, it is anticipated that the disposal facility would provide qualified individuals to supervise loading of RIM into transport containers to ensure that each container meets the WAC for the disposal facility. The disposal facility may not be able to provide sufficient workers to allow for substitution to minimize gamma exposures. Implementation of the remedial action would not be performed in a manner that would result in an unacceptable risk to any worker or anyone else. However, managing worker exposures, especially for those involved in the RIM sorting and loading operations, who are expected to be the maximally exposed individuals, could present challenges for implementation of this alternative and therefore represents a short-term risk for this alternative.

6.2.7.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from the 1,000 Partial Excavation Alternative. As noted in the BRA (Auxier, 2000) and the updated BRA (Auxier, 2016a), some of the ecosystems present at the Site are the result of existing institutional controls and other limitations on land use within or adjacent to OU-1 that have allowed field succession to take place. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Excavation of RIM, regrading of Areas 1 and 2, and construction of the engineered landfill cover under the 1,000 Partial Excavation Alternative would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the Site would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.7.5.5 Ability to Monitor Effectiveness

Measurement of gamma radiation and radon flux through the newly constructed landfill cover would be conducted on Areas 1 and 2 after construction is complete. Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2. Measurements of subsurface occurrences of landfill gas and radon levels would be conducted along the property boundaries adjacent to Areas 1 and 2 to verify that off-site gas migration above regulatory thresholds does not occur.

6.2.7.5.6 Time Until Remedial Action Objectives Are Achieved

The RAOs of (1) preventing direct contact with contaminated media; (2) preventing exposure by inhalation and external radiation; (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; and (5) controlling radon and landfill gas emissions from Areas 1 and 2 would be met once construction of the new engineered landfill cover over Areas 1 and 2 is completed. The RAO related to the Lot 2A2 Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas.

Initiation of this alternative would require significant planning and permitting due to the limited number of off-site disposal facilities capable of taking this material and the extensive logistics associated with identifying, handling, classifying and loading the materials for transport to the selected off-site facility. Preparation of the remedial design should be completed within approximately 15 months of authorization to proceed with the RD. RD could take significantly longer if full-scale pilot testing of solids separation equipment was to be performed. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 7 years after approval of the RD. Therefore, the remedial action objectives should be achieved within 8.3 years of approval to proceed with the RD (Appendix J). This schedule estimate assumes that the buyout of the asphalt company lease and relocation of the solid waste transfer station occurs during the remedial design phase. Otherwise, the schedule would be longer.

The projected construction schedule and the cost estimate for the 1,000 Partial Excavation Alternative are highly dependent on the waste material swell factor; that is, the amount the in-place waste volume expands as it is excavated, handled and loaded for transport to an off-site disposal facility. For purposes of this FFS, a swell factor of 1.5 has been assumed. A swell factor greater than 1.5 would result in an increase to the overall construction schedule and the estimated costs. The projected construction schedule and the cost estimate for the 1,000 Partial Excavation Alternative also are highly dependent on the number of rail cars that could be loaded and shipped per day. The schedule and cost estimate developed in this FFS for this alternative assume that a sufficient number of IM containers and rail cars can be made available, loaded, switched out, and replaced every day. If the actual rate is less than the projected rates of RIM excavation used to develop the construction schedule, the time required to complete construction and consequently the costs for the 1,000 Partial Excavation Alternative would increase.

6.2.7.6 Implementability

The 1,000 Partial Excavation Alternative would involve excavation and off-site disposal of a portion of the RIM in Areas 1 and 2, repair and restoration of the disturbed portions of the OU-2 landfill units adjacent to Areas 1 and 2, surface grading and installation of upgraded landfill covers over Areas 1 and 2, long-term monitoring and maintenance of the covers, and long-term monitoring of landfill gas and groundwater and surface water quality.

Excavation of RIM would require removal of substantial amounts of overburden and material from the sidewalls of the excavations in order to maintain stability of the excavation areas. Overburden removal would entail removing and temporarily relocating part of the above-grade areas of the North Quarry portion of the Bridgeton Landfill to access the underlying RIM in Area 1 of OU-1. This would require modification and later restoration of the leachate and gas control systems associated with the Bridgeton Landfill, and the excavation will present the risk of oxygen intrusion into the Bridgeton Landfill. The total amount of non-RIM waste required to be removed under this alternative is estimated to be 645,000 bcy, which—based on addition of 10% for daily cover and an expansion factor of 1.5—would result in the need to handle, stockpile, and replace approximately 2,730,000 lcy of waste. Management of exposed waste in both the excavation areas and the stockpiles, including management of stockpiles, stormwater runon and runoff, odor emissions, attraction to birds and other vectors, and litter control would be a significant undertaking, especially taking into consideration the relatively new age of the North Quarry waste. The amount of space available for stockpiling the overburden material is limited, and therefore overburden material from Area 1 would likely need to be transported to Area 2 while waiting for final placement and capping. Similarly, the total volume of RIM that would be excavated under this alternative is estimated to be 38,700 bcy, which with the addition of daily cover and expansion is equivalent to 63,900 lcy. Accounting for the excavation and handling of overburden, side slope cut material, and RIM, a total of approximately 1.13 million cubic yards of waste would be handled (not counting double handling of overburden) under this alternative.

An additional complication arises from the proximity of the Bridgeton Transfer Station. In order to access the RIM in the southwest portion of Area 1, the solid waste transfer station would need to be relocated, as removal of waste material would extend up to and along the base of the transfer station such that the integrity of the transfer station building foundation and above-grade structure would be compromised. The only available space for relocation of the solid waste transfer station is the area currently occupied by Simpson Asphalt Company, which holds a long-term (99-year) lease on this area. This lease would have to be bought out and the asphalt company would need to be relocated before the solid waste transfer station could be relocated to this area.

It is anticipated that a new structure would be constructed to shelter the RIM staging and loading operations to minimize stormwater contact, odor emissions, and bird attraction. It is anticipated that such a structure would be constructed along the north side of the Site access road in the area that is currently being used to store new, reclaimed, and surplus equipment and materials associated with ongoing operation and maintenance and closure activities for the Bridgeton Landfill. These materials would need to be relocated to another portion of the Site prior to construction of such a structure.

In order to minimize potential vehicle interactions between normal traffic to and from the solid waste transfer station and the construction operations associated with this alternative, a temporary overpass would likely need to be constructed over the Site access road to allow for uninterrupted movement of construction traffic between Areas 1 and 2. An overpass is considered the most efficient and safest means for transfer of overburden waste from Area 1 to stockpile locations in Area 2 and then back to Area 1. In addition, as discussed above, a single RIM staging and loading building would be constructed and operated as part of this alternative. RIM removed from Area 1 would need to be transferred over the Site access road. Installation of an overpass would eliminate the potential for RIM to be tracked across the Site access road and potentially tracked off site.

While excavation with subsequent off-site transportation and disposal have been implemented at other sites containing radioactively-impacted materials, materials from these other sites have not included significant amounts of landfill solid wastes. Significant technical and administrative implementability issues are associated with excavating the RIM and loading it into IM containers for transportation if this alternative was to be implemented. These include the following:

- Reduced excavation production rates and increased volume of RIM subject to excavation resulting from application of daily cover over an extended excavation schedule;

- Ability to locate and obtain a lease to an off-site rail spur for use as a truck-to-rail transfer facility, or alternatively the ability to construct an on-site rail spur and rail loading facility;

- Increased potential for bird strikes to aircraft as a result of excavation of putrescible or organic solid waste overburden waste from the North Quarry portion of the Bridgeton Landfill and Areas 1 and 2, as well as excavation of RIM contaminated waste from Areas 1 and 2, all of which are located within flight paths of Lambert–St. Louis International Airport; and

- Impacts to other Site operations and traffic on surrounding roads from additional truck traffic used to haul wastes to an off-site truck-to-rail transfer facility and to haul earthen materials to the Site for daily cover, stockpile covers, and construction of the final cover.

Design and construction of post-RIM-excavation landfill covers over Areas 1 and 2, with subsequent monitoring and maintenance, are not expected to pose any implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 after RIM removal are available. These technologies have been proven through application at other landfills. Design and construction of landfill covers post RIM removal over Areas 1 and 2 are not expected to pose any significant implementability challenges.

The actions included for the Buffer Zone/Lot 2A2—that is, testing and excavation of surface soil—are regularly and easily implementable.

Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of the engineered landfill cover that would be placed over Areas 1 and 2. These methods are easily implemented.

6.2.7.6.1 Ability to Construct and Operate the Technology

In general, excavation and off-site disposal are standard technologies. However, there are unique circumstances associated with excavation of RIM in Areas 1 and 2, located as they are within a larger closed/inactive landfill site, which would complicate implementation of standard excavation technologies.

RIM excavation and placement in IM containers and hauling of the containers by truck for subsequent transfer to rail is also expected to present implementability concerns, challenges, and risks, specifically those associated with the following:

- Excavation and handling of contaminated materials;

- Safety risks associated with encountering methane gas during excavation;

- Safety risks associated with the potential of oxygen intrusion into the exposed younger waste mass of the Bridgeton Landfill;
- Management of fugitive dust and potential odors;
- Mitigation of bird hazards;
- Management and treatment of stormwater exposed to RIM during excavation; and
- Identifying, segregating, and disposing off-site any hazardous wastes, PCBs, or RACM that may be encountered during RIM excavation.

If hazardous wastes, PCBs, or RACM are encountered during excavation of RIM, these materials would need to be segregated from the other waste materials, characterized, and transported to an off-site disposal facility in containers separate from the other RIM. Additional health and safety procedures would be required during excavation of these materials. These materials would require separate handling at the off-site disposal facility and could require treatment prior to disposal. Depending on the characteristics of any hazardous waste encountered during excavation, the hazardous waste could need to be transported to a different off-site facility for treatment and disposal in accordance with RCRA.

Directing and controlling the RIM excavation process using radiological scanning and sampling techniques would significantly impact overburden and RIM excavation production rates. Based on experience in excavation of radiologically-impacted waste at other sites, a reduction in efficiency is expected for overburden excavation and a greater reduction is expected for RIM excavation. Because thorium-230 cannot be detected using field survey instruments, excavation activities would have to rely on collection and laboratory analyses of samples for guidance. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities, as well as initial confirmation that all of the RIM had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that all RIM has been removed from a particular area would also be subjected to off-site laboratory analyses and data validation.

While potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses, as well as by moving excavation activities to other areas while waiting on the results of verification of confirmation sample analyses. However, even with these measures it is likely that some short-term delays to the construction work on the order of hours to days will likely occur due to waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedule developed for this alternative.

Daily soil cover and tarps would need to be placed over open excavation areas and stockpiled overburden to minimize dust, odor, and the attraction of birds and other wildlife. The proximity of Areas 1 and 2 to Lambert-St. Louis International Airport poses a potential risk to aviation operations. The St. Louis Airport Authority and the U.S. Department of Agriculture have identified as a problem the potential for increased bird activity in conjunction with waste excavation at the Site and the resultant increased risk of aviation bird strikes. Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed overburden and wastes), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be evaluated for use at Areas 1 and 2. The size of open excavations may limit the constructability of wire or monofilament grids. Careful evaluation of material properties would be necessary during remedial design to assure that the appropriate strength and elasticity of materials are considered, that the materials are available, and that grids can be reasonably constructed.

Effective stormwater controls could be readily implemented using conventional construction equipment and materials. Temporary berms to direct stormwater away from open excavations would need to be constructed and precipitation accumulation in depressions created by the excavation activities would need to be pumped out and managed. Direct precipitation or runoff that may contact waste material could become contaminated with soils or wastes containing thorium or radium. These elements would be entrained in colloidal material that would readily settle in low areas or in the tanks used to collect and store stormwater prior to treatment and discharge. At the end of excavation activities, after all RIM above cleanup levels would have been removed, accumulated sediment in any low areas or the tanks would also be removed and, depending upon activity levels, either placed in Area 1 or 2 or transported to the off-site disposal facility.

Excavated RIM exposed to precipitation would be subject to the PFLT as necessary to determine if free liquids exist prior to being loaded for off-site disposal. If the excavated material to be hauled off-site does not pass the PFLT, a dewatering area would need to be staged and collected water treated and/or disposed, potentially through off-site disposal. The current costs and schedules do not address any dewatering activities. Should such activities be necessary, a suitable area would have to be identified within the Site.

Truck hauling of IM containers of RIM to a truck-to-rail transloading facility and transferring the RIM to railcars is technically implementable. Loading RIM directly into railcars on-site if a rail spur could be extended onto the West Lake Landfill Site is theoretically implementable. However, it is not known whether extension of a spur onto the property is actually feasible. If construction of an on-site rail spur were to be considered, an engineering study and development of a detailed design would be necessary to determine the feasibility and implementability. As discussed in detail in Sections 6.2.4.6.5 and 6.2.4.6.6 above, construction of an on-site rail spur would also require coordination with a number of local and state regulatory authorities, as well as private landowners.

An initial comparison of the US Ecology Grand View facility WAC to estimated activity levels in the OU-1 RIM under the 1,000 Partial Excavation Alternative is presented on Table 6-4. Although a representative of the turnkey contractor would be on-site during RIM excavation to coordinate loading of containers, there is a potential that one or more shipping containers could contain activity levels that exceed the WAC and may have to be unloaded and re-distributed prior to shipment or, in even returned to the Site by the disposal facility and/or sent to a different disposal facility. These additional activities could result in additional worker exposures, additional time to complete the project, and potentially additional costs.

Regrading the landfill surface and placement of final cover is implementable and has been performed at other landfills, including CERCLA sites. Environmental monitoring is routinely performed at most sites and is not expected to present any feasibility challenges.

6.2.7.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material has been performed at facilities and is generally a reliable technology. It should be noted, however, that none of these sites involved such large-scale excavations of radiological materials commingled with municipal solid waste and disposed in a landfill setting included under this alternative. The reliability associated with disposal in an off-site facility would be dependent on the integrity of the liner and cover systems at the off-site facility being maintained, as well as the effectiveness of the various off-site facility monitoring programs.

Landfill cover systems such as those that would be implemented over Areas 1 and 2 after partial removal of RIM, and which are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance, have been demonstrated to be reliable at: (1) minimizing percolation and infiltration of precipitation; (2) minimizing leachate generation; (3) minimizing impacts to groundwater quality; (4) minimizing impacts to surface water quality and quantity; (5) minimizing erosion of cover material; and (6) minimizing uncontrolled releases of landfill gas. Landfill cover systems have been demonstrated to be reliable methods for isolating waste materials. Similarly, access restriction measures have been demonstrated to be reliable mechanisms to prevent unauthorized access to a site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed RIM and waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated reliable technologies under proper operating and excavating conditions. While visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness in not assured. In addition, the FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are well-established technologies that are implemented at most landfill sites. For this alternative, gravity settling of suspended solids potentially containing radionuclides is a well-established and reliable technology.

6.2.7.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

Because all of the RIM would not be removed during implementation of this partial excavation alternative, it is possible that EPA could later require removal of additional RIM. If such a decision were to occur after construction completion of this alternative, performance of any such additional remedial action in the future would be very difficult and costly. Such actions would require removal of the newly constructed engineered landfill cover and re-excavation of materials previously removed and replaced as part of this partial excavation alternative.

The only other potential additional remedial actions that may need to be taken for the 1,000 Partial Excavation Alternative would be maintenance activities to sustain the cover system, repair areas of differential settlement or erosion, or possible implementation of a contingent landfill gas control system. Regrading and contouring the existing waste materials to achieve final grades would require re-compaction of the regraded waste materials in order to minimize the potential for compaction or differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill cover may result in differential compaction of the waste materials, depending on the nature, age, and amount of prior degradation of those materials. Runoff of stormwater can result in formation of erosional rills. Depressions caused by differential settlement of the wastes or erosional features can easily be (and commonly are) addressed at landfill sites through placement of additional soil material to fill such features.

Under this alternative, part of the landfill gas system currently being operated in the North Quarry portion of the Bridgeton Landfill would likely have to be removed in conjunction with the waste excavation activities and replaced after completion of the excavation and regarding activities. In the event that monitoring of subsurface landfill gas and radon detects the presence of gas levels above regulatory thresholds along the perimeter of the landfill, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system, and/or possible use of a carbon adsorption system to remove radon from the extracted gas stream. Installation of a contingent gas system can easily be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund site solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would be straightforward, primarily entailing placement of additional fill, regrading, and revegetation of the repaired area.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarps), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated to be readily implementable at landfill sites.

Stormwater management measures other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures are not anticipated.

6.2.7.6.4 Ability to Monitor Effectiveness of Remedy

Demonstrating the effectiveness of the cover systems constructed over Areas 1 and 2 after partial excavation of RIM would be accomplished by implementing monitoring programs for the cover surface, landfill gas system, groundwater and surface water programs as previously described in Section 5.4.6. These types of monitoring programs are easily implemented and have been proven to be successful at demonstrating cover effectiveness in landfill settings.

6.2.7.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the 1,000 Partial Excavation Alternative would require approvals from other agencies, including the following:

- Approval from the FAA to conduct waste excavation activities within 10,000 feet of an active airport runway. FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, "Hazardous Wildlife Attractants On or Near Airports," recommends "against locating a MSWLF [municipal solid waste landfill] within the separation distances identified in Sections 1-2 through 1-4. The separation distances should be measured from the closest point of the airport's AOA [airport operations area] to the closest planned MSWLF cell." AC 150/5200-33B, p. 4. The separation distances referenced are 5,000 feet from the end of a runway for airports serving piston-powered (propeller) aircraft; 10,000 feet for airports serving turbine-powered (jet) aircraft; and 5 miles of protection from hazardous wildlife movement for approach, departure and circling airspace. The FAA strongly recommends against allowing a waste disposal operation within 10,000 feet of a jet aircraft runway if the material contains putrescible waste and so has the potential to attract wildlife that could threaten air traffic. The excavation of RIM material containing putrescible waste within 10,000 feet of the westernmost runway (11/29, formerly known as 12W/30W) at Lambert-St. Louis International Airport, as would occur during excavation of the RIM in Areas 1 and 2, is limited by the need to mitigate potential bird activity during excavation to address the requirements of the FAA Advisory Circular and to comply with the same prohibitions in the Missouri solid waste regulations. It may be necessary to work directly with the FAA and MDNR to identify specific bird mitigation measures during implementation.

- Approval of St. Louis Airport Authority (STLAA) relative to obtaining a release for the Negative Easement and Declaration of Restrictive Covenants Agreement. Excavation of RIM from Areas 1 and 2 poses a potential to increase the bird populations at the Site if mitigation procedures are not employed or prove ineffective. An increase in bird populations presents a greater potential for aircraft bird strikes. The STLAA and USDA have identified this as a concern relative to construction and operation of a new on-site disposal cell that was included in the full excavation of RIM with on-site disposal alternative evaluated in the SFS. Based on the STLAA's position stated in the STLAA's September 20, 2010 letter to EPA, STLAA acceptance of RIM waste excavation would not be likely if bird activity were to increase. It may be necessary to work directly with the FAA and the STLAA to address these concerns, either by amending the FAA ROD, amending the Negative Easement, requiring specific bird mitigation measures during implementation, or making other changes to secure STLAA's cooperation. By letters dated August 11, 2014 and August 11, 2017 (Appendix A), the Airport again submitted comments to EPA, emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives.

- Location of an off-site truck-to-rail loading facility. At the discussion held in September 2010, the STLAA indicated that they would not allow the use of the existing SLAPS truck-to-rail transloading facility for loading waste from the West Lake Landfill into railcars. The SLAPS rail spur is reportedly owned by the U.S. Army Corps of Engineers and the land upon which the rail spur is built is owned by the City of St. Louis. It is not clear that the STLAA could prevent use of the SLAPS rail spur for loading and shipping via contractual means. However, as the STLAA is the owner of the property, their concurrence must be considered. No other nearby off-site truck-to-rail loading facilities have been identified.

- Compliance with EPA's Off-Site Rule. The EPA Region where the off-site disposal facility is located would need to be contacted every 60 days during the period of off-site waste shipments to obtain a compliance determination as to whether the disposal facility currently meets the criteria under the OSR to accept CERCLA waste. If, during RIM excavation, the contracted off-site disposal facility was to be out of compliance for a period of time, excavation and transportation would need to cease until the facility becomes compliant or RIM would need to be transported to another facility that is determined to be in compliance with the OSR. Besides schedule delays, temporary stoppage of construction would present significant technical implementability concerns regarding open excavation areas.

- Rocky Mountain Low Level Radioactive Waste Compact Consent. If RIM were to be disposed at the Clean Harbors Deer Trail, CO facility, an application would have to be submitted to and accepted by the Rocky Mountain Low Level Radioactive Waste Compact. Disposal at the US Ecology Grand View, ID, US Ecology Wayne, MI, and Energy*Solutions* Clive, UT facilities would not be subject to a Waste Compact consent.

6.2.7.6.6 Coordination with Other Agencies

Although not all would be considered “agencies,” coordination with many entities would be necessary to implement the 1,000 Partial Excavation Alternative. Coordination with the landfill owner and operator and the owners or occupants of the various parcels that comprise the West Lake Landfill Site would be necessary because of the following:

- Termination of the asphalt company lease and removal of the asphalt plant followed by relocation of the Bridgeton solid waste transfer facility and construction of an overpass between Areas 1 and 2 over the Site access road would need to occur prior to the start of RIM excavation;

- Access to operations conducted on other portions the Site would need to be maintained.

- Areas 1 and 2 are within a larger existing landfill footprint, and use of areas on the West Lake Landfill Site outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction.

- Implementation of this alternative would require excavation of portions of landfill units located outside of OU-1. Upon completion of removal of the RIM, disturbed portions of the adjacent landfill units would need to be repaired and restored, and regrading and installation of a replacement landfill cover over areas outside of OU-1 would need to be performed. Coordination would also be required relative to integration of the slopes and grading for adjacent landfill areas, as well as the routing and design of stormwater diversion and conveyance structures between OU-1 and other landfill areas.

- Use of other areas of the West Lake Landfill Site that may be necessary for stockpiling of overburden and staging or routing of trucks or rail cars used to haul the excavated RIM off site.

For the duration of excavation, off-site transport, and importation of cover materials, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the current on-site solid waste transfer station and other Site tenants.

If a truck-to-rail transloading facility at an off-site rail spur location were to be used, a suitable location would need to be identified and a lease secured with the land/rail spur owner for the duration of the RIM loading and transport operations. As noted above, it does not appear that the existing SLAPS truck-to-rail transloading facility would be available, so costs for establishing a new facility would need to be considered[75].

If a rail spur were to be extended onto the West Lake Landfill Site:

- Land located across St. Charles Rock Road would either need to be purchased or long-term leases would be needed with landowners;
- State and local government, private landowner, facility occupant, and community approval to construct a rail spur across private property located to the east of St. Charles Rock Road, across St. Charles Rock Road, and along the access roads which serve the existing solid waste transfer station and asphalt plant operations located at the Site would need to be obtained;
- Appropriate safety measures for the crossing at St. Charles Rock Road would have to be installed, consistent with requirements of state and local governments;
- The long-term lease of the asphalt plant for land south of the solid waste transfer station would need to be bought out or otherwise acquired; and
- Because of the high traffic volume on St. Charles Rock Road during the day, dropping off empty and picking up loaded railcars would likely be possible only during late nighttime and early morning hours.

Provision of and switching of gondola railcars either at a truck-to-rail transloading facility spur or an on-site rail spur would need to be coordinated with the railroad company that would be hauling the railcars to the off-site disposal facility.

Future groundwater monitoring activities could require obtaining and maintaining access to off-site properties if off-site groundwater monitoring is required as part of the remedy.

The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a major concern of the FAA and St. Louis Airport Authority. The effectiveness of proposed bird nuisance mitigation measures would be of interest to the FAA and Airport Authority. Consequently, the FAA and Airport Authority would need to be involved in the remedial planning process.

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[75] The unit cost estimates provided by US Ecology for purposes of this FFS include costs to secure an off-site rail spur for a truck-to-rail transloading facility.

Coordination with other agencies including the Earth City Flood Control District, MSD, and MDOT, as well as the adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities both during and after completion of construction;

- Coordinate with MSD regarding permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from AAA Trailer for testing and, if necessary, remediation of the Crossroads Property and possibly for implementation of remedial actions that may need to be performed along the property boundary (e.g., regrading, fencing, etc. in Area 2).

As discussed at the beginning of this section (6.2.6.6), in order to access RIM in Area 1, the Bridgeton Transfer Station would need to be relocated. The only suitable area for relocation of the solid waste transfer station is the area currently under lease and occupied by Simpson Asphalt Company. The asphalt company lease would need to be bought out and their equipment removed from the Site before the transfer station could be relocated. Relocation of the transfer station would normally be subject to permitting by the City of Bridgeton and St. Louis County. However, because relocation of the transfer station would be performed as part of a Superfund remedial action and the transfer station would remain on site, additional permitting is not anticipated to be required. However, it is likely that public meetings and hearings may be necessary, which would require coordination with the City of Bridgeton and St. Louis County and could impact the timing for the start of construction of a 1,000 Partial Excavation Alternative.

6.2.7.6.7 Availability of Off-site Treatment, Storage and Disposal Services and Capacity

As discussed in Section 4.3.5.4., four off-site disposal facilities that could accept excavated RIM from the West Lake Landfill OU-1 have been identified. At least three of these facilities (located in Idaho, Utah, and Colorado) have accepted radiologically-impacted soil from projects or sites in the United States, although none of them have previously accepted radiologically-impacted materials mixed with solid waste. All four of the identified facilities have available capacity to accept the estimated volume of RIM from the Site. The volumetric rate of acceptance for all facilities would be limited by the number of IM containers and railcars that could be provided and loaded at or near the Site, as well as the number that could be unloaded at or near the disposal facility. Off-site treatment, storage, and disposal may be required if hazardous wastes or regulated asbestos-containing materials (RACM) are encountered in the overburden or RIM excavated from Areas 1 and 2.

The identified facilities are also permitted to: (1) accept liquid wastes, should any stormwater that may accumulate in excavations during RIM excavation become contaminated and require disposal off-site; (2) accept mixed wastes if mixed wastes are encountered during excavation; and (3) treat soil and/or debris that contains hazardous waste or mixed waste.

As discussed in Section 3.1.4.1, the CERCLA OSR requires that waste materials removed from a CERCLA site only be placed in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during remedial design and would need to be regularly evaluated and updated during remedy implementation.

Offsite treatment and discharge of any leachate that may be encountered or stormwater that may contact waste materials during the landfill re-contouring activities could also be required. Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater. Initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.7.6.8 Availability of Necessary Equipment and Specialists

Materials, equipment and personnel required for excavation and transport of RIM to an off-site disposal facility are readily available. Trained health physics technicians and specialized equipment required to monitor personnel, monitor environmental conditions, and assist in directing the RIM excavation sequencing are also available.

As discussed above, there are a limited number of disposal facilities that can accept these types of wastes, and most of these have stringent waste acceptance criteria which may limit the ability of some of the facilities to receive the wastes.

Availability of rail service, particularly the number of rail cars that can be made available and switched daily by the railroad, would also affect the production rate of RIM excavation and disposal, and therefore the cost.

All the materials, equipment, and personnel to remove the designated portion of the RIM and to construct the engineered landfill cover over Areas 1 and 2 are readily available. The necessary technologies have been generally proven through application at other landfills. The implementability and potential cost of the covers would be influenced by the availability and location of clean cover materials and/or off-site borrow sources at the time this alternative would be implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006) and during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI, 2008). Information obtained from the vendors at these times indicated that rock, clay, and clean cover material were readily available from sources located near the Site. If these local sources of cover materials become exhausted prior to and during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

The necessary materials, equipment, and personnel required for assessment and removal of RIM that may be present at the Buffer Zone/Lot 2A2 above unrestricted use levels, and to implement the institutional controls and monitoring components of this alternative are also readily available.

6.2.7.6.9 Availability of Prospective Technologies

The 1,000 Partial Excavation Alternative is based on proven, established, and commonly-used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.7.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the 1,000 Partial Excavation Alternative are included in Appendix K-7 and summarized on Table 6-1. Conceptual excavation, backfill, and bottom and top of final cover grading plans as well as stormwater control features used as the basis for the 1,000 Partial Excavation Alternative capital cost estimate are provided in Appendix M. The estimated cost to conduct the 1,000 Partial Excavation Alternative (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $379,000,000 based in part on unit costs provided by US Ecology. These costs do not include costs to conduct full-scale pilot testing of solids separation equipment. The estimated annual OM&M costs range from $176,000 to $389,000 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring and years when landfill cover repairs and 5-year reviews may occur). The cost estimates provided in this FFS are feasibility-level cost estimates which were developed to a level of accuracy such that the actual costs incurred to implement this alternative are expected to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of a 1,000 Partial Excavation Alternative are projected to be $287 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $372 million. The total non-discounted costs for the 1,000 Partial Excavation Alternative over 30 years are projected to be $384 million.

Given the long life of the radionuclides present at OU-1, the costs for the 1,000 Partial Excavation Alternative were also evaluated for 200- and 1,000-year periods (without consideration of any constraints on annual expenditures). The total non-discounted costs of the 1,000 Partial Excavation Alternative are projected to be $417 million over a 200-year period. The total present-worth costs of the 1,000 Partial Excavation Alternative are projected to be $288 million based on a 7% discount rate or $388 million based on a 0.7% discount rate over a 200-year period. The total non-discounted costs of the 1,000 Partial Excavation Alternative are projected to be $569 million over a 1,000-year period. The present-worth costs over a 1,000-year period are projected to be $288 million based on a 7% discount rate or $394 million based on a 0.7% discount rate.

ere the material is ultimately disposed.

For purposes of demonstrating how much shipping of mixed waste could influence costs, it was assumed that mixed waste would represent 0.5% of the sum of the volumes of overburden wastes (645,000 bcy) and RIM (38,700 bcy) for the 1,000 Partial Excavation Alternative. Accounting for daily cover and the volume increase that would occur upon excavation and assuming 0.5% is hazardous/mixed wastes results in 5,320 lcy of hazardous waste and 320 lcy of mixed waste. The incremental additional costs for handling, sampling/analysis, and treating of mixed waste for this alternative are estimated to range from $7,000 to $167,000 (Appendix K-10). The additional cost for handling, sampling/ analysis, shipping, treating, and disposal of hazardous waste from excavation of overburden material is estimated to be $1.1 to 4.1 million (Appendix K-10). These ranges of costs primarily result from variations in the fees charged by the off-site disposal facilities and uncertainties associated with the nature of such wastes and the required method of treatment. Therefore, the additional costs that may be incurred if mixed and hazardous wastes are encountered during overburden relocation and RIM excavation for the 1,000 pCi/g Partial Excavation Alternative, could range from approximately $1.1 to $4.3 million (Appendix K-10). If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher.

6.2.8 Risk-Based Partial Excavation Alternative

Under this partial excavation alternative, RIM containing combined radium or combined thorium activities greater than levels that would be protective of future (1000 year) industrial land uses (*i.e.*, outdoor storage yard worker) in Areas 1 and 2 would be removed (the “risk-based partial excavation”). This alternative is based on examination of potential risks that may remain after completion of regrading to a 5% surface slope, but, at EPA’s direction, before installation of a new landfill cover.[76] The potential risks addressed by this remedial alternative are described in Appendix L and include reduction of radon emissions at the surface of Areas 1 and 2, ensuring that levels of radium that may be present at the future grade level are below risk-based criteria for industrial land use, gamma radiation is below acceptable levels for industrial use, and the potential risks to any industrial worker are below 1×10^{-4}.

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[76] A landfill cover is required in order to comply with the Missouri Department of Natural Resources’ regulatory requirements for all completed remedial actions on OU-1, and is an applicable ARAR. Notably, the installation of an engineered cover would eliminate any unacceptable risk to future industrial users.

As previously discussed in Section 5.9, this alternative would include many of the same components that were previously described for the other alternatives, including:

- Relocation of waste material on the northern slopes of Areas 1 and 2 and the eastern slope of Area 2 to reduce the slope angles to less than the 25% maximum slope angle;
- Separation of RIM from the other regraded material and loading and shipment of the RIM for off-site disposal;
- Excavation of additional RIM from Areas 1 and 2 that poses a potential risk to future industrial workers based on exposure to gamma radiation or inhalation of radon;
- Survey and identification of the presence and extent of radiologically-impacted soil on the Buffer Zone and Lot 2A2;
- Excavation of any soil from the Buffer Zone and/or Lot 2A2 that contains radionuclides at levels greater than those that would be allowed for unrestricted use;
- Loading and transport of the RIM and impacted soil and disposal of these materials at an off-site disposal facility;
- Regrading of the remaining solid waste materials within Areas 1 and 2 to meet the minimum (5%) and maximum (25%) slope criteria;
- Installation of an engineered cover meeting the UMTRCA design, performance, and longevity standards over Areas 1 and 2;
- Design, installation, and maintenance of surface water runoff controls;
- Groundwater monitoring consistent with the requirements for UMTRCA and sanitary landfills;
- Landfill and radon gas monitoring and control, as necessary;
- Institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill site containing radionuclides; and
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2.

Under this alternative, an estimated 15,570 bcy of RIM would be excavated from Areas 1 and 2 for off-site disposal. The volume of material would increase upon excavation due to swelling, handling, and loading for transport to an off-site disposal facility. Applying the swell factor of 1.5 and accounting for daily cover, it is estimated that approximately 25,700 lcy would be transported and disposed off-site. An additional estimated 2,900 bcy of impacted soil would be excavated from the Buffer Zone/Lot 2A2 and also shipped to an off-site disposal facility.

In conjunction with the risk-based partial excavation alternative, the remaining solid waste materials in Areas 1 and 2 would be regraded to achieve minimum surface slopes of 5% and maximum slopes of 25% or less in accordance with Missouri's final closure standards for sanitary landfills. Because waste containing radionuclides above unrestricted use standards would still remain in Areas 1 and 2, the cover system would be designed to meet the requirements of the UMTRCA performance standards (see prior discussions in Section 5.4).

This alternative also includes installation and maintenance of surface water runon and runoff controls, groundwater and landfill gas monitoring, and institutional controls for Areas 1 and 2 and the Buffer Zone. Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site meets State of Missouri standards or other ARARs. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the perimeter of Areas 1 or 2. Landfill gas and groundwater monitoring, as described in Sections 5.3.1.7 and 5.3.1.11, respectively, are also included as part of the Risk-Based Partial Excavation Alternative.

Existing institutional controls would be maintained and enforced, as previously described in Section 5.3.2.1 for the ROD-selected remedy, to ensure that land and resource uses are consistent with permanent waste disposal. These institutional controls are necessary to ensure that residential uses do not occur at the landfill and that commercial and industrial uses or ancillary uses that could result in unacceptable risks do not occur on Areas 1 and 2 or the Buffer Zone. In addition to prohibiting land uses that could result in potential exposure to waste materials or contaminants at the Site, these institutional controls would also limit or prohibit land uses or activities that could disrupt the integrity, performance or longevity of the new landfill cover or other components of the remedy. Any modifications to the existing institutional controls or any additional controls that EPA may determine are necessary would be implemented as part of remedial design.

Long-term inspections and maintenance activities of the engineered components, similar to that described for the ROD-selected remedy (Section 5.3.1.10), and enforcement of the institutional controls (Section 5.3.2.1) would also be required.

6.2.8.1 Overall Protection of Human Health and the Environment

The Risk-Based Partial Excavation Alternative would protect human health and the environment through (1) removal and off-site disposal of RIM above risk-based levels associated with industrial land use, and (2) engineered containment of the remaining waste materials (RIM and non-RIM) in conjunction with long-term surveillance and maintenance, and institutional controls on land and resource use. The UMTRCA cover would reduce potential risks from exposure to external gamma radiation or radon gas emissions and eliminate potential risks associated with inhalation or ingestion of contaminated soils or other wastes, dermal contact with contaminated soils or other wastes, and wind dispersal of fugitive dust.

The presence of an engineered cover would prevent users of the Site from exposure to external gamma radiation primarily through shielding and increasing the distance to the radiation source (i.e., the cover materials would be of sufficient thickness and design to attenuate gamma radiation). The depth of cover required for gamma radiation shielding is 3 feet. The total thickness of the final cover for the Risk-Based Partial Excavation Alternative would be a minimum of 5 feet (2 feet of clay soil, 2 feet of biointrusion rock/rubble and drainage layer, and 1 foot of vegetative soil).

The cover materials would also be of sufficient thickness and design to retard or divert the vertical upward migration of radon. The engineered cover would act as a diffusion barrier, allowing time for the decay of the relatively short-lived radon-222 gas (the half-life for radon-222 is 3.8 days) during migration through the pore spaces of the cover soil. Radon is continually produced from the radium source, but need only be detained in the cover materials for a few days to decay to its non-radiological progeny, thereby eliminating any significant radon emissions. The radon may also be intentionally vented or diverted to a landfill gas control system. Calculations presented in Appendix F indicate that the cover system's design, a clay layer thickness of 2 feet, combined with a 2-foot-thick rock/rubble layer and a 1-foot-thick vegetative layer, would provide sufficient radon attenuation to meet the radon emissions ARAR of 20 pCi/m^{2}s. As discussed in Appendix F, these calculations were based on the increased levels of radium expected to be present at the Site after 1,000 years of ingrowth of radium from decay of thorium based on the maximum of the 95% UCL values for Area 1 or 2.

The potential for direct contact with waste materials is eliminated by partial removal of RIM and by placing a barrier (multi-layer landfill cover including biointrusion layer) between the remaining RIM/waste materials and any potential receptors. Likewise, there is no potential for the generation of fugitive dust from the waste material as long as the barrier remains in place.

The multi-layer cover would also be designed to minimize infiltration of surface water through the wastes, thereby reducing the potential for leaching of contaminants to the groundwater. This is typically accomplished by promoting surface drainage and using a hydraulic barrier (e.g., a compacted clay layer and/or geosynthetic liner meeting the specified permeability requirements). These are all conventional functions for landfill cover technologies and are widely used by government and industry to address similar circumstances where contaminated materials must be encapsulated to protect against future potential contact. Long-term maintenance of the cover and monitoring of the groundwater would ensure that the Risk-Based Partial Excavation Alternative functions as intended.

Environmental monitoring of groundwater quality would be performed to ensure that groundwater quality at the perimeter of the Site meets State of Missouri standards or other ARARs. Monitoring of subsurface occurrences of landfill gas and radon and, if necessary, implementation of contingent landfill gas extraction along the perimeter of Areas 1 and 2, would be performed to ensure that gas migration above regulatory thresholds does not occur beyond the Site perimeter.

Institutional controls would ensure that land and resource uses are consistent with permanent waste disposal. The use restrictions would reflect the presence of radionuclides at the Site.

6.2.8.2 Compliance with ARARs

Insofar as the Risk-Based Partial Excavation Alternative includes excavation and off-site disposal of only a portion of the RIM, some RIM would remain on Site. Therefore, regrading of the remaining solid wastes and installation of a new engineered cover over Areas 1 and 2 would need to meet relevant and appropriate requirements of the UMTRCA performance standards set forth in 40 CFR 192 Subpart A. Because the Site would still contain solid wastes, the relevant and appropriate requirements of the Missouri solid waste rules for sanitary landfills, in particular the final closure standards for sanitary landfills, would also be relevant and appropriate to this alternative. Upon completion of the risk-based partial excavation, the remaining RIM and solid waste in Areas 1 and 2 would be regraded to achieve minimum 5% and maximum 25% slopes, and an engineered cover that would meet the performance standards of UMTRCA and also be consistent with the cover requirements for a solid waste landfill without a liner would be installed. Sections 6.2.3.2.1 and 6.2.3.2.2 contain full discussions of the MDNR solid waste regulations and the UMTRCA standards. The design of the landfill cover would meet these requirements.

The Risk-Based Partial Excavation Alternative would also need to comply with the ARARs of the CERCLA Off-site Rule, WAC for Off-site Disposal, Off-site Transportation Requirements, NESHAPs, the Safe Drinking Water Act, NRC Standards for Protection Against Radiation, the Missouri Well Construction Code, and the Missouri Storm Water Regulations. Sections 6.2.3.2.2, 6.2.3.2.4 through 6.2.3.2.7, and 6.2.4.2.2 to 6.2.4.2.4 contain full discussions of these regulatory requirements. These requirements would be met or achieved using the same methods as previously described in Sections 6.2.4.2.3 through 6.2.4.2.8 with respect to the full excavation of RIM alternative.

6.2.8.3 Long-Term Effectiveness and Permanence

These criteria refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time. The Risk-Based Partial Excavation Alternative would reduce risk through removal of a portion of the RIM and by providing engineered containment in conjunction with monitoring, maintenance, and land use controls designed to be effective over the long term for the RIM remaining onsite. For this alternative, the risk-based excavation would eliminate the potential for unacceptable risk from gamma exposure, inhalation of radon gas or dust containing radionuclides or other constituents, dermal contact with impacted materials, and incidental ingestion of soil containing radionuclides or other chemicals. Installation of an engineered landfill cover would provide additional protection from these exposure pathways and reduce the potential for leaching of radionuclides or chemicals to the underlying groundwater. Maintaining the integrity of the engineered cover would protect the underlying RIM from erosion and intrusion. An UMTRCA-compliant cover would provide a reliable method to control exposure of the RIM to surface receptors and mitigate potential migration of the covered materials. To meet the risk-based levels, this alternative would also require that at least 2-feet of non-RIM, or inert fill material, be present between the engineered cover and the remaining RIM (see additional discussion in Appendix L).

The proximity (approximately 1.5 miles) of the Site to the Missouri River presents some uncertainty with regard to meeting the UMTRCA longevity criteria. The West Lake Landfill, including Areas 1 and 2, is located within the geomorphic floodplain of the Missouri River, indicating that within geologic time frames, the river at one time was located in the vicinity of what is now the West Lake Landfill. Given the long-term risk posed by the RIM, it is possible that the river could meander back into this area; however, the ability of the river to expand near or to the Site area is currently controlled by the historic channelization of the River and the presence of the Earth City levee. Implementation of the remedial alternatives is anticipated to include installation of a starter berm that would result in placement of at least 26 feet of soil/rock fill at the base of the starter berm at the toe of the landfill, which would protect against any erosion from flooding in the event of levee failure in a flood event with a recurrence interval greater than 500 years. In addition, a potential to include rock armoring (e.g., rip-rap) at the toe of the starter berm will be evaluated during remedial design. The longevity of an UMTRCA-type cap could be affected by long-term settlement and consolidation of the waste material requiring potential repairs/replacement in the future, though such repairs/replacement would be addressed by the long-term care called for as part of the OM&M.

Long-term site management plans and institutional controls would be made as robust and durable as possible. Long-term groundwater monitoring would be effective in verifying a remedy is performing as required and groundwater is protected. The landfill cover would also passively prevent potential contaminant migration and human exposures for an indefinite period in the unlikely event of a loss of institutional controls.

By removing any contaminated soil from the Buffer Zone/Lot 2A2 and disposing of this soil offsite, the remedy would provide long-term effectiveness and permanence as to the Buffer Zone/Lot 2A2.

6.2.8.3.1 Magnitude of Residual Risk

The calculated lifetime risks following the exposure scenarios in the risk assessment after (a) completion of the risk-based partial excavation, (b) an engineered landfill cover has been installed, and (c) the remainder of this remedial alternative has been implemented (Appendix H) are as follows:

- Area 1: 2.3×10^{-7} for year 1, 8.6×10^{-9} for year 1,000, and 2.0×10^{-8} for year 9,000.
- Area 2: 4.3×10^{-7} for year 1, 9.3×10^{-9} for year 1,000, and 2.2×10^{-8} for year 9,000.

These calculated risk levels are within or below EPA's target risk range of 1×10^{-6} to 1×10^{-4}, and therefore the magnitude of residual risk in Areas 1 and 2 is acceptable. These calculated risk levels are attributable to gamma radiation and radon emissions from any radionuclide occurrences that would remain in Areas 1 and 2 after completion of the risk-based excavation and installation of a new engineered cover, and are also reflective of access restrictions and institutional controls. They do not specifically include potential exposures from non-radiological landfill wastes after construction is complete; however, those wastes would also be covered by a cap, which would prevent exposures. It should be noted that unlike the other alternatives, the presence of 2.2 feet of non-RIM waste material between the base of the landfill cover and the RIM material effectively increases the cover thickness for this alternative to 7.2 feet, thereby providing a greater reduction in both gamma radiation and radon emissions compared to the other alternatives. Another result is that, unlike the risks for the other alternatives which increase between one year and one thousand years due to ingrowth of radium from thorium, the calculated risks for this alternative decrease between 1 year and year 1000. This decrease results from a change in the porosity of the 2.2 feet of non-RIM waste material from 60% initially to 40% at 1,000 years due to decomposition and consolidation of the waste material over time. Additional information regarding the risk assessment calculations is presented in Appendix H.

Direct contact with the remaining RIM under the engineered cover on Areas 1 and 2, and exposure by ingestion, inhalation, or dermal contact with such materials, is not expected to occur. These are the primary exposure pathways for any non-radiological COPCs which may be mixed with the RIM and landfill wastes that would remain in Areas 1 and 2 after partial excavation. Because no complete exposure pathway would exist for such materials after completion of the partial excavation and cap construction in Areas 1 and 2, the landfill waste materials would not be expected to produce non-carcinogenic effects or carcinogenic risks.

After soils containing radionuclide concentrations above unrestricted use levels are removed from the Buffer Zone/Lot 2A2, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.8.3.2 Adequacy and Reliability of Controls

The risk-based partial excavation should eliminate potential unacceptable risks, including potential risks from direct contact, inhalation, ingestion of RIM, gamma radiation, and inhalation of radon or its decay products. Addition of a new engineered landfill cover would provide an additional level of protection. The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. Cover construction is based on and relies upon the use of natural materials that would be expected to remain in place and meet performance criteria for at least 200 years, as required by the UMTRCA performance standards. Post-closure inspection and maintenance of the cover – as required by the solid waste regulation ARARs, and as routinely performed at thousands of landfills across the country – also would ensure long-term reliability of the engineered cover.

The surfaces of Areas 1 and 2 are not currently graded to promote drainage of stormwater, but instead are generally flat with several surface depressions which act to increase precipitation accumulation and infiltration through the waste mass. In addition, no engineered landfill cover exists over these areas. Removal of a portion of the RIM, regrading Areas 1 and 2 to promote drainage, and installation of the engineered landfill cover included as part of the Risk-Based Partial Excavation Alternative would significantly reduce infiltration of precipitation and potential for leaching, thereby providing further protection against potential impacts to groundwater.

Long-term OM&M would include routine cover and stormwater ditch inspection and service to mitigate erosion, and OM&M of a landfill gas collection and treatment system if such a system is needed. Long-term monitoring would also be implemented to assess compliance with environmental performance standards. The performance of these engineering controls would also be re-evaluated during statutory 5-year reviews.

The current Covenants and Restrictions for Areas 1 and 2 would be adequate to provide protection to human health. The permanence of these restrictions is assumed to be adequate for the foreseeable future, as both EPA and MDNR approval are required to remove or modify the restrictions. The adequacy of the restrictions will be evaluated during remedial design and modifications implemented as needed. The adequacy of the restrictions would also be continually evaluated during the statutorily required 5-year reviews.

6.2.8.3.3 Climate Changes and Potential Impacts of a Tornado

Because RIM and municipal solid waste would still remain in Areas 1 and 2 after the Risk-Based Partial Excavation Alternative is implemented, a new engineered landfill cover would be installed over these areas. Because radionuclides above unrestricted use levels would remain in Areas 1 and 2, the engineered landfill cover that would be installed under this alternative would include the 2-foot-thick low permeability layer, 2-foot-thick rock/rubble biointrusion layer, and 1-foot-thick vegetative layer, as previously described for the UMTRCA cover alternative (Sections 5.4 and 6.2.3). This engineered landfill cover would be classified as an in-situ containment system (EPA, 2014a).

Because the engineered landfill cover to be installed over Areas 1 and 2 under the Risk-Based Partial Excavation Alternative is the same as the landfill cover to be installed under the UMTRCA cover alternative, the analysis of the potential effects of climate change or impacts of a tornado are the same for both alternatives. These effects were previously discussed in Section 6.2.3.3.3 for the UMTRCA cover alternative and therefore are only summarized below.

As discussed in connection with the capping remedies, the vegetative layer of the UMTRCA cover to be installed under the Risk-Based Partial Excavation Alternative could be vulnerable to increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health and vitality of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potential increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence. In addition, the design of the engineered cover may include a rock mulch in the upper portion of the vegetative layer in order to protect against soil erosion by wind or water in the event of loss of the vegetation.

The CCL and GCL layers could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low-permeability materials (CCL or GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Such impacts are not considered to be significant because the cover system would still represent an improvement from historic conditions given that the Site has existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration. In addition, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards and are projected to remain below these standards in the future (see prior discussion in Section 2.3.1 and also in RI Addendum Section 7.1.1.1). Therefore, even if desiccation of the low-permeability layer were to occur, it is not expected to have significant impacts on the durability of the cover system. More importantly, the vegetative layer would show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL/GCL. Therefore, although the low-permeability layer could potentially be vulnerable to the effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities, such as temporary irrigation to maintain the grass cover, overseeding with grasses that require less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Further, such impacts are not expected to result in the release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying biointrusion layer and potentially the low-permeability layer. The design of an UMTRCA cover is anticipated to include a rock mulch to reduce the potential for erosion of the vegetative layer and thus increase the longevity of the cover system. Any erosion of the landfill cover would be readily identifiable by visual inspection. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot-thick rock layer above the low permeability layer, stormwater erosion—even under the most severe storm event—is not anticipated to result in erosion down through the entire landfill cover.

Heavy precipitation events could impact the integrity or performance of stormwater drainage conveyance structures, including: erosion of drainage channels; damage to or bypassing of let-down and erosion control structures and features; or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs if any are needed. Therefore, the vegetation layer and stormwater controls are potentially vulnerable to impacts from heavy precipitation events. However, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Furthermore, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading and repair and replacement of cover material in response to any damage that may occur.

The Risk-Based Partial Excavation Alternative is not anticipated to be impacted by flooding that may occur in the area of the Site. As previously discussed in Section 2.1.6, based on the Flood Insurance Rate Map developed by FEMA, Areas 1 and 2 are located outside of the area of the 500-year floodplain (and are further protected by a levee system), and the surfaces of Areas 1 and 2 are above the projected 500-year flood level even in the event of a failure of the levee system (see Figure 2-9). The areas to the north and west of Area 2 (*e.g.*, Crossroads Industrial Park and Earth City Industrial Park), including the potential toe of the cover system, along with the eastern edge of Area 1, are within the 500-year floodplain, but protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park.

As previously discussed in Section 6.2.2.3.3 in connection with the ROD-selected remedy, an evaluation of potential impacts associated with a tornado was previously performed and submitted to EPA (EMSI, 2013f). Similar to the ROD-selected remedy, the Risk-Based Partial Excavation Alternative is not vulnerable to impacts from a tornado. Specifically, a tornado is not expected to damage the vegetative layer of a cover system. Even if it did, such an impact is not considered to be significant because it could be easily identified and, due to the design and thickness of the engineered cover, would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy aboveground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not expected to be significant because they would be readily identified and easily repaired or replaced. Therefore, the Risk-Based Partial Excavation Alternative is not considered to be vulnerable to impacts from a tornado.

Although the Risk-Based Partial Excavation Alternative is not considered to be vulnerable to climate change, implementation of adaptation measures could be considered during remedial design to provide a degree of adaptation for climate change. For example, regrading of the surfaces of Areas 1 and 2 to a 2% slope instead of a 5% slope could be considered to reduce the velocity of runoff across the surface of Areas and 1 and 2, and thereby reduce erosion and soil loss potential under extreme precipitation events.[77] Installation of a runoff collection and diversion system along the base of the above-grade portion of the North Quarry portion of the Bridgeton Landfill adjacent to Area 1, and along the north sides of the Closed Demolition Landfill and the Inactive Sanitary Landfill adjacent to Area 2, could be included to divert runoff from these areas around Areas 1 and 2 and thereby reduce the potential for impacts from heavy precipitation events. Use of grass seed mixtures that are more tolerant of long-term changes in precipitation or temperature and/or soil addition to increase water storage capacity could be evaluated as part of the design. Similarly, inclusion of a geotextile at the base of the vegetative layer and/or biointrusion layer could be considered to minimize the potential for water or wind erosion extending down into the underlying low-permeability layer. The design grades of the stormwater conveyance structures could be evaluated to provide a balance between the ability to quickly route stormwater away from Areas 1 and 2 while minimizing the stormwater velocity and the associated potential for erosion of the stormwater conveyance structures. Identification and evaluation of additional adaptation measures can be addressed as part of the design of the engineered landfill cover and stormwater controls to increase the overall resilience of these features to heavy precipitation events. Continuous re-evaluation of potential vulnerabilities, system resilience, and possible adaptation measures should be included as part of the ongoing inspection and maintenance program.

6.2.8.3.4 Potential Impacts of a Subsurface Heating Event

Because radionuclides above unrestricted use levels would still remain at the Site under the Risk-Based Partial Excavation Alternative, radionuclide-related impacts similar to those described in Section 6.2.2.3.4 for the ROD-selected remedy could potentially occur if an SSR were to occur in Areas 1 or 2. Specifically, a localized, temporary increase in radon emissions from the ground surface could occur.

In the event that a subsurface heating event were to occur in Area 1 or Area 2, such an event is not expected to impact the long-term effectiveness of this alternative. As discussed above, there would only be a temporary potential increase in radon emissions, which is not expected to pose unacceptable risks. Destruction or modification of the waste material by increased temperatures could result in a reduction in volume, which could cause subsidence and/or differential settlement of the waste mass. Subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time, could result in displacement or disruption of an engineered cover system, thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

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[77] Since identification of the RIM to be removed under this alternative is based on the projected 5% grade for the final waste surface, changing the grade to 2% could change the locations and amount of RIM that would be removed under this alternative.

- Installation and operation of a heat extraction barrier or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system, followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions, after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2, the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills such as those located in the deeper quarry landfill, and Areas 1 and 2 therefore lack the insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

6.2.8.3.5 Effects of an Isolation Barrier

An isolation barrier could take different forms, such as a physical barrier or a heat extraction system. Installation of a physical barrier, such as a vertical wall of inert material, would require excavation and regrading of the above-grade areas of the North Quarry portion of the Bridgeton Landfill wastes located over the southern portion of Area 1. Because of the limited extent and shallow nature of the RIM excavation under the Risk-Based Partial Excavation Alternative, no impacts are anticipated if an isolation barrier were to be installed prior to implementation of the Risk-Based Partial Excavation Alternative. However, the design of the engineered cover included in this alternative may need to be modified to account for any changes in the surface grades, stormwater drainage system and the presence of any above-grade features (*e.g.*, heat extraction points, temperature monitoring probes, or additional gas extraction wells) that may be installed in conjunction with a barrier. In contrast, if a physical barrier were installed after the risk-based partial excavation and construction of the engineered cover, that portion of the engineered landfill cover that extended over the area of an isolation barrier and the associated revised landfill grades would need to be removed as part of the construction of an isolation barrier.

Installation of a thermal isolation barrier using a heat extraction system would not require excavation or regrading of the landfill surface. If a heat extraction barrier were to be installed within the footprint of the remedial actions (e.g., excavation for RIM removal or installation of a cover system) prior to implementation of a remedial action for OU-1, the in-ground components (e.g., heat extraction points or temperature monitoring probes) would likely be destroyed during implementation of an OU-1 remedy. Above ground components (e.g., heat exchange unit, conveyance piping, etc.) may be salvageable. In contrast, if a heat extraction system were installed after implementation of an OU-1 remedy, any impacts to the OU-1 remedy (e.g., penetrations through the cover system) could be mitigated using standard landfill operations and maintenance techniques.

6.2.8.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.3.6 as part of the evaluation of long-term effectiveness of the ROD-selected remedy, a screening-level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of this alternative.

6.2.8.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. A portion of the RIM would be removed in this alternative, removing that material that poses an unacceptable risk to future industrial users. However, the Risk-Based Partial Excavation Alternative is primarily a containment remedy, and therefore generally would not reduce the toxicity, mobility, or volume of the waste material through treatment.

As discussed in Section 4, radionuclides are naturally occurring elements which cannot be fully neutralized or destroyed by treatment. Occurrences of radionuclides within Areas 1 and 2 are dispersed within soil material that is further dispersed throughout the overall, heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted soil materials in Areas 1 and 2. Consequently, ex-situ treatment techniques are considered impracticable. In addition, the heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix in portions of Areas 1 and 2 make in-situ treatment techniques equally impracticable. The remedy for the Buffer Zone/Lot 2A2 also would not reduce toxicity, mobility, or volume through treatment because it consists of moving radiologically-impacted soil from the Buffer Zone/Lot 2A2 to an off-site disposal facility.

Because this alternative would remove 15,570 bcy of RIM, much of which will contain radionuclides at levels near the unrestricted use criteria, which is close to background, ex-situ physical separation of impacted soil from the solid wastes using solids separation techniques combined with radiological separation (see prior discussion in Sections 4.3.5.2 and 4.4.1.2) is not expected to be effective for this alternative.

In the event that hazardous wastes are encountered during implementation of the remedy, such materials would be separated from the other solid wastes and subjected to waste profiling to determine the appropriate treatment and disposal requirements. To the extent that hazardous wastes or mixed wastes are encountered, they would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's LDR program and UTS) and in accordance with the permits and standard operating procedures of the receiving facility. After arriving at an off-site disposal facility and undergoing a waste receipt analysis, any RCRA soil/debris and RCRA soil/debris with radionuclide material would be stabilized prior to placement in a disposal cell. Depending on its physical characteristics, RCRA debris and RCRA debris with radionuclide material would undergo either micro- or macro-encapsulation prior to placement in a disposal cell. To the extent that treatment of the hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous waste and radiologically-impacted components of the mixed waste. Toxicity and volume would not be reduced by these technologies but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of the remedial action at the Site.

Section 6.2.2.4 contains a full discussion of the procedures, protocols and concerns associated with the off-site shipment of hazardous wastes or mixed wastes.

6.2.8.5 Short-Term Effectiveness

This section presents an evaluation of potential risks to on-site workers and the surrounding community or potential impacts to the environment that may arise from implementation of this alternative. It also presents the estimated time frames before the remedial action objectives are achieved.

6.2.8.5.1 Protection of the Community During Remedial Actions

Potential environmental risks to the community that could potentially arise during implementation of this alternative stem from various sources. One such source is impacts from air emissions from trucks and excavation equipment, as well as the RIM itself, once exposed. Calculation of potential risks to the community is presented in Appendix H. Based on these calculations, the projected carcinogenic risks that may be posed to off-site residents by this alternative were calculated to be less than 3.8×10^{-7} (Appendix H). No non-carcinogenic risks are expected to occur.

The risk assessment (Appendix H) also includes an estimate of the projected incidence of transportation accidents associated with each FFS alternative. For the Risk-Based Partial Excavation Alternative, the projected incidence of transportation accidents associated with shipping of RIM for off-site disposal and importing of materials for construction of the multi-layer landfill cover is 2.4, meaning that approximately 2 transportation-related accidents are projected to occur if this alternative were implemented. This risk is associated with transportation of excavated RIM from the Site to the disposal facility. Based on the anticipated activity level of the RIM to be disposed off-site under this alternative, it is assumed that 50% of the RIM will be disposed at the US Ecology facility in Idaho and 50% at the US Ecology facility in Michigan. Risks associated with transportation were calculated accordingly based on transportation to the rail transloading facility, hauling by rail, and transport of the RIM from the destination rail off-loading facility to the Idaho disposal site and direct transport by truck from the Site to the Michigan disposal facility. Transportation risks associated with truck traffic required for delivery of construction materials to be used for construction of the new engineered landfill cover on Areas 1 and 2 have also been included.

Disturbing the waste material may expose the community to radioactive waste, methane and radon gas, dust, and particulates, and may cause an undesirable release of odors. Excavation of existing waste materials could result in odor emissions during the period of time that existing wastes may be handled or exposed; however, given the total amount of waste being moved under this alternative (approximately 115,000 yards), the total time that waste will be disturbed is approximately 30 weeks (see Appendix J). Additionally, this remedial alternative will not involve disturbance of the newer North Quarry landfill material. Mitigation of odors through engineering means is limited.

The Risk-Based Partial Excavation Alternative would contribute carbon dioxide equivalent emissions to the atmosphere as a result of vehicle operations associated with the remedial work. In particular, approximately 38,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere as a result of landfill regrading and cover construction in Areas 1 and 2, the excavation, loading, and transport of the RIM to an off-site disposal facility, and the importation of materials used to construct the multilayer landfill cover for Areas 1 and 2 (Appendix I, Table I-7).

Under this alternative, RIM to be disposed offsite would be excavated in conjunction with regrading of the surfaces of Areas 1 and 2, and therefore no stockpiling or storage of overburden would be required for this alternative. In addition, it is expected that the RIM to be disposed offsite would be directly loaded into containers or trucks near the excavation areas. Therefore, this alternative does not include staging or storage of RIM prior to loading and shipment for off-site disposal. As a result, this alternative should have a reduced potential for nuisance attraction to and congregation by birds at and above the affected areas. The main concern would be the potential for increased bird strikes to aircraft approaching and departing from the Lambert-St. Louis International Airport during the limited time that waste is exposed. Additional mitigation measures such as excavation best management practices, which include application of daily soil cover and/or placement of tarps over areas of exposed waste, visual and auditory frightening devices, or wire or monofilament grids positioned over exposed refuse to prevent bird access, could be implemented to minimize bird attraction to and congregation at and above the disturbed areas.

It is anticipated that, due to the shallow nature of regrading and RIM removal activities associated with this alternative, implementation of this alternative will not result in creation of depressions in the landfill area that could otherwise increase the potential for accumulation of precipitation.

This alternative could be adversely affected by severe weather impacts; however, the projected short duration required for the regrading and RIM removal activities for this alternative would minimize the potential for impacts from severe weather. Severe weather could delay construction due to direct delays to the landfill regrading and RIM excavation work from such an event and also indirectly if such an event results in diversion of resources (*e.g.,* equipment) from waste regrading or RIM excavation activities to mitigation of impacts of a severe weather event. Severe weather events could potentially increase the volume of contact stormwater that would need to be contained and managed, which may further limit waste excavation activities and increase the amount of time required to implement this alternative. In addition, severe weather events could increase the potential for loss of stormwater containment through failure of best management practices for controlling stormwater impacts. Scouring of soil/waste and suspended phase transport with stormwater runoff may result in an increased potential for release and off-site transport of radionuclides or chemicals in any stormwater that contacts waste material or soil containing radionuclides.

Because Areas 1 and 2 would be regraded and RIM would be excavated and loaded into transport containers, stormwater controls would be implemented in accordance with the Missouri Storm Water regulations, 10 CSR 20-6.200, to protect the community. During construction, consideration would be given to minimizing the areas of excavation that would be open and exposed to waste materials at any given time. Temporary diversion berms using daily cover material would also be constructed above the open excavation areas on the previously excavated (and temporarily covered) surface of any excavation depressions in order to divert precipitation runoff around the open excavation and thereby prevent the runoff from contacting uncovered waste materials. Precipitation that contacts uncovered waste materials would flow into the low point of the excavation and be pumped out into temporary storage tanks using portable gas-driven pumps. Samples from each tank would be collected and sent to a laboratory for analysis. The stored water would be directly discharged or treated and disposed appropriately based on the analytical results.

6.2.8.5.2 Environmental Justice Considerations

As was previously discussed in Section 6.2.2.5.2 as part of the evaluation of short-term impacts associated with the ROD-selected remedy, a screening-level analysis did not identify any environmental justice concerns. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community.

Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

6.2.8.5.3 Protection of Workers During Remedial Actions

This alternative would entail excavation, handling, loading, and transport of RIM, and therefore would pose potential increased radiological exposure risks as well as construction safety risks to on-site workers.

Workers involved in the excavation activities would be subject to potential short-term risks. Possible short-term impacts associated with excavation of the RIM and regrading of the waste include the following potential risks: exposure of workers to contaminated waste; excavation/trenching instability; stormwater runoff entering areas where waste is exposed, resulting in the exposure of workers to contact storm water; and odor emissions or other aesthetic issues arising from exposed waste. Worker exposures would be addressed through development and implementation of a Site safety plan, use of personal protective equipment, and performance of personnel and environmental monitoring during implementation of remedial action. Workers would be protected during construction by adhering to OSHA practices; however, as this alternative entails excavation, handling, and transportation of RIM, OSHA work practices and personal protective equipment may not provide full protection against exposure to external gamma radiation.

The risk assessment (Appendix H) presents an evaluation of potential risks to Site workers that may occur for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the Risk-Based Partial Excavation Alternative, the projected incidence of industrial accidents is 8.7 over the life of the project. The projected carcinogenic risk to the maximally exposed individual is 5.0×10^{-5} and the projected hazard index is 27. The projected radiation dose to a remediation worker is 108 mrem/yr (Appendix H). Use of protective clothing and equipment and adherence to project safety requirements is expected to lessen the potential risks to workers including the projected non-carcinogenic risks identified above.

Excavation would require construction workers and equipment that would disturb the waste materials. Dust control measures would be required to limit worker exposure to fugitive dust during construction.

6.2.8.5.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected from this alternative. As noted in the BRA (Auxier, 2000) and the updated BRA (Auxier, 2017a), some of the ecosystems present at the landfill are the result of existing institutional controls and other limitations on land use within or adjacent to OU-1 that have allowed field succession to take place. Much of the habitat on Areas 1 and 2 was removed in 2016 in conjunction with construction of the non-combustible cover. Excavation of RIM, regrading of Areas 1 and 2, and construction of the engineered landfill cover under the Risk-Based Partial Excavation Alternative would destroy the remaining portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. Vegetative cover would be placed on the Site as a part of the final cover, and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

6.2.8.5.5 Ability to Monitor Effectiveness

Measurement of gamma radiation and radon flux through the newly constructed landfill cover would be conducted on Areas 1 and 2 after construction is complete. Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2. Measurements of subsurface occurrences of landfill gas and radon levels would be conducted along the property boundaries adjacent to Areas 1 and 2 to verify that off-site gas migration above regulatory thresholds does not occur.

6.2.8.5.6 Time Until Remedial Action Objectives Are Achieved

The RAOs of (1) preventing direct contact to contaminated media (2) preventing exposure by inhalation and external radiation would be met upon installation of an engineered landfill cover. The RAOs of: (3) minimizing infiltration and any resulting contaminant leaching to groundwater; (4) controlling and managing leachate; and (5) controlling landfill gas emissions, including radon from Areas 1 and 2, would be met once construction of the new landfill cover over Areas 1 and 2 is completed. The RAO related to the Lot 2A2 Property soil would be met upon removal of any remaining soil containing radionuclides above unrestricted levels from these areas.

Initiation of this alternative would require significant planning and permitting due to the limited number of off-site disposal facilities capable of taking this material and the logistics associated with identifying, handling, classifying, and loading the materials for transport to the selected off-site facility. However, the limited volume and shorter duration of off-site shipment will streamline the logistical planning for the risk-based excavation as compared to the other excavation alternatives. Preparation of the remedial design should be completed within approximately 15 months of authorization to proceed with the RD. The RD would take significantly longer if full-scale pilot testing of solids separation equipment were to be performed. Given the limited volume of material at issue here, such a demonstration is not expected due to the absence of any value. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 2.6 years after approval of the RD. Therefore, the RAOs should be achieved within 3.9 years of approval to proceed with the RD (Appendix J).

The projected construction schedule and the cost estimate for the Risk-Based Partial Excavation Alternative are dependent on the waste material swell factor; that is, the amount the in-place waste volume expands as it is excavated, handled and loaded for transport to an off-site disposal facility. For purposes of this FFS, a swell factor of 1.5 has been assumed. A swell factor greater than 1.5 would result in an increase to the overall construction schedule and the estimated costs. The projected construction schedule and the cost estimate for the Risk-Based Partial Excavation Alternative also are dependent on the availability and number of IM containers and the availability of rail cars or trucks for shipping the RIM to the disposal facility. The schedule and cost estimate developed in this FFS for this alternative are based on an assumption that a sufficient number of IM containers and rail cars/trucks would be available such that off-site transportation of RIM will not constrain the construction schedule. If the actual rate of RIM transportation is less than the projected rates of RIM excavation used to develop the construction schedules, the time required to complete construction and consequently the costs for Risk-Based Partial Excavation Alternative would increase.

6.2.8.6 Implementability

This alternative would involve excavation and off-site disposal of a portion of the RIM in Areas 1 and 2, grading of the surfaces and installation of upgraded landfill covers over Areas 1 and 2, long-term monitoring and maintenance of the covers, and long-term monitoring of landfill gas and groundwater and surface water quality.

Excavation of RIM under this alternative would be performed in conjunction with regrading of the surfaces of Areas 1 and 2 and therefore is not expected to require removal or stockpiling of substantial amounts of overburden.

While excavation with subsequent off-site transportation and disposal have been implemented at other sites containing radioactively-impacted materials, materials from these other sites have not included significant amounts of landfill solid wastes. Significant technical and administrative implementability issues are associated with excavating the RIM and loading it into IM containers for transportation if this alternative were to be implemented. These include the following:

- Reduced excavation production rates and increased volume of RIM subject to excavation resulting from application of daily cover over an extended excavation schedule;

- Ability to locate and obtain a lease to an off-site rail spur for use as a truck-to-rail transfer facility (this would apply to shipment to any facility other than US Ecology's Wayne Disposal facility in Michigan, to which the waste would be shipped by truck);

- Increased potential for bird strikes to aircraft as a result of regrading of solid waste and excavation of RIM from Areas 1 and 2, which are located within flight paths of Lambert–St. Louis International Airport;

- Impacts to other Site operations and traffic on surrounding roads from additional truck traffic used to haul wastes to off-site and to haul earthen materials to the Site for daily cover, stockpile covers, and construction of the final cover.

Design and construction of landfill covers over Areas 1 and 2 after RIM removal, with subsequent monitoring and maintenance, are not expected to pose any implementability challenges. Materials and services necessary for the regrading and construction of the final landfill covers over Areas 1 and 2 after RIM removal are available and the technologies have been proven through application at other landfills. The actions included for the Buffer Zone/Lot 2A2—that is, testing and excavation of surface soil—are regularly and easily implementable.

Monitoring of the cover surfaces, landfill gas, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of the engineered landfill cover that would be placed over Areas 1 and 2 and are easily implemented.

6.2.8.6.1 Ability to Construct and Operate the Technology

In general, regrading landfill surfaces and excavation and off-site disposal of waste material are standard technologies. However, there are unique circumstances associated with excavation of RIM in Areas 1 and 2, insofar as they are located within a larger closed/inactive landfill site, which would complicate implementation of standard excavation technologies.

RIM excavation and placement in IM containers and hauling of the containers by truck for subsequent disposal offsite is also expected to present implementability concerns, challenges, and risks, specifically those associated with the following:

- Excavation and handling of contaminated materials;

- Safety risks associated with encountering methane gas during excavation, although given that this alternative only includes excavation of approximately 115,000 bcy of waste, and much of that will be from shallow excavations, the potential for methane accumulation is likely to be minimal for this alternative;

- Management of fugitive dust and potential odors;
- Mitigation of bird hazards;
- Management and treatment of stormwater exposed to RIM during excavation; and
- Identifying, segregating, and disposing off-site any hazardous wastes, PCBs, or RACM that may be encountered during RIM excavation.

If hazardous wastes, PCBs, or RACM are encountered during excavation of RIM, these materials would need to be segregated from the other waste materials, characterized, and transported to an off-site disposal facility in containers separate from the other RIM. Additional health and safety procedures would be required during excavation of these materials. These materials would require separate handling at the off-site disposal facility and could require treatment prior to disposal. Depending on the characteristics of any hazardous waste encountered during excavation, the hazardous waste could need to be transported to a different off-site facility for treatment and disposal in accordance with RCRA.

Directing and controlling the RIM excavation process using radiological scanning and sampling techniques would significantly impact landfill regrading and RIM removal production rates. Based on experience in excavation of radiologically-impacted waste at other sites, a reduction in efficiency is expected for RIM excavation. Because thorium-230 cannot be detected using field survey instruments, excavation guidance would have to rely on collection and laboratory analyses of samples. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities and initial confirmation that all RIM had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that all RIM required to be removed has been removed would also be subjected to off-site laboratory analyses and data validation. Potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses, as well as moving grading and RIM excavation activities to other areas while waiting on the results of verification of confirmation sample analyses. However, even with these measures, it is likely that some short-term delays to the construction work on the order of hours to days will likely occur due to waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedule developed for this alternative.

Daily soil cover and tarps would need to be placed over open excavation areas minimize dust, odor, and the attraction of birds and other wildlife. The proximity of Areas 1 and 2 to Lambert-St. Louis International Airport poses a potential risk to aviation operations. The St. Louis Airport Authority and the U.S. Department of Agriculture have identified as a problem the potential for increased bird activity in conjunction with waste excavation at the Site and the resultant increased risk of bird strikes to aircraft. Bird nuisance mitigation measures such as best management practices (including, but not limited to, daily soil cover and tarps over exposed overburden and wastes), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, could be evaluated for use at Areas 1 and 2. The size of grading and RIM excavation areas may limit the constructability of wire or monofilament grids. Careful evaluation of material properties would be necessary during remedial design to assure that the appropriate strength and elasticity of materials are considered, that the materials are available, and that grids can be reasonably constructed.

Effective stormwater controls could be readily implemented using conventional construction equipment and materials. Temporary berms to direct stormwater away from open excavations would need to be constructed, and precipitation accumulation in depressions created by the excavation activities would need to be pumped out and managed. Direct precipitation or runoff that may contact waste material could become contaminated with soils or wastes containing radionuclides or chemical constituents. These elements would be entrained in suspended material that would readily settle in low areas or in the tanks used to collect and store stormwater prior to treatment and discharge. At the end of excavation activities, after all RIM above cleanup levels would have been removed, accumulated sediment in any low areas or the tanks would also be removed and, depending upon activity levels, either placed in Area 1 or 2 or transported to the off-site disposal facility as part of this alternative.

Excavated RIM exposed to precipitation would be subject to the paint filter liquids test (PFLT) as necessary to determine if free liquids exist prior to being loaded for off-site disposal. If the excavated material to be hauled off site does not pass the PFLT, a dewatering area would need to be staged and collected water treated and/or disposed, potentially through off-site disposal. The current costs and schedules do not address any dewatering activities. Should such activities be necessary, a suitable area would have to be identified within the Site.

Truck hauling of RIM or containers of RIM to an off-site disposal facility is technically implementable. Truck hauling of IM containers of RIM to a truck-to-rail transloading facility and transferring the RIM to railcars is technically implementable. The volume of RIM to be removed under the Risk-Based Partial Excavation Alternative (approximately 15,700 bcy) does not appear to justify the cost for permitting, constructing and operating an on-site rail loading facility. If construction of an on-site rail spur were to be considered, an engineering study and development of a detailed design would be necessary to determine the feasibility and implementability. As discussed in detail in Sections 6.2.4.6.5 and 6.2.4.6.6 above, construction of an on-site rail spur would also require coordination with a number of local and state regulatory authorities as well as private landowners.

An initial comparison of the US Ecology Michigan and Grand View facilities' WAC to estimated activity levels in the OU-1 RIM under the Risk-Based Partial Excavation Alternative is presented on Table 6-5. Although a representative of the turnkey contractor would be on-site during RIM excavation to coordinate loading of containers, there is a potential that one or more shipping containers could contain activity levels that exceed the WAC and may have to be unloaded and re-distributed prior to shipment or, in the worst case, returned to the Site by the disposal facility and/or sent to a different disposal facility. These additional activities could result in additional worker exposures, additional time to complete the project, and potentially additional costs.

Regrading the remaining landfills and placement of final cover is implementable and has been performed at other landfills, including CERCLA sites. Environmental monitoring is routinely performed at most sites and is not expected to present any feasibility challenges.

6.2.8.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material is a reliable technology that has been performed at number of facilities including other CERCLA sites, FUSRAP sites, and DOE Land Management sites. It should be noted, however, that most of those projects did not involve excavation of radiological materials commingled with municipal solid waste and disposed in a landfill setting, and none of those projects involved excavations of MSW volumes as large as those envisioned for this alternative (i.e., 115,000 bcy of total waste excavation with approximately 15,570 bcy of RIM). The reliability associated with disposal in an offsite facility would be dependent on the integrity of the liner and cover systems at the off-site facility being maintained, as well as the effectiveness of the various off-site facility monitoring programs.

Landfill cover systems such as those that would be implemented over Areas 1 and 2 after partial removal of RIM, and which are designed and constructed consistent with State and Federal regulations and with post-closure care implemented in accordance with current regulatory guidance, have been demonstrated to be reliable at: (1) minimizing percolation and infiltration of precipitation; (2) minimizing leachate generation; (3) minimizing impacts to groundwater quality; (4) minimizing impacts to surface water quality and quantity; (5) minimizing erosion of cover material; and (6) minimizing uncontrolled releases of landfill gas. Landfill cover systems have been demonstrated to be reliable methods for isolating waste materials. Similarly, access restriction measures have been demonstrated to be reliable mechanisms to prevent unauthorized access to a site.

Bird nuisance mitigation measures such as best management practices (including, but not limited to daily soil cover and tarps over exposed RIM and waste), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated reliable technologies under proper operating and excavating conditions. However, while visual or auditory frightening devices can be effective in the short-term, birds tend to habituate to deterrents over time, causing the deterrent to lose effectiveness. Frequent relocation of predator birds and predator effigies and/or altering the timing of auditory activation may help, but long-term effectiveness is not assured. In addition, the FAA has stated that "[t]o date, no . . . [putrescible waste] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife [birds] to levels that existed before the putrescible-waste landfill operations began operating." (FAA, 2007).

Stormwater controls are well-established technologies that are implemented at most landfill sites. For this alternative, gravity settling of suspended solids potentially containing radionuclides is a well-established and reliable technology.

6.2.8.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

Because all of the RIM would not be removed during implementation of this partial excavation alternative, it is possible that EPA could later require removal of additional RIM. If such a decision were to occur after construction completion of this alternative, performance of any such additional remedial action in the future would be very difficult and costly. Such actions would require removal of the newly constructed engineered landfill cover and re-excavation of materials previously removed and replaced as part of this partial excavation alternative.

Other than the possibility of additional excavation in the future, the only potential additional remedial actions that may need to be taken for the Risk-Based Partial Excavation Alternative would be maintenance activities to sustain the cover system, repair areas of differential settlement or erosion, or possible implementation of a contingent landfill gas control system. Regrading and contouring the existing waste materials to achieve final grades would require re-compaction of the regraded waste materials in order to minimize the potential for compaction or differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill cover may result in differential compaction of the waste materials, depending upon the nature, age, and amount of prior degradation of the waste materials. Runoff of stormwater can result in formation of erosional rills. Depressions caused by differential settlement of the wastes or erosional features can easily be (and commonly are) addressed at landfill sites through placement of additional soil material to fill such features.

In the event that monitoring of subsurface landfill gas and radon detects the presence of gas levels above regulatory thresholds along the perimeter of the Site, a landfill gas control system could be implemented as an additional remedial action. Implementation of a contingent landfill gas control system would entail drilling and installation of gas extraction wells, installation of conveyance piping, installation and operation of landfill gas extraction blowers and a landfill gas treatment (flare) system, and/or possible use of a carbon adsorption system to remove radon from the extracted gas stream. Installation of a contingent gas system could be performed as a future action. Any disruption to the final landfill cover resulting from the installation of a contingent gas extraction system would need to be repaired. Such activities are commonly and routinely undertaken at solid waste disposal sites.

Long-term monitoring and maintenance of the landfill covers at other Superfund sites and at non-Superfund solid waste landfills is typically required to assess whether differential settlement or surface erosion of the cover has occurred over time. Long-term maintenance, including cover inspection and repair, would be part of this alternative. Cover repair, if necessary, would be straightforward, primarily entailing placement of additional fill, regrading, and revegetation of the repaired area.

Bird nuisance mitigation measures such as best management practices (including, but not limited to, selective excavation, daily soil cover, and tarps), visual and auditory frightening devices, and wire or monofilament grids strung over exposed refuse to prevent bird access, are demonstrated to be readily implementable at landfill sites.

Stormwater management measures other than those using conventional earth-moving equipment, piping, pumps, liners, filtration and carbon adsorption water treatment equipment, rip-rap, and pond outlet structures are not anticipated.

6.2.8.6.4 Ability to Monitor Effectiveness of Remedy

Demonstrating the effectiveness of the cover systems constructed over Areas 1 and 2 after partial excavation of RIM would be accomplished by implementing monitoring programs for the cover surface, landfill gas system, groundwater and surface water programs, as previously described in Section 5.4.6. These types of monitoring programs have been proven at demonstrating cover effectiveness and are easily implemented.

6.2.8.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the Risk-Based Partial Excavation Alternative would require approvals from other agencies, including the following:

- Approval from the FAA to conduct waste excavation activities within 10,000 feet of an active airport runway. FAA Advisory Circular AC 150/5200-33B, dated August 28, 2007, “Hazardous Wildlife Attractants On or Near Airports,” recommends “against locating a MSWLF [municipal solid waste landfill] within the separation distances identified in Sections 1-2 through 1-4. The separation distances should be measured from the closest point of the airport’s AOA [airport operations area] to the closest planned MSWLF cell.” AC 150/5200-33B, p. 4. The separation distances referenced are 5,000 feet from the end of a runway for airports serving piston-powered (propeller) aircraft; 10,000 feet for airports serving turbine-powered (jet) aircraft; and 5 miles of protection from hazardous wildlife movement for approach, departure and circling airspace. The FAA strongly recommends against allowing a waste disposal operation within 10,000 feet of a jet aircraft runway if the material contains putrescible waste and so has the potential to attract wildlife that could threaten air traffic. The excavation of RIM containing putrescible waste within 10,000 feet of the westernmost runway (11/29, formerly known as 12W/30W) at Lambert-St. Louis International Airport, as would occur during excavation of the RIM in Areas 1 and 2, is limited by the need to mitigate potential bird activity during excavation to address the requirements of the FAA Advisory Circular and to comply with the same prohibitions in the Missouri solid waste regulations. It may be necessary to work directly with the FAA and MDNR to identify specific bird mitigation measures during implementation.

- Approval of St. Louis Airport Authority (STLAA) relative to obtaining a release for the Negative Easement and Declaration of Restrictive Covenants Agreement. Excavation of RIM from Areas 1 and 2 poses a potential to increase the bird populations at the Site if mitigation procedures are not employed or prove ineffective. An increase in bird populations presents a greater potential for aircraft bird strikes. The STLAA and USDA have identified this as a concern relative to construction and operation of a new on-site disposal cell that was included in the full excavation of RIM with on-site disposal alternative evaluated in the SFS. Based on the STLAA's position stated in the STLAA's September 20, 2010 letter to EPA, STLAA acceptance of RIM waste excavation would not be likely if bird activity were to increase. It may be necessary to work directly with the FAA and the STLAA to address these concerns, either by amending the FAA ROD, amending the Negative Easement, requiring specific bird mitigation measures during implementation, or making other changes to secure STLAA's cooperation. By letters dated August 11, 2014 and August 11, 2017 (Appendix A), the Airport again submitted comments to EPA, emphasizing and reiterating the need for consideration of bird nuisance mitigation in any evaluation of isolation barrier alternatives.

- Compliance with EPA's OSR. The EPA Region where the off-site disposal facility is located would need to be contacted every 60 days during the period of off-site waste shipments to obtain a compliance determination as to whether the disposal facility currently meets the criteria under the OSR to accept CERCLA waste. If, during RIM excavation, the contracted off-site disposal facility was to be out of compliance for a period of time, excavation and transportation would need to cease until the facility becomes compliant or RIM would need to be transported to another facility that is determined to be in compliance with the OSR. Besides schedule delays, temporary stoppage of construction would present significant technical implementability concerns regarding open excavation areas.

- Rocky Mountain Low Level Radioactive Waste Compact Consent. If RIM were to be disposed at the Clean Harbors Deer Trail, CO facility, an application would have to be submitted to and accepted by the Rocky Mountain Low Level Radioactive Waste Compact. Disposal at the US Ecology Grand View, ID, US Ecology Wayne, MI, and Energy*Solutions* Clive, UT facilities would not be subject to a Waste Compact consent.

6.2.8.6.6 Coordination with Other Agencies

Although not all would be considered "agencies," coordination with many entities would be necessary to implement the Risk-Based Partial Excavation Alternative. Coordination with the landfill owner and operator and owners or occupants of the various parcels that comprise the West Lake Landfill Site would be necessary because of the following:

- Access to operations conducted on other portions the Site would need to be maintained.

- Areas 1 and 2 are within a larger existing Site footprint, and use of areas on the Site outside of Areas 1 and 2 might be necessary to stockpile cover materials or otherwise to facilitate cover construction.

- Implementation of any additional institutional controls or modifications to existing institutional controls that EPA may require would need to be approved and accepted by the individual entities that own the various parcels that comprise the Site.

For the duration of excavation, off-site transport, and import of cover materials, the flow of vehicles associated with remedy construction would need to be coordinated with the traffic patterns of vehicles associated with the current on-site solid waste transfer station and other Site tenants.

Future groundwater monitoring activities could require obtaining and maintaining access to off-site properties if off-site groundwater monitoring were required as part of the remedy.

The potential for increased bird strikes to aircraft approaching and departing the Lambert-St. Louis International Airport is a concern of the FAA and STLAA. The effectiveness of proposed bird nuisance mitigation measures would be of interest to the FAA and STLAA. Consequently, the FAA and STLAA would need to be involved in the remedial planning process.

Coordination with other agencies, including the Earth City Flood Control District, MSD, and MDOT, as well as the adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

- Coordinate with the Earth City Flood Control District regarding the design of non-contact stormwater management and discharge facilities, both during and after completion of construction;

- Coordinate with MSD regarding permitting and design of leachate/contact stormwater discharge during construction;

- Coordinate with MDOT for access to areas along St. Charles Rock Road and for any traffic control or ingress and egress additions along St. Charles Rock Road in the vicinity of the Site entrance; and

- Obtain legal and physical access from AAA Trailer for testing and if necessary remediation of the Lot 2A2, and possibly for implementation of remedial actions that may need to be performed along the property boundary (e.g., regrading, fencing, etc. in Area 2).

6.2.8.6.7 Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity

As discussed in Section 4.3.5.4, four off-site disposal facilities that could accept excavated RIM from the West Lake Landfill OU-1 have been identified. At least three of these facilities (located in Idaho, Utah, and Colorado) have accepted radiologically-impacted soil from projects or sites in the United States, although none of them have previously accepted radiologically-impacted soil mixed with solid waste. All four of the identified facilities have available capacity to accept the estimated volume of RIM from the Site. The volumetric rate of acceptance for all facilities would be limited by the number of IM containers and railcars that could be provided and loaded at or near the Site, as well as the number that could be unloaded at or near the disposal facility. Off-site treatment, storage and disposal may be required in the event that hazardous wastes or RACM are encountered in the overburden or RIM excavated from Areas 1 and 2.

The identified facilities are also permitted to: (1) accept liquid wastes, should any stormwater that may accumulate in excavations during RIM excavation become contaminated and require disposal off-site; (2) accept mixed wastes if mixed wastes are encountered during excavation; and (3) treat soil and/or debris that contains hazardous waste or mixed waste.

As discussed in Section 3.1.4.1, the CERCLA OSR requires that waste materials removed from a CERCLA site be placed only in a facility operating in compliance with RCRA or other applicable Federal or State requirements. EPA makes such determinations every 60 days. The compliance status of an off-site disposal facility would need to be evaluated during remedial design and would need to be regularly evaluated and updated during remedy implementation.

Offsite treatment and discharge of any leachate that may be encountered or stormwater that may contact waste materials during the landfill re-contouring activities could also be required. Off-site treatment and discharge of any leachate that may be encountered or stormwater that may contact RIM during the landfill excavation activities could also be required. Initial discussions with MSD indicated that they are willing to accept leachate and contact stormwater. Initial discussions with the Earth City Flood Control District indicated a willingness to accept stormwater, subject to installation of additional stormwater detention/retention capacity.

6.2.8.6.8 Availability of Necessary Equipment and Specialists

Materials, equipment and personnel required for excavation and transport of RIM to an off-site disposal facility are readily available. Trained health physics technicians and specialized equipment required to monitor personnel, monitor environmental conditions, and assist in directing the RIM excavation sequencing are also available.

As discussed above, there are a limited number of disposal facilities that can accept these types of wastes, and most of these have stringent waste acceptance criteria which may limit the ability of some of the facilities to receive the wastes.

Availability of rail service, particularly the number of rail cars that can be made available and switched daily by the railroad, would also affect the production rate of RIM excavation and disposal and therefore the cost. This constraint may be negated if all, or the majority of the waste can be shipped by truck to the US Ecology facility in Michigan.

All the materials, equipment, and personnel necessary to remove the designated portion of the RIM and to regrade and construct the engineered landfill cover over Areas 1 and 2 after the designated portion of the RIM (*i.e.*, RIM that poses a potential risk to future industrial workers) has been removed are readily available. The necessary technologies have been generally proven through application at other landfills. The implementability and potential cost of the covers would be influenced by the availability and location of clean cover materials and/or off-site borrow sources at the time this alternative would be implemented. Potential vendors of rock, clay, and soil were contacted during the development of the FS (EMSI, 2006) and during preparation of the Remedial Design Work Plan for the ROD-selected remedy (EMSI, 2008) regarding availability, and the availability of some of the materials was verified in conjunction with construction of the NCC. Information obtained from the vendors at these times indicated that rock, clay, and clean cover material were readily available from sources located near the Site. If these local sources of cover materials become exhausted prior to or during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

The necessary materials, equipment, and personnel required for assessment and removal of RIM that may be present at the Buffer Zone/Lot 2A2 above unrestricted use levels, and to implement the institutional controls and monitoring components of this alternative, are also readily available.

6.2.8.6.9 Availability of Prospective Technologies

The Risk-Based Partial Excavation Alternative is based on proven, established, and commonly-used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.8.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the Risk-Based Partial Excavation Alternative are included in Appendix K-8 and summarized on Table 6-1. Conceptual excavation, backfill, and bottom and top of final cover grading plans, as well as stormwater control features used as the basis for the Risk-Based Partial Excavation Alternative capital cost estimate are provided in Appendix M. The estimated cost to conduct the Risk-Based Partial

Excavation Alternative (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $187,000,000. This cost estimate is based in part on unit costs provided by US Ecology. The estimated annual OM&M costs range from $173,000 to $301,000 per year depending upon the specific activities that occur each year (e.g., higher costs for years with additional environmental monitoring and years when landfill cover repairs and 5-year reviews may occur). The cost estimates provided in this FFS are feasibility-level cost estimates which were developed to a level of accuracy such that the actual costs incurred to implement this alternative are expected to fall within a range bounded by 50% above and 30% below these estimates.

The present-worth costs of the Risk-Based Partial Excavation Alternative are projected to be $165 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 0.7%, the present worth costs would be $189 million. The total non-discounted costs for the Risk-Based Partial Excavation Alternative over 30 years are projected to be $193 million.

Given the long life of the radionuclides present at OU-1, the costs for the Risk-Based Partial Excavation Alternative were also evaluated for 200- and 1,000-year periods. The total non-discounted costs of the Risk-Based Partial Excavation Alternative are projected to be $224 million over a 200-year period. The total present-worth costs of the Risk-Based Partial Excavation Alternative over 200-years are projected to be $165 million based on a 7% discount rate or $204 million based on a 0.7% discount rate over a 200-year period. The total non-discounted costs of the Risk-Based Partial Excavation Alternative are projected to be $374 million over a 1,000-year period. The present-worth costs over a 1,000-year period are projected to be $165 million based on a 7% discount rate or $211 million based on a 0.7% discount rate.

For purposes of demonstrating how much shipping of mixed waste could influence costs, it was assumed that mixed waste would represent 0.5% of the sum of the volumes of overburden wastes (88,000 bcy) and RIM (15,570 bcy) for the Risk-Based Partial Excavation Alternative. Accounting for daily cover and the volume increase that would occur upon excavation and assuming 0.5% is hazardous/mixed wastes results in 730 lcy of hazardous waste and 130 lcy of mixed waste. The incremental additional costs for handling, sampling/analysis, and treating of mixed waste for this alternative are estimated to range from $3,000 to $67,000 (Appendix K-10). The additional cost for handling, sampling/analysis, shipping, treating, and disposal of hazardous waste from excavation of overburden material is estimated to be $151,000 to $568,000 (Appendix K-10). These ranges of costs primarily result from variations in the fees charged by the off-site disposal facilities and uncertainties associated with the nature of such wastes and the required method of treatment. Therefore, the additional costs that may be incurred if mixed and hazardous wastes are encountered during overburden relocation and RIM excavation for the Risk-Based Partial Excavation Alternative, could range from approximately $154,000 to $635,000 (Appendix K-10). If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher.

7 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a comparative analysis of the No Action alternative, the ROD-selected remedy, the UMTRCA cover alternative, the full excavation of RIM with off-site disposal alternative and the full excavation of RIM with on-site disposal alternative, and the three partial excavation alternatives. The comparative analysis is based on the conceptual designs[78] of the alternatives presented in Section 5 and the evaluations of each of the alternatives relative to the NCP criteria presented in Section 6. The relative performance of each alternative, including advantages and disadvantages, is compared to the performance of the other alternatives for each of the threshold (subsection 7.1) and primary balancing (subsection 7.2) criteria prescribed in the NCP, as previously discussed in Section 6 and summarized below.

Threshold Criteria:
- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria:
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

As discussed in Section 6, the NCP "modifying criteria" (state acceptance and community acceptance) will be evaluated by EPA as part of any decision process that may be undertaken by EPA after completion of the FFS. Therefore, a comparison of alternatives using the modifying criteria is beyond the scope of this FFS, and is not undertaken here.

The comparative analysis identifies the general similarities and differences between the alternatives, the relative advantages and disadvantages of each alternative, and trade-offs among the alternatives in terms of the NCP criteria. The purpose of the comparative analysis is to provide information for a balanced remedy selection. The results of this comparative analysis are discussed below and summarized on Table 7-1.

[78] The conceptual designs of the alternatives presented in Section 5 were developed to provide a basis for evaluation of the anticipated performance, long-term and short-term risks, construction schedules, costs and other factors required for evaluation of the NCP criteria.

7.1 Threshold Criteria

Two of the nine criteria specified in the NCP relate directly to statutory findings that must ultimately be made in the ROD. These two criteria are (1) overall protection of human health and the environment, and (2) compliance with ARARs. They are classified as threshold criteria, as each alternative must meet both of these two criteria.

7.1.1 Overall Protection of Human Health and the Environment

This criterion addresses how risks would be eliminated, reduced, or controlled by each remedial alternative to provide short- and long-term protection of human health and the environment from unacceptable risks posed by contaminants present at the Site.

Based on the results of the updated BRA evaluations (Auxier, 2017), conditions associated with OU-1 do not currently pose an unacceptable risk to on-site workers or the off-site community. These analyses also indicated that the potential risks posed to a future (1,000 year) outdoor storage yard worker working in Areas 1 and 2, a future (1,000 year) off-site farmer to the north or west of the Site, or a future (1,000 year) off-site commercial building user to the north or on Lot 2A2 could be above the generally accepted risk range used by EPA. Therefore, the No Action alternative would not be adequately protective of human health. The potential for future leaching to groundwater or erosion and transport of waste or radionuclides by stormwater also indicates that the No Action alternative would not be protective of the environment.

All of the other alternatives are expected to be protective of human health and the environment through the use of engineered containment, alone or in conjunction with full or partial removal of RIM, combined with long-term surveillance and maintenance, and institutional controls on land and resource use.

Excavation of RIM under the full excavation of RIM and partial excavation alternatives and installation of a new engineered landfill cover under all of the alternatives would reduce potential risks from exposure to external gamma radiation or radon gas emissions from the RIM in Areas 1 and 2. Installation of a new engineered landfill cover over Areas 1 and 2 is included as part of all of the remedial alternatives. This landfill cover would eliminate potential risks associated with inhalation or ingestion of contaminated soils or wastes, dermal contact with contaminated soils or wastes, and wind dispersal of gases or fugitive dust. It would also reduce the potential for infiltration of precipitation and thus the potential for leaching of contaminants from wastes into groundwater.

Long-term maintenance of the engineered cover included under each remedial alternative, as well as monitoring of the groundwater and subsurface occurrences of landfill gas and radon, would ensure that each remedial action functions as intended and remains protective. The institutional controls included as part of each remedial alternative would ensure that land and resource uses are consistent with permanent waste disposal. These use restrictions address the presence of radionuclides and chemical constituents within the waste mass under the ROD-selected remedy and partial excavation alternatives, as well as the presence of chemical constituents under the full excavation of RIM alternative.

Summary of Overall Protection of Public Health and the Environment – All of the alternatives, except No Action, would be protective of public health and the environment.

7.1.2 Compliance with ARARs

An alternative must comply with Federal and State ARARs in order to be selected as a remedy, unless a waiver is obtained for any particular ARAR. ARARs that may be potentially applicable or relevant and appropriate to the remedial alternatives are summarized on Tables 3-1 through 3-3.

7.1.2.1 Chemical-Specific ARARs

As discussed in Section 6.2.1.2, the No Action alternative is expected to meet some but not all of the potential chemical-specific ARARs. All of the other remedial alternatives will meet the chemical-specific ARARs. These include: the UMTRCA and NESHAP standards for radon emissions; the UMTRCA standards for cleanup of contaminated land, as modified by the EPA OSWER Directives regarding use of these standards at Superfund sites; the UMTRCA groundwater protection standards; the Nuclear Regulatory Commission (NRC) Criterion 6(6) relative benchmark dose for radionuclides; the NRC radiation protection standards; the maximum concentrations for groundwater protection under the UMTRCA standards; and the Missouri maximum contaminant levels (MCLs). The alternatives are also expected to meet the requirements of various TBCs including OSWER Directives 9200.4-18 and 9200.4-25 regarding cleanup of radionuclides, Directive 9285.6-20 regarding radiation risk assessment, Directive 9200.4-23 regarding ARARs, 9200.4-25P regarding use of the benchmark dose criterion, Directive 9283.1-14 regarding uranium drinking water standards, and EPA's December 21, 2016 Memorandum regarding non-cancer oral reference dose for uranium.

7.1.2.2 Location-Specific ARARs

The entire Site is located outside of the 100-year floodplain. Therefore, all of the alternatives (including the No Action alternative) would meet the location-specific ARARs found in the Missouri Solid Waste Management regulations for landfills located within the 100-year floodplain and Executive Order 11988 relative to management of activities that may occur within or otherwise affect the 100-year floodplain. As discussed in Section 2.1.6, evaluations of the floodplain by FEMA indicate that with the exception of the easternmost portions of Areas 1 and

2 (which do not contain waste materials), Areas 1 and 2 are also located outside of the area of the 500-year floodplain that is protected by levees. The Buffer Zone and Lot 2A2 are located within the area of the 500-year floodplain that is protected by levees.

The only alternative that includes construction of a new landfill unit is the Full Excavation with On-Site Disposal Alternative. The only available unused space on which to locate a new on-site disposal cell is the location of the current Bridgeton Landfill soil borrow/stockpile area. This location was considered for evaluation of the Full Excavation with On-Site Disposal Alternative. However, this area is located within 10,000 feet of the end of the westernmost runway at Lambert St. Louis International Airport and, therefore, this alternative may not comply with the Missouri Solid Waste Management regulations restriction on siting of landfills within 10,000 feet of an airport runway. FFA guidance related to siting of new landfills, although not an ARAR, may be a TBC. That guidance recommends siting new landfills no less than 10,000 feet from airports used by turbine powered aircraft and identifies a prohibition on new MSWLFs within 6 miles of certain airports. In addition, the St. Louis Airport Authority currently possesses a negative easement for the majority of the Site, including the soil borrow/stockpile area, all of Area 1, and the southern portion of Area 2.

Alternate on-site locations outside of 10,000 feet of the runway have been identified, including locations on top of Closed Demolition Landfill or in the northern portion of Areas 2; however, this latter location would require removal of the existing waste material (including RIM) prior to construction of a new disposal cell. The potential for use of these other locations would require additional evaluation in order to determine their suitability for a new, engineered disposal cell meeting UMTRCA design and longevity requirements. Therefore, it is likely that the Full Excavation with On-Site Disposal Alternative may not comply with ARARs or TBCs related to siting of new landfill units near airports.

Because all of the alternatives include regrading and relocation of the existing waste materials to one degree of the other, including within portions of Site located within 10,000 feet of the end of the airport runway, all of the alternatives have the potential to increase bird congregation and activity that could affect aircraft operations. The longer the duration of the excavation and exposure of wastes, and the greater the volumes of wastes exposed, the greater the anticipated bird activity and associated risks. The Missouri Solid Waste Management regulation requirements for airport safety require owners or operators of sanitary landfills located within 10,000 feet of an airport runway end-used by turbojet aircraft to demonstrate to MDNR that a landfill is designed and operated such that it does not pose a bird hazard to aircraft. Waste excavation under the complete and partial excavation alternatives and waste regrading activities under all of the remedial alternatives (except for No Action Alternative) would also need to be performed in a manner that minimizes attractions for birds in order to meet the requirements of the TBC including the FAA ROD and guidance documents and the requirements of the Negative Easement held by the City of St. Louis. Specifically, an avian management plan that incorporates the various techniques described in Section 4.3.6.2 of this FFS would need to be developed and approved by the appropriate entities. Such a plan would also be of interest to the FAA and the Airport Authority, as well as the USDA. The FAA has stated, “[t]o date, no [landfill] facility has been able to demonstrate an ability to reduce and sustain hazardous wildlife to levels that existed before the putrescible-waste landfill began operating." (FAA Advisory Circular 150/5200-33B at page 16, August 2007). Preliminary bird mitigation plans were previously developed on behalf of Bridgeton Landfill, LLC (LGL, Ltd, 2015) as part of the Isolation Barrier Alternatives Assessment (EMSI, et al., 2014 and 2015) and were expected to be effective at controlling bird populations during the waste excavation activities associated with construction of a potential isolation barrier (each of which such proposed activities were expected to last less than one year). Detailed bird mitigation plans would need to be developed and determined to be effective for any alternative that may be selected for the Site. Based on the assumption that an effective bird mitigation plan can be developed, it is currently anticipated that all of the alternatives would comply with this requirement.

7.1.2.3 Action-Specific ARARs

Because there are no active engineering measures or waste handling, treatment, or disposal activities associated with the No Action alternative, there are no action-specific ARARs for the No Action alternative. All of the other remedial alternatives would meet the requirements of the action-specific ARARs. In particular, all of the other remedial alternatives would meet the UMTRCA standards for control of residual radioactive materials, Missouri closure and post-closure standards of the solid waste regulations, and the NRC radiation protection standards.

For all of the alternatives that would result in RIM remaining in Areas 1 and 2, the engineered cover to be installed over these areas would meet the UMTRCA design and performance standards. The conceptual design of the engineered cover included in the UMTRCA cover alternative and the three partial excavation alternatives was primarily focused on the UMTRCA performance standards, and is consistent with the conceptual cover designs used at UMTRCA sites. The design of the cover systems included under all the alternatives (except the full excavation of RIM alternative) would need to be sufficiently thick to shield against gamma radiation and attenuate radon emissions under both current and future conditions (including projected in-growth of radium from thorium decay over time). In addition, a layer of rock (biointrusion layer) would be included in the design of all the cover systems to address the longevity criteria of the UMTRCA standards. The design of the UMTRCA cover would place the rock layer above the low-permeability layer to provide long-term protection against burrowing animals, vegetation roots, or erosion from impacting the low-permeability layer. The design of the cover included in the ROD-selected remedy would place the biointrusion layer beneath the low-permeability layer to prevent burrowing animals or erosion from exposing the waste materials. Relocation of the rock layer from beneath the low-permeability layer to above it would provide increased protection of the low-permeability layer. The UMTCRA cover design also includes an option for the use of a rock mulch in the upper portion of the vegetative layer to provide protection against wind or water erosion in the event of loss of some or all vegetation, and therefore may potentially provide increased longevity of the cover system.

All of the alternatives would also meet the design standards for solid waste landfill covers established by the Missouri Solid Waste Management regulations. For the full excavation of RIM alternatives, all the material containing radium and/or thorium levels above those that would allow for unrestricted use is assumed to have been removed; therefore, the design of the engineered covers for Areas 1 and 2 would only need to meet the standards for MSW landfills established by the Missouri Solid Waste Management regulations.

All of the alternatives are expected to comply with the other action-specific ARARs, such as the Missouri stormwater regulations relative to construction activities and the bird mitigation requirements of the Missouri Solid Waste Regulations.

The off-site disposal component of the partial excavation and the full excavation of RIM alternatives would also need to be designed and implemented to meet the requirements of the CERCLA Off-Site Rule, DOT and NRC requirements for transport of radioactive materials/ wastes, and the waste acceptance criteria (WAC) of any off-site disposal facility. A Stennett analysis would also be required for off-site disposal at any facility that is not licensed by the NRC. It is anticipated that all of these requirements can be met.

Additional action-specific ARARs would apply to the Full Excavation with On-Site Disposal Alternative. The design, operation, closure, monitoring and post-closure of the on-site cell would need to meet the applicable UMTRCA standards in 40 C.F.R. Part 192, Subpart D, the NRC criteria for disposition of radioactive wastes, and the Missouri Solid Waste Regulations. The design of the on-site cell would also meet the requirements of the July 1989 Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments (EPA, 1989c) and the April 2004 (Draft) Technical Guidance for RCRA/CERCLA Final Covers (EPA, 2004b), both of which are considered to be TBCs for an on-site disposal cell.

Summary of Compliance with ARARs – All of the alternatives, except for the No Action alternative (and certain aspects of the Full Excavation with On-Site Disposal alternative), are anticipated to be able to meet chemical-, location- and action-specific ARARs. The design of the engineered cover system included in the UMTRCA cover and three partial excavation alternatives would be more protective of the low-permeability layer and therefore could increase the longevity of the performance of the cover system relative to the current design of the OU-1 ROD-selected remedy. The full excavation of RIM with off-site disposal and partial excavation alternatives would meet the DOT and NRC requirements for shipment of radioactive wastes, the WAC for the off-site disposal facility(ies), and the criteria of the CERCLA Off-Site Rule. The Full Excavation with On-Site Disposal alternative, however, may not be able to meet the siting requirements of the Missouri Solid Waste Regulations, the TBCs relative to landfill siting contained in the FAA guidance or the terms of the negative easement on most of the landfill property that is held by the St. Louis Airport Authority.

7.2 Primary Balancing Criteria

The five NCP primary balancing criteria are: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility, or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost. Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria represent the main technical criteria upon which the alternatives evaluation is based, and provide the primary basis for differentiation among the various alternatives.

Since the No Action Alternative does not meet the threshold criteria, it is not included in the evaluation of the primary balancing criteria. Therefore, the discussion of the primary balancing criteria only considers the other alternatives (*i.e.*, ROD-selected remedy, UMTRCA cover alternative, full excavation of RIM with off-site or on-site disposal alternatives, and the three partial excavation alternatives).

7.2.1 Long-Term Effectiveness and Permanence

This criterion addresses the risks that may remain at a site after the remedial action objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by the wastes that remain at the site.

7.2.1.1 Magnitude of Residual Risks

Although conditions associated with OU-1 currently do not pose an unacceptable risk to on-site workers or the off-site community, the BRA analyses indicated that the potential risks posed to a future (1,000 year) outdoor storage yard worker in Areas 1 and 2, a future (1,000 year) off-site farmer to the north or west of the Site, or a future (1,000 year) off-site commercial building user on Lot 2A2 or north of the Site could be above the generally accepted risk range used by EPA in CERCLA actions (Auxier, 2017) if no remedial action is taken at the Site. None of the remedial alternatives pose long-term radiological or chemical exposure-related risks to on-site workers or the general public above EPA's accepted risk range after completion of the remedial action. The long-term risks associated with each of the alternatives are all projected to be within or below EPA's acceptable risk range. Specifically, the estimated residual cancer risks posed to the potentially maximally exposed individual (*i.e.*, a future outdoor storage yard worker in Area 1 or 2 for all of the alternatives except for the on-site cell alternative for which the resident is the MEI) under all of the remedial alternatives after 1, 1,000 and 9,000 years are projected to be within or below EPA's target risk range of 1×10^{-6} to 1×10^{-4} (Tables 7-1 and 7-2). The projected future risks at 1,000 years are lowest (9.3×10^{-9}) for the Risk-Based Partial Excavation Alternative (the additional 2 plus feet of non-RIM refuse results in an effective cover thickness of 7 plus feet which provides greater radon attenuation), followed by 5.4×10^{-8} for the Full Excavation with Off-Site Disposal (which only includes a 3-foot thick cover), and 2.7×10^{-7} for the 1,000 pCi/g partial excavation alternative. The projected risks for the other four alternatives range from 2.3 to 7.3 x 10^{-6}. Projected radiation doses after 1,000 years of radium in-growth for all of the remedial alternatives are less than 0.02 mrem/year, which is below the limit of 100 mrem per year established by NRC for the general public and the 12 mrem per year EPA considers for evaluation of the protectiveness of ARARs (EPA, 2014e). Detailed information regarding the estimated potential long-term risks and estimated radiation doses relative to a future on-site storage yard worker or other potential receptors associated with each remedial alternative is provided as part of the assessment of risks included as Appendix H.

7.2.1.2 Adequacy and Reliability of Controls

All of the remedial alternatives result in some amount of waste materials remaining on-site, thereby necessitating installation, maintenance and monitoring of engineered containment structures and institutional controls. Engineering measures are the primary method that would be used to prevent exposure to and control waste materials that remain on-site. The primary engineering measures included in the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives are the construction, inspection, and maintenance of multi-layer engineered landfill cover systems over Areas 1 and 2 that are designed not only to prevent direct contact with waste materials but also to reduce potential exposures to gamma radiation and radon, including increased levels of gamma radiation and radon emissions occurring after 1,000 years of radioactive decay of thorium. The full excavation alternatives would remove all of the RIM from Areas 1 and 2 and dispose of it in engineered disposal cells (either off-site or on-site). Therefore, once such a remedy was fully implemented, these alternatives would provide a high degree, or in the case of the off-site disposal alternative the highest degree of protection against possible exposures to gamma radiation, direct contact with or ingestion of radionuclides, or inhalation of radon or radionuclides in particulate matter. The partial excavation alternatives rely on removal of portions of the RIM combined with engineered containment for protection from exposure to the remaining radionuclide or chemical constituents in Areas 1 and 2. All three partial excavation alternatives are projected to initially (Year 1) result in the same levels of long-term risks and therefore the same levels of protection (see Tables 7-1 and 7-2). Due to the greater thickness of non-RIM and cover materials and resultant greater degree of radon attenuation, the longer-term risks (Years 1,000 and 9,000) are projected to be less for the Risk-Based Partial Excavation Alternative (Tables 7-1 and 7-2). Of the three partial excavation alternatives, the Partial Excavation to 52.9 pCi/g and 16-foot depth would remove the largest volume of RIM, and the Partial Excavation to 1,000 pCi/g would remove the RIM with the highest activity levels.

The ROD-selected remedy and the UMTRCA cover alternative rely on engineered containment for protection from exposure to radionuclide or chemical constituents in Areas 1 and 2 and to contain such constituents from migrating into the environment. The partial excavation alternatives rely on removal of portions of the RIM combined with engineered containment for the remaining radionuclide or chemical constituents in Areas 1 and 2 to contain such constituents from migrating into the environment. The full excavation alternatives include removal of all

RIM from Areas 1 and 2 and therefore would provide the greatest levels of protection from potential leaching of radionuclides from Areas 1 and 2. By disposing of all of the RIM offsite, the Full Excavation of RIM with Off-Site Disposal Alternative would provide the greatest degree of protection from potential leaching of radionuclides from Areas 1 and 2. The Full Excavation with On-Site Disposal, by disposing of RIM in a lined disposal cell, would provide a similar level of protection from leaching of radionuclides from Areas 1 and 2.

The Full Excavation of RIM with Off-Site Disposal alternative entails removal and off-site disposal of all RIM containing radionuclides at levels above those that would allow for unrestricted use. The Full Excavation of RIM with On-Site Disposal alternative entails removal of RIM from Ares 1 and 2 and disposal in a new engineered on-site disposal cell. Both of the full excavation of RIM alternatives rely on placement of an engineered landfill cover to provide protection from exposure to chemical constituents that would continue to remain in Areas 1 and 2 and to prevent such constituents from migrating into the environment.

The engineered cover system included in the ROD-selected remedy would include a layer of rock or other suitable material to reduce the potential for biointrusion or erosion into the underlying waste materials. The UMTRCA cover system included as part of the UMTRCA cover alternative and the partial excavation alternatives would include a layer of rock above the low-permeability layer to reduce the potential for biointrusion, rooting of vegetation, or erosion into the low-permeability layer. As such, the UMTRCA cover system would provide greater protection of the low-permeability layer, which is the component that provides for radon attenuation and reduction of infiltration. The UMTRCA cover may also include a rock mulch layer in the upper portion of the vegetative layer to provide additional protection from wind or water erosion in the event of loss of some of the vegetation in response to drought conditions. These features of the UMTRCA cover design would increase the long-term permanence of the cover system as compared to the cover system included in ROD-selected remedy.

Because all of the RIM is anticipated to be removed under the two full excavation of RIM alternatives, these alternatives would not need to address potential gamma exposures or radon emissions from Areas 1 and 2 and therefore would not include the rock/rubble layer that would be part of the landfill cover system included under the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives.

All of the remedial alternatives rely on regrading of the landfill surface to promote drainage and construction, and on inspection and maintenance of multilayer covers to prevent or reduce the potential for infiltration of precipitation and the resulting potential of leaching of radionuclides or chemical constituents to groundwater. The full excavation of RIM alternative and the partial excavation alternatives include removal of at least some of the RIM from the Site, thus providing a corresponding additional level of effectiveness and permanence relative to gamma radiation, radon emissions and the potential leaching of radionuclides or chemical constituents to groundwater. The design of the UMTRCA cover includes a lower permeability clay layer (10^{-7} cm/sec) and also a geosynthetic liner, both of which would further reduce the potential for infiltration of precipitation and the leaching of radionuclide or chemical constituents, as compared to the clay layer included in the ROD-selected remedy and the full excavation of RIM alternatives (10^{-5} cm/sec). The on-site disposal alternative includes a double-lined bottom liner with leachate collection systems in addition to an UMTRCA cover and therefore would provide a greater degree of protection from leaching compared to the ROD-selected remedy, the UMTRCA cover alternative or the partial excavation alternatives. The performance and effectiveness of the engineered measures for each of the remedial alternatives is primarily based on the durability of natural earthen materials used to construct these measures. Natural earthen materials such as clay and rock are extremely durable and, with minimal maintenance and repair over time, are expected to remain effective for decades or centuries. The conceptual designs of the cover systems included in the ROD-selected remedy, the UMTRCA cover alternative, and the partial excavation alternatives have been determined to be effective at limiting exposures to projected gamma radiation and radon levels after 1,000 years of radioactive decay, using only the performance of those natural earthen components. The potential effects of erosion by precipitation, intrusion by woody vegetation or burrowing animals, or potential human actions that could affect any of the cover systems, including those for the full excavation alternatives, would necessitate regular and ongoing inspections and maintenance to ensure that the cover system continues to remain effective over time.

The engineering measures implemented under each remedial alternative would be augmented and supported by maintenance of the existing institutional controls at the Site and implementation of additional institutional controls, as necessary. Institutional controls would limit future uses of the land and resources at the Site so as to eliminate or restrict potential exposure to the wastes or contaminated media and to reduce the potential for future land uses to impact or reduce the effectiveness of the engineered measures. Areas 1 and 2 currently are solid waste disposal units and would remain as such under all of the remedial alternatives. Institutional controls would be necessary to restrict future land uses that could interfere with the landfill closure at Areas 1 and 2 for all alternatives, regardless of the presence of RIM. Modification and/or augmentation of the existing intuitional controls is expected to be performed during remedial design to incorporate the requirements of the Missouri Environmental Covenant Act or other revisions EPA identifies as necessary.

7.2.1.3 Climate Change and Potential Impacts of a Tornado

Potential effects of climate change were evaluated in Section 6 for each of the alternatives; pertinent considerations are briefly discussed below.

The vegetative layer included in the landfill covers for all of the alternatives could be vulnerable to potential increased occurrences of extreme temperatures, sustained changes in average temperatures, decreased precipitation, and an increase in drought occurrences. Increased temperatures or decreased precipitation/drought could affect the viability of the vegetation (*e.g.*, grasses) on the surface of the landfill cover. Any changes to the overall health of the vegetative cover would be readily identifiable by visual inspection. Therefore, although the vegetative cover may be vulnerable to potentially increased temperatures or drought conditions, the potential for impacts to the vegetative layer could be anticipated and readily identified in advance of any such occurrence. In addition, the design of the UMTRCA cover may include a rock mulch layer in the upper portion of the vegetative layer in order to protect against soil erosion by wind or water in the event of loss of the vegetation.

The CCL and GCL layers could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the low-permeability materials (CCL or GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation or increased radon emissions. Even without an engineered cover, the current radon emissions from the surfaces of Areas 1 and 2 are below the UMTRCA and NESHAP standards. Installation of an engineered cover will ensure that radon flux remains below these standards in the future (see prior discussion in Section 2.3.1 and also Appendix F). Therefore, even if desiccation of the low-permeability layer were to occur, the impacts to groundwater quality or radon emissions are not expected to be significant. More importantly, the vegetative layer would show significant signs of stress from increased temperatures/drought prior to the occurrence of any impacts to the underlying low-permeability layer, thereby providing advance notice of a potential impact to the CCL/GCL. Therefore, although the low-permeability layer could potentially be vulnerable to effects of increased temperature or drought, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence. In the event that such impacts were to occur, additional maintenance activities such as temporary irrigation to maintain the grass cover, overseeding with grasses that required less water, placement of additional soil to repair erosion, or other typical cover repair measures would be implemented. Furthermore, such impacts (if realized) are not expected to result in a release of contamination.

Increased heavy precipitation events could result in erosion of the vegetation layer and, if left untended, could result in erosion of the underlying layers and lead to potential exposure of the waste materials. Any erosion of the landfill cover would be readily identifiable by visual inspection. The design of an UMTRCA cover is anticipated to include a rock mulch layer intended to reduce the potential for erosion of the vegetative layer. Given the overall 5-foot thickness of the landfill cover and the inclusion of the 2-foot-thick rock layer in the base of the cover system for the ROD-selected remedy and above the low-permeability layer for the UMTRCA cover and partial excavation alternatives, stormwater erosion—even under the most severe storm events—is not anticipated to result in erosion down through the entire landfill cover. Inclusion of the biointrusion layer above the low-permeability layer in the UMTRCA cover design would provide greater protection of the key components used to limit radon emissions and infiltration of precipitation. Since the landfill cover under the full excavation of RIM alternative would not include that 2-foot-thick rock layer in the base of the cover system, stormwater erosion under a severe storm event could potentially erode more easily down through the entire landfill cover, resulting in temporary exposure of non-radiological waste materials.

Heavy precipitation events could also impact the integrity or performance of stormwater drainage conveyance structures, including erosion of drainage channels, damage to or bypassing of let-down and erosion control structures and features, or damage to stormwater detention structures. Heavy precipitation events could also temporarily restrict access to portions of the landfill cover, stormwater control structures, and environmental monitoring points, thereby causing delays in implementation of repairs (if any are needed). The vegetation layer and stormwater controls are therefore potentially vulnerable to impacts from heavy precipitation events; however, due to the overall thickness and design of the landfill cover, any potential impacts are not expected to result in exposure of the waste material or release of contamination. Further, any impacts that occur could be readily addressed as part of normal maintenance and repair of the landfill cover, including localized regrading, repair, and replacement of cover material, and repair or implementation of stormwater controls in response to any damage that may occur.

None of the alternatives are expected to be impacted by flooding that may occur in the vicinity of the Site. The area to the north and west of Area 2 (*e.g.*, Lot 2A2 and the Buffer Zone) could potentially be subject to flooding by the Missouri River associated with a 500-year, 0.2% flood risk; however, this area is protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park. However, all of the alternatives include removal of any soil from these areas (Lot 2A2 and the Buffer Zone) that would pose a risk for unrestricted use or otherwise contains radionuclides at levels that exceed ARARs. Therefore, upon completion of any of the remedial alternatives, these areas would not pose a risk of release in the event of flooding. As previously discussed in Section 2.1.6, the current flood insurance rate map (FIRM) by FEMA indicates that, with the exception of the easternmost portions of Areas 1 and 2 (which do not contain waste materials or RIM), Areas 1 and 2 are located outside of the 500-year floodplain. In the event of a failure of the levee system during a 500-year plus recurrence flood event, flood waters could reach the toe of Area 2. However, the conceptual designs for the ROD-selected remedy and the UMTRCA cover system include construction of a perimeter (starter) berm along the toe of the entire northern boundary of Area 2, which would result in placement of approximately 26 feet of rock and soil between any possible floodwaters and the landfilled waste. This perimeter berm may be further protected from flooding by placement of rip-rap along the base of the berm. Therefore, although increased occurrences of flooding in the area of the Site may be a potential impact of climate change, none of the remedial alternatives are expected to be vulnerable to flooding.

Because all of the alternatives, except for the Full Excavation with Off-Site Disposal alternative, would leave some RIM on Site, and the RIM will continue to exceed unrestricted use levels for thousands of years, the potential for changes in the river course pose some uncertainty regarding long-term stability of the waste material. The Site is located on the geomorphic floodplain. Although the Missouri River is currently channelized and levees exist in the area of the Site that prevent flooding, over a period of tens of thousands of years, it is possible that the river course could change, resulting in the river being located either closer to or further away from the Site.

Severe weather events could result in erosion of portions of the engineered landfill cover over Areas 1 and 2 or the new on-site cell; however, the overall thickness of the cover systems (e.g., 5 feet for all of the alternatives except for Full Excavation with Off-Site Disposal which would be 3 feet thick) should prevent exposure of the waste. The conceptual design of the UMTRCA cover (included in all alternatives except for the ROD-Selected Remedy and the Full Excavation with Off-Site Disposal) includes an upper erosion/biointrusion layer above the low-permeability layer which should protect the underlying low-permeability layer. The design of the UMTRCA may also be augmented to include a rock mulch layer to limit erosion in the event of loss of vegetation. The proposed modification to the ROD-selected remedy and all of the alternatives include construction of starter berms along the base of the steeper portions of the landfill slopes which should also protected against erosion. Any erosion of other damage to the landfill cover resulting from extreme weather events should be easily identified and repaired using standard landfill operations techniques. Of all of the alternatives, the Full Excavation with Off-Site Disposal would, due to the thinner nature of the landfill cover, have the greatest potential for severe weather to cause erosion that could expose waste; however, under this alternative, all of the RIM would be removed and therefore no exposure to or release of radionuclides above unrestricted levels would occur.

An evaluation of the potential impacts of a tornado was included as part of the evaluation of the long-term effectiveness of each of the alternatives in Section 6. This evaluation concluded that none of the alternatives are vulnerable to such impacts (see Section 6.2.2.3.3). No technical data or evaluations of the potential impacts of a tornado on the vegetative covers were identified. However, based on published assessments and photographic documentation, it was shown that historically, grassy areas did not display visible impacts in areas damaged or destroyed by tornadoes, so a tornado is not expected to damage the vegetative layer. Even if a tornado were to damage the vegetation, such an impact is not considered to be significant because it could be easily identified and, due to the design and thickness of the engineered cover, would not result in exposure of the underlying waste or release of contamination. A tornado could damage or destroy above-ground infrastructure such as signage, fencing, or environmental monitoring equipment. However, such impacts are not considered to be significant because they would be readily identified and easily repaired or replaced. Therefore, none of the alternatives are considered to be vulnerable to impacts from a tornado.

Although the remedial alternatives are not considered to be vulnerable to effects of climate change, implementation of adaptive measures (discussed in Section 6) could be considered during remedial design to minimize any potential impacts from future climate change. For example, consideration could be given to reducing the final grades of the landfill surface under the complete and partial excavation alternatives from 5% to 2% to reduce the potential for erosion of the cover soil.

7.2.1.4 Subsurface Heating Event and Thermal Isolation Barrier

At EPA's request, a qualitative evaluation of the conditions and processes known to be associated with subsurface heating events at landfills was previously completed by the Respondents (EMSI, 2014e). EPA subsequently reviewed this study and, in a letter dated March 28, 2014, commented on the conclusions set forth therein. Those conclusions and EPA's observations and comments are as follows:

- The RIM disposed of in West Lake Areas 1 and 2 would not become more or less radioactive in the presence of heat. Likewise, the RIM is not explosive and would not become explosive in the presence of heat. EPA agreed with these conclusions (EPA, 2014).

- A subsurface heating event does not create conditions that could carry RIM particles or dust off the Site. The heat generated by such an event is not high enough to ignite non-RIM wastes or chemical compounds or to cause them to explode. EPA (2014) agreed with the second part of this conclusion but indicated that heating could affect the structural integrity of the cap resulting in permeation of the cap and possibly in creation of fissures that could extend down into the waste materials and could possibly allow for escape of fine particulates.

- An increase in subsurface temperatures may allow radon gas to more easily rise through the ground and reach the surface of the landfill than would otherwise occur, because heat would reduce the amount of moisture in the buried solid waste (trash), thereby increasing the amount of air between the soil particles and thus reducing the ability of the buried solid waste to retain radon below ground. Any radon gas that does make it to the surface would dissipate quickly in open air. This potential increase in the rate of release of radon gas at the surface of the landfill would be limited to the area of increased temperatures (regardless of the cause of such increase) and would quickly reach an equilibrium at a lower rate reflective of the rate of radon emanation. EPA also identified the potential for increased radon gas emissions as a possible result of increased temperatures or gas pressures associated with a reaction.

  The SSE evaluation concluded that in the unlikely event that increased subsurface temperatures were to occur in West Lake Area 1 or 2, this would not result in any additional long-term risks to people or the environment. EPA (2014) disagreed with this conclusion based on the potential for increased radon emissions and potential for increased leachate production.

- Any short-term risks associated with increased subsurface temperatures (regardless of the cause of such increase) would be due to the temporary increase in radon gas coming from the surface of Areas 1 and 2, assuming no cover is installed, or if the cover was not properly maintained. EPA (2014) also identified the potential for increased radon emissions and potential for increased leachate production as possible short-term impacts.

- These short-term risks can be addressed by designing, constructing, and maintaining the landfill cover required under all of the remedial alternatives and by the Missouri landfill closure regulations, and by maintaining the land use restrictions already in place on the entire Site that prevent certain land uses. EPA (2014) concluded that short-term risks may be present even with proper cap design and installation.

Based on the aforementioned conclusions, the primary potential impact that may occur due to a subsurface heating event would be a temporary, localized increase in radon emissions.

It is expected that all of the RIM above unrestricted levels would be removed from Areas 1 and 2 under the full excavation of RIM alternatives and either disposed of off-site or in a new engineered disposal cell that would be physically separated from the Bridgeton Landfill. Therefore, there is no potential impact to radionuclides from migration of a subsurface heating event for the two full excavation alternatives. Impacts of an independent subsurface heating event occurring within the newly engineered cell would be the same as evaluated above. Even with a potential short-term increase in radon emissions as a result of a heating event, the projected radon flux is estimated to meet ARARs for all remedial alternatives (Appendix E), especially after installation of a new landfill cover (Appendix F). Although there is not a consensus opinion on the potential for additional leachate generation, leachate collection is a contingent component of all the remedial alternatives since waste will be left in place. In the event additional leachate were generated, the Bridgeton Landfill leachate treatment plant has a capacity of 300,000 gallons per day which should be sufficient to treat any additional leachate that may be generated.

Destruction or modification of the waste material by increased temperatures could result in a reduction in volume which could cause subsidence and/or differential settlement of the waste mass. In turn, subsidence or differential settlement of the waste mass, whether as a result of a heating event or natural decomposition of the waste material over time, could result in displacement or disruption of an engineered cover system, thereby affecting the integrity and performance of the cover system. Such impacts would be prevented or mitigated through a combination of one or more of the types of actions previously implemented to address the increased temperatures in the South Quarry portion of the Bridgeton Landfill, including but not limited to:

- Installation and operation of a heat extraction isolation barrier (IB) or other engineering controls to prevent or limit migration of an SSR into Area 1 or Area 2;

- Installation and operation of landfill gas extraction, leachate collection, and/or temperature monitoring probes as necessary to monitor and/or mitigate any impacts that may be caused by increased temperatures; and

- Performance of routine or additional inspections of the engineered cover to identify potential differential settlement and possible disruption of the integrity of the cover system, followed by temporary placement of additional soil to fill areas of subsidence, repair the landfill cover, and reduce odor emissions, after which permanent repair or replacement of any portions of the cover system that have been adversely affected by such an event would be performed.

Due to the age and degree of decomposition of the waste materials located in Areas 1 and 2 (as discussed further below), the potential for occurrence of a subsurface heating event in these materials is believed to be less likely. Furthermore, the waste materials located in Areas 1 and 2 are relatively thin compared to the thicker landfills, such as those located in the deeper quarry landfill. That thicker waste provides a significant insulating effect that allows for sustained increases in temperature. The thinner nature of the waste materials in Areas 1 and 2 would likely result in reduced insulation by the waste material and an increased potential for heat loss along boundary conditions (ground surface at the top and rock/alluvium at the base). The lower degree of insulation and higher degree of heat loss associated with thinner waste materials would limit the degree to which temperatures could increase within the Area 1 and 2 waste masses.

In the event that a heating event were to occur near or within Area 1 or 2, EPA would promptly implement response actions, or require response actions to be implemented, to control or contain such a reaction and to mitigate any effects. Responses actions could include, but are not necessarily limited to, repair of landfill cover or other engineered systems affected by a reaction, installation of additional landfill cover materials such as EVOH (which serves as a radon barrier), implementation of heat extraction systems or physical barriers, implementation of or expansion of landfill gas extraction, implementation of or expansion of leachate collection, or other measures as appropriate. Such response actions would limit the timeframe for any emissions or other potential releases, thereby reducing the potential exposure durations for on-site workers or the community. These measures, as implemented in the South Quarry, have proven to be effective to mitigate the effects and extent of the reaction.

The low potential for an SSR to occur in Area 1 or 2, the measures Bridgeton Landfill has implemented to control and contain the existing reaction in the South Quarry and to provide early detection of any potential reaction in the North Quarry, and the anticipated timeliness of response actions required by EPA, all serve to lessen the potential for an SSR to impact radionuclide occurrences, migration or releases from Area 1 or 2 and potential risks to on-site workers or the community.

7.2.1.5 Environmental Justice Considerations

As discussed in Section 6.2.2.3.6, a screening-level analysis did not identify any environmental justice concerns relative to the Site. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are addressed as part of the Community Involvement Plan for the Site.

In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the evaluation of long-term effectiveness and permanence of the alternatives. Because no such communities were identified, no long-term impacts to such communities would occur in conjunction with implementation of any of the alternatives.

Summary of Long-Term Effectiveness and Permanence – All of the remedial alternatives (except No Action) will result in residual risks that are within or below EPA's accepted risk range. Although the full excavation of RIM alternative would remove all RIM from the Site, all of the alternatives result in some amount of waste materials remaining on-site. Therefore, all of the alternatives include installation of a new engineered landfill cover and inspection, maintenance and repair of the cover as necessary, institutional controls, and monitoring.

Because all RIM would be removed under the Full Excavation of RIM with Off-Site Disposal Alternative, with respect to radionuclides, this alternative would be more reliable and permanent than any of the other alternatives relative to eliminating potential exposure to or risks from radionuclides and reducing the potential for leaching of radionuclides.

The Full Excavation with On-Site Disposal Alternative would remove the RIM from Areas 1 and 2 and place it in an UMTRCA engineered cell that include components (e.g., liner system) associated with hazardous waste landfills. Therefore, this alternative would provide a greater level of effectiveness and permanence for eliminating potential exposures to or leaching of radionuclides than any of the partial excavation or containment alternatives and a nearly similar level to the off-site disposal alternatives.

The partial excavation alternatives, in addition to installation of new engineered landfill covers, include removal of some of the RIM and therefore potentially offer a greater level of effectiveness and permanence compared to the containment-only alternatives. Each of the partial excavation alternatives are based on different objectives: that is, removal of material with the highest activity levels under the 1,000 pCi/g alternative, removal of the uppermost material down to a level ten times above the unrestricted use standard under the 52.9 pCi/g alternative, or removal of material that would pose a risk to future industrial workers under the risk-based alternative. Because the risk-based alternative would reduce potential risks to future workers that may conduct activities on the surface of Areas 1 and 2, it is considered the most effective and permanent of the partial excavation options for reducing potential exposures to gamma radiation or radon. The 52.9 pCi/g alternative would also remove the uppermost RIM and therefore should be protective of future workers. By removing the highest activity material and RIM that is located deeper in the landfill, the 1,000 pCi/g should be the most effective and permanent of the three partial excavation alternatives for reducing the potential for leaching to groundwater. However, this last alternative would result in RIM containing radium and thorium below 1,000 pCi/g remaining at the Site, including RIM potentially located at relatively shallow depths, and therefore this alternative is not considered to be as effective or permanent for protection of future workers.

The cover systems for all of the alternatives would rely primarily on long-lasting earthen materials. The cover systems for the ROD-selected remedy, UMTRCA cover alternative, and partial excavation alternatives would be designed to include components necessary to increase the longevity of the performance of such systems. The UMTRCA cover would include a lower permeability clay layer and a geosynthetic liner, and therefore may provide greater long-term effectiveness relative to control of radon emissions and infiltration of precipitation and potential leaching to groundwater compared to the cover included in the ROD-selected remedy. Placement of the biointrusion layer above the low-permeability layer in the UMTRCA cover and partial excavation alternatives is expected to provide greater long-term permanence for the low-permeability layer, the key component for controlling radon emissions and limiting infiltration. All of the alternatives include actions (full excavation of RIM or cover designs) that will protect from current and future (1,000 year) exposures to gamma radiation and radon emissions including increases anticipated to occur due to radium in-growth from thorium decay over time.

Potential impacts from climate change, severe weather, or a tornado to any of the alternatives are not expected to result in exposure to or release of the waste materials. Furthermore, such impacts would be easily identified by stress to or loss of surface vegetation cover and/or visible erosion of the vegetative soil. Such impacts are easily repaired with conventional construction activities. Flooding is not expected to impact the performance of any of the alternatives because the waste materials in Areas 1 and 2 are not located within the floodplain, the Site and surrounding area is protected from flooding from the Missouri River by the Earth City levee and flood control system, the margins of the waste will include starter berms of earth and/or rock that will greatly limit the potential for flooding to contact or erode the waste material if it were to occur, and all of the alternatives other than full excavation of RIM may also include riprap along the toe of Area 2 for erosion protection. Although the Buffer Zone and Lot 2A2 are located within the area of the 500-year flood that is protected by levees, all of the alternatives include removal of any soil containing radionuclides above unrestricted levels from these locations. None of the alternatives are considered to be vulnerable to impacts from tornadoes. Removal of all of the RIM under the full excavation of RIM alternative would provide the most permanent method to prevent impacts from climate change, flooding, tornadoes, or other severe weather conditions. Removal of some of the RIM under the various partial excavation alternatives would reduce the amount of source material and therefore could reduce the potential for release of radionuclides in the event flooding of or adjacent to the landfill were to occur in the future. However, the containment systems included as part of the partial excavation and containment only alternatives would be designed and expected to protect against such impacts.

The primary impact that may occur if an SSR were to extend into or otherwise occur in Area 1 or 2 would be a temporary increase in radon emissions that are projected to be below the UMTRCA standard and radon NESHAP. Other impacts that may occur, such as damage to the landfill cover or additional leachate generation, could be addressed through standard landfill practices that are already in use at the Site. If a subsurface heating event were to occur within OU-1, specific engineering controls, if implemented appropriately, are predicted to manage potential effects such that unacceptable risks are expected to be avoided. An isolation barrier installed before implementation of a remedial alternative, particularly the full or partial excavation alternatives, would likely be affected by the implementation of any remedial actions. Conversely, installation of an isolation barrier after implementation of the remedy could, depending upon the nature and design of such a barrier, impact the remedy alternative. Installation of a heat extraction barrier consisting of heat extraction points would be expected to have minimal impact on an engineering landfill cover, assuming the standard procedures for repair and sealing of any penetrations through such a cover are implemented.

A screening-level analysis did not identify any environmental justice concerns relative to the Site. Because no such communities were identified, no long-term impacts to such communities would occur in conjunction with implementation of any of the alternatives.

7.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference to select remedial actions that employ treatment technologies which permanently and significantly reduce toxicity, mobility, or volume of hazardous substances as their principal element.

None of the alternatives include treatment technologies that would reduce the toxicity, mobility, or volume of the waste material through treatment. Treatment technologies are generally not applicable to solid waste landfills due to the overall large volume and heterogeneity of the wastes, which make treatment impracticable (EPA, 1991b and 1993b).

Radionuclides are naturally-occurring elements which cannot be fully neutralized or destroyed by treatment. Occurrences of radionuclides are dispersed within soil material that is further dispersed throughout portions of the overall heterogeneous matrix of municipal refuse, construction and demolition debris, and other non-impacted landfill materials within portions of Areas 1 and 2. Due to the highly heterogeneous nature of the waste materials, in-situ treatment techniques would likely be ineffective.

The heterogeneous nature of the solid waste materials and the dispersed nature of the radionuclide occurrences within the overall solid waste matrix, combined with the inability to neutralize or destroy radionuclides, would also make ex-situ treatment ineffective. Ex-situ treatment techniques such as solidification or stabilization could be used on the soil containing radionuclides if such soil could effectively be separated from the other components, including decomposed organic matter, unimpacted soil, and other fine-grained materials in the solid wastes.

Physical separation or segregation of soil from the solid waste could potentially reduce the volume of materials handled as RIM (but not the overall total volume of waste materials in Areas 1 and 2). Ex-situ physical separation processes used to separate impacted soil from solid wastes such as hand-picking of large, bulky items is applicable to all of the alternatives. Shredding and physical sorting with various fixed, vibrating, or rotating screens could potentially also be used to separate the soil fraction from other solid waste in order to reduce the volume of waste material that may need to be disposed at an off-site disposal facility under the Full Excavation of RIM with Off-Site Disposal or partial excavation alternatives. While not a “treatment” process, revolving cylindrical Trommel sieve screens have been used in conjunction with landfill mining and reclamation (LFMR) projects to separate materials by size, with the soil fraction passing through the screen. Because such processes have not been applied to a solid waste matrix that contains RIM, no information is available on the percentage of soil that may be retained in the solid waste materials after such separation. Any soil that would be retained on the solid waste material after physical separation of RIM would likely contain some radionuclides. However, the amount of such soil and the levels of radionuclides that may be retained cannot be determined or estimated from either the available literature or site data. Therefore, though the potential exists as part of the Full Excavation of RIM with Off-Site Disposal or some of the partial excavation alternatives to reduce the volume of RIM (but not the overall volume of waste materials at the Site), the potential viability of any physical separation technology cannot be determined based on existing information. Full-scale pilot testing of such a physical separation process during remedial design, using excavated materials from Area 1 and/or Area 2, would be necessary to evaluate the reduction in volume of RIM, as well as the effectiveness, implementability, and cost of the technology. Additional evaluation would also be necessary to assess the potential for increased short-term risk to workers and off-site receptors due to additional materials handling associated with pilot testing, or full-scale operation of any physical separation process. Use of these techniques could potentially reduce the amount of RIM that would need to be disposed in an on-site disposal cell under the Full Excavation with On-Site Disposal Alternative. However, because sufficient space should be available in an on-site cell to dispose of all of the RIM material without volume reduction, the potential exposures, risks, additional time and additional cost required for volume reduction may not be warranted for the on-site disposal alternative.

The lack of a measurable gamma signature from thorium-230 indicates that use of radiological segregation techniques that rely on measurements of gamma radiation to separate radionuclide soil from non-radionuclide soil—such as the segmented gate system—would not be effective except possibly for alternatives with high cleanup levels. Therefore, for most of the alternatives developed in this FFS, physical separation and/or radionuclide segregation are unlikely to be effective for the waste materials and radionuclides in Areas 1 and 2. Such techniques may potentially be usable for actions involving higher levels of radionuclides, such as those associated with the 1,000 pCi/g partial excavation alternative. Such actions would not require such a comprehensive physical separation to achieve the associated cleanup goal as would be required for the full excavation of RIM alternative, and are also expected to include measurable gamma activities associated with the radium occurrences that could be used to segregate radionuclide from non-radionuclide bearing soil. The potential effectiveness, implementability and cost-benefit of using such techniques relative to large scale disposal of any RIM removed as part of this alternative would have to be evaluated during remedial design.

Accordingly, under all of the alternatives, no treatment processes would be employed on-site. Because radionuclides cannot be destroyed or altered by physical, chemical, or biological treatment processes, treatment is not anticipated to occur at an off-site disposal facility, either. Solidification or encapsulation of solid waste and debris containing radionuclides may be necessary in conjunction with disposal at an off-site facility to minimize void spaces and/or future decomposition and associated consolidation of the solid waste materials. Therefore, there would not be any reduction in toxicity, mobility, or volume through treatment for RIM under any alternative.

To the extent that hazardous wastes or mixed wastes are encountered under any of the alternatives, such wastes would be shipped off-site and would be treated at the disposal facility in accordance with the hazardous waste regulations (e.g., EPA's Land Disposal Restriction (LDR) program and Universal Treatment Standards (UTS)) and in accordance with the permits and standard operating procedures of the receiving facility. Examples of treatment processes for hazardous wastes or mixed wastes include solidification/stabilization of soil and micro- or macro-encapsulation of debris. To the extent that treatment of any hazardous waste or mixed waste would be required for off-site disposal, stabilization or encapsulation treatment would result in a reduction of the mobility of the hazardous constituents or the radiological components of the waste. Toxicity and volume would not be reduced by these technologies, but may be reduced by other technologies potentially applicable to hazardous wastes that do not contain RIM, if such wastes were encountered during implementation of remedial action at the Site.

Summary of Reduction in Toxicity, Mobility, or Volume through Treatment – Radionuclides cannot be altered or destroyed by physical, chemical, or biological processes. In-situ stabilization and solidification techniques are not considered to be effective or implementable due to the heterogeneous nature of the overall solid waste matrix. Ex-situ physical separation and segregation of soil-sized material from the bulk of any solid waste that may be excavated could potentially reduce the volume of material that would need to be transported to and disposed of at an off-site facility. No prior application or demonstration of such processes for separating radiologically-impacted soil from solid waste were identified. Accordingly, the potential effectiveness, implementability and cost of such processes relative to the alternatives being considered for OU-1 could not be evaluated. Because the available literature does not contain any data or information on the degree of separation that potentially could be achieved by such techniques, the potential effectiveness of these processes could not be determined. To the extent that such physical separation does not result in complete or nearly complete separation of the soil fraction from the other solid waste materials, such techniques may not be effective in reducing the volume of material that may need to be disposed off-site. If the soil fraction can effectively be separated from the other solid wastes, a radiological segregation technique, such as the segmented gate system, could potentially be used to further separate radiologically-impacted soil from other soil. Because a primary radionuclide of concern at the West Lake Landfill is thorium-230, which does not emit measurable gamma radiation, such techniques are unlikely to be effective for the full excavation of RIM or partial excavation alternatives with low cleanup values. Such techniques may be effective for the 1,000 pCi/g partial excavation alternative because the presence of radium and its associated gamma emissions could be used to identify RIM, including thorium, by setting the gamma screening threshold low enough to segregate RIM containing thorium above the cleanup criteria.

7.2.3 Short-Term Effectiveness

This criterion addresses the effects that would occur during construction and implementation of the alternatives prior to achievement of the Site RAOs. Factors considered in the evaluation of this criterion include protection of the community during the remedial action, protection of workers, environmental impacts, and the time until the RAOs are met. Environmental justice considerations that may occur during implementation of the alternatives are also discussed in this section. Severity of impacts among the excavation and disposal alternatives corresponds to the duration and extent (volume, area) of the remedial action. Because the full excavation of RIM alternative is of significantly longer duration and requires contact with a substantially greater volume of the RIM than the partial excavation alternatives, it has significantly greater short-term impacts.

7.2.3.1 Protection of the Community

None of the remedial alternatives pose significant short-term radiological or chemical exposure-related risks to the general public during remedy implementation. Potential exposures to area residents that may occur during construction of each and all of the alternatives were projected to pose total radiocarcinogenic and chemocarcinogenic risks of 1.9×10^{-6} or less, which would be within or below EPA's target risk range of 10^{-4} to 10^{-6}. Projected non-carcinogenic hazard indices for all of the alternatives were projected to be approximately 0.001 or less, well below a hazard index of 1.0 used by EPA to identify unacceptable toxic effects.

The greatest potential risks to the community are associated with the off-site disposal components of the full excavation of RIM and partial excavation alternatives, with the full excavation of RIM alternative posing the greatest risk. These risks arise largely from the greater number of truck trips associated with off-site disposal and the resultant potential for spills or releases of RIM during transport. The off-site disposal components of the full excavation of RIM and partial excavation alternatives pose the potential for an off-site release resulting from potential vehicle accidents or other losses of vehicle or container integrity during material handling and transfer activities and transport to an off-site disposal facility. However, due to the anticipated short duration of potential exposure during any such release, the projected risks to the community if a transportation related release were to occur would be within EPA's acceptable risk range.

Transportation of RIM for off-site disposal will result in greater traffic congestion on St. Charles Rock Road and other nearby highways and associated potential for traffic accidents and fatalities along with greater greenhouse gas emissions and greater noise impacts. The projected incidence of transportation-related accidents (Table 7-1) is 41.4 for the full excavation with off-site disposal alternative, 16.1 for the 1,000 pCi/g partial excavation alternative, 7.5 for the 52.9 pCi/g partial excavation alternative, 1.4 for the full excavation with on-site disposal alternative, 2.4 for the Risk-Based Partial Excavation Alternative, 0.6 for the UMTRCA cover alternative, and the

ROD-selected remedy, respectively[79]. Projected carbon dioxide equivalent (greenhouse gas) emissions are also substantially greater for the full excavation with off-site and on-site disposal alternatives with90,000 and 80,000 tons of carbon dioxide equivalent emissions, respectively, compared to 36,000 tons, 38,000 tons and 48,000 tons for the 52.9, risk-based, and 1,000 partial excavation alternatives, respectively, and 19,000 tons for the ROD-selected remedy and the UMTRCA cover alternative (Table 7-1).

The ROD-selected remedy as modified, UMTRCA cover alternative, and the Risk-Based Partial Excavation Alternative all include limited regrading and relocation of approximately 105,000 to 112,000 bcy of waste materials (including up to 33,000 bcy of concrete rubble and other inert fill material) as part of regrading of the existing landfill surfaces and removal of RIM under the Risk-Based Partial Excavation Alternative. In contrast, the full excavation of RIM and partial excavation for the 1,000 pCi/g and 52.9 pCi/g alternatives would require excavation of large amounts of waste materials from Areas 1 and 2 and adjacent areas including up to 1,821,000 bcy of waste for the full excavation alternatives, 684,000 bcy for the 1,000 pCi/g alternative, and 274,000 bcy for the 52.9 pCi/g alternative. Excavation of RIM from Areas 1 and 2 under the two full or these two partial excavation alternatives would require (1) removal of the existing landfill cover; (2) removal of non-RIM overburden over Areas 1 and 2 and portions of adjacent OU-2 areas; (3) removal of RIM above cleanup levels in Areas 1 and 2; and (4) replacement of the removed non-RIM overburden. The large volumes of waste that would need to be excavated, stockpiled and replaced, combined with the comparatively longer duration of the construction activities (see Section 7.2.3.5 below) associated with the full excavation alternatives (5,820,000 ly) and the 1,000 pCi/g partial excavation alternative (2,730,000) increase the potential for attraction of birds for these alternatives compared to the other alternatives. Excavation, handling, stockpiling, and replacement of overburden is also likely to result in generation of significant amounts of odor. The full excavation of RIM and 1,000 pCi/g partial excavation alternatives would require removal, temporary relocation and, subsequent replacement of a large amount of the above-ground area of the North Quarry portion of the Bridgeton Landfill that overlies the southwestern portion of Area 1. Because this waste was placed in the 2003 to 2004 timeframe, it is likely to be less decomposed (putrescible). Putrescible waste poses a greater potential to attract birds and emit odors than that posed by the older waste materials in Areas 1 and 2. Additionally, because this area has active gas and leachate collection systems, these systems will need to be bypassed and later replaced. Excavation of this North Quarry area also presents a risk of oxygen intrusion into the remainder of the Bridgeton Landfill.

The volume estimates identified above do not account for the additional handling associated with temporary stockpiling or subsequent replacement of the overburden material. They also do not include the additional volume created by placement of daily cover over the excavation and stockpile areas both during excavation and overburden replacement. For municipal solid waste

[79] If it were feasible to extend a rail spur onto to the West Lake Landfill Site such that RIM could be directly loaded into rail cars for transport to an off-site disposal facility, the projected incidence of traffic accidents for the full excavation of RIM or partial excavation alternatives may be reduced; however, even if the trains were only transferred at night, an at-grade rail crossing would still represent a safety issue for traffic on St. Charles Rock Road.

landfills, it is typically assumed that daily cover requires 10% of the available air space. Using this factor, the total volume increase associated with placement of daily cover would be 40% (10% for daily cover on the excavation surfaces, 10% on the stockpile surfaces during stockpiling of overburden, 10% on the excavation areas during replacement of non-RIM overburden, and 10% on the stockpile surfaces during removal of the overburden in conjunction with replacement in the excavated areas) Therefore, the actual volumes of waste being handled under the excavation alternatives would be significantly greater than the amounts listed above.

Excavation of overburden and RIM would also create depressions in the landfill areas during the period of time required to remove the RIM and regrade and cover the remaining landfill wastes. Precipitation that falls on the landfill while such depressions are open would potentially flow into and accumulate in the depressions. Any accumulation of precipitation[80] in depressions created during waste excavation could result in infiltration of precipitation runoff through the underlying waste materials, which in turn could result in leaching of soluble contaminants from the waste materials.

During construction, consideration would be given to minimizing the area of excavation that would be open and exposed to waste materials at any given time, though the ability to accomplish this for the full excavation of RIM and partial excavation alternatives may be limited. Application of daily soil cover or placement of tarps over areas of exposed waste at the end of each work day would be employed to reduce the potential for odor generation, attraction of birds, and infiltration of precipitation. Stormwater BMPs, including temporary diversion berms, would also be constructed above the open excavation areas to divert precipitation runoff and attempt to prevent the runoff from contacting uncovered waste materials. Precipitation that would contact uncovered waste materials would flow into the low point of the excavation and be pumped out of the excavation into temporary storage tanks using portable gas-driven pumps. Samples from each tank would be collected and sent to a laboratory for analysis. The stored water would be directly discharged on-site or treated and disposed off-site based on the analytical results.

7.2.3.2 Environmental Justice Considerations During Remedy Implementation

As discussed in Section 7.2.1.5, a screening-level analysis did not identify any environmental justice concerns relative to the Site. In the event that any potential environmental justice community(ies) had been identified, potential impacts to such communities would have been addressed as part of the short-term impact analysis. Because no such communities were identified, no short-term impacts to such communities would occur in conjunction with implementation of any of the alternatives. EPA did identify a need for implementation of more traditional (non-electronic) communication methods to inform and ensure meaningful involvement of residents in the Terrisan Reste mobile home community. These actions are

[80] Accumulation could be significant during a heavy rainstorm, as the maximum historical 24-hour rainfall for the St. Louis area ranges from a low of 3.7 inches in November to a high of 8.8 inches in August (NOAA, 2011).

addressed as part of the Community Involvement Plan for the Site. Because the exact methods and routes that will be used to transport RIM to the off-site disposal facility cannot be determined at this time, no evaluation of potential environmental justice concerns associated with the haul routes has been performed.

7.2.3.3 Worker Protection

All of the remedial alternatives pose potentially increased cancer risks to workers involved with the remedy implementation, although the risks associated with the full excavation of RIM and partial excavation alternatives are higher than those associated with the ROD-selected remedy and UMTRCA cover alternative (Table 7-1). Workers involved with remedy implementation would be exposed to gamma radiation owing to their proximity to RIM. Carcinogenic risks to the reasonably maximally-exposed individual, determined to be a radiation technician, were projected to range from a high of 1.1×10^{-2} for the 1,000 partial excavation alternative to 3.7×10^{-3} for the two full excavation of RIM alternatives, to and 2.2×10^{-3} for the 52.9 pCi/g partial excavation alternative to lows of 5.0×10^{-5} for the Risk-Based Partial Excavation Alternative and 2.8×10^{-5} for the ROD-selected remedy and UMTRCA cover alternatives (see Table 7-1 and Appendix H). The total effective dose equivalent (TEDE) to remediation workers are projected to be approximately 13,400 mrem/year for the 1,000 pCi/g partial excavation alternative, 6,940 mrem/per year for the 52.9 pCi/g partial excavation alternative, 1,820 mrem per year for the two full excavation of RIM alternatives, 108 mrem/year for the Risk-Based Partial Excavation Alternative, and 60.2 mrem/year for the ROD-selected remedy and UMTRCA cover alternatives. The TEDEs associated with the 1,000 and 52.9 partial excavation alternatives are projected to exceed the OSHA and NRC standards of 5,000 mrem/year. Remediation workers would also be exposed to non-carcinogenic risks from exposure to chemicals within the waste materials. All of the alternatives are projected to result in hazard indices greater than 1.0 for worker exposures to chemical (non-radiological) constituents.

Potential risks to on-site workers are also associated with the projected incidence of industrial accidents, which were estimated to be 25.7 and 25.5 accidents for the full excavation with on-site and offsite disposal alternatives, respectively, 16.1 and 7.5 accidents for the 1,000 pCi/g and 52.9 pCi/g partial excavation alternatives, respectively, 8.7 for the Risk-Based Partial Excavation Alternative, and 5.1 and 5.6 accidents for the ROD-selected remedy and UMTRCA cover alternative, respectively (Table 7-1).

For all of the alternatives, workers would be instructed and trained in safe work practices, work practices at hazardous waste and radioactive sites, work practices in extreme temperatures, vehicle and pedestrian safety, use and care of personal protective equipment and monitoring devices, and other measures to reduce worker exposures and the potential for accidents. Risks and doses to workers from exposure to radiation can be controlled by limiting exposure durations.

7.2.3.4 Environmental Impacts

No measurable long-term impacts to plants or animals in surrounding ecosystems are expected to occur from any of the alternatives. No wetlands are located within the on-site construction footprint of the alternatives, and no endangered species were identified in the Site area. Excavating and regrading Areas 1 and 2 and constructing new landfill covers over these areas would affect the wildlife and plant life on those portions of the landfill. Disturbance of the landfill surface would occur under all of the remedial alternatives and would destroy those portions of the habitats that currently exist on the surface of Areas 1 and 2, forcing wildlife to migrate to other areas. This disruption would be temporary and would last for the period of active construction[81]. Vegetative cover would be placed on the Site and the landfill would be allowed to return to an early-stage field ecosystem with periodic mowing and maintenance.

As discussed in the prior section, excavation of overburden and RIM could result in creation of depressions which could accumulate stormwater. Accumulation of stormwater in these depressions would increase infiltration and potential leaching and transport of chemicals or radionuclides, which could result in impacts to the underlying groundwater quality. Such impacts are expected to only be temporary because once regrading is completed, no further stormwater accumulation and infiltration would be expected to occur.

7.2.3.5 Time to Achieve Remedial Action Objectives (RAOs)

The RAOs would be achieved upon completion of construction, which is estimated to be finished within the following timeframes after notice to proceed with remedial design is issued (see also Table 7-1 and Appendix J):

- Approximately 2.8 years for the ROD-Selected Remedy (as modified),
- Approximately 2.8 years for the UMTRCA Cover Alternative,
- Approximately 4.1 years for the Risk-Based Partial Excavation Alternative,
- Approximately 5.0 years for the 52.9 pCi/g Partial Excavation Alternative,
- Approximately 8.3 years for the 1,000 pCi/g Partial Excavation Alternative,
- Approximately 14.6 years for the Full Excavation of RIM with Off-Site Disposal Alternative; and

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[81] It should be noted that much of the vegetative cover was recently removed from Areas 1 and 2 as part of construction of the Non-Combustible Cover.

- Approximately 14.8 years for the Full Excavation of RIM with On-Site Disposal Alternative.

These estimated durations assume that remedial design for each alternative can be completed and approved within one year to 15 months of remedy approval and authorization to begin the RD phase, and that construction of the remedy is not fiscally constrained. The ROD-selected remedy and the UMTCRA cover alternative would achieve the RAOs in the shortest amount of time, while the two full excavation of RIM alternatives would take the longest time to achieve RAOs.

The preliminary construction schedules presented in Appendix J and the cost estimates presented in Appendix K include an assumption that any waste relocation activities that require identification and separation of RIM would necessarily require more time. To account for the potential reductions in productivity associated with operating in a hazardous environment, use of personal protective equipment, personnel scanning and decontamination procedures, the need for field measurements and laboratory sample results to guide the excavation activities, excavation, stockpiling and subsequent relocation of overburden material, application of daily cover or tarping of excavation areas and stockpiles at the end of each shift, regulatory oversight and other factors, a 50% reduction has been applied to the standard construction activity rates developed by RS Means relative to waste excavation and loading. To offset this reduction in productivity, the number of crews used for the waste excavation and loading tasks have been doubled in order to match the anticipated waste hauling rates.

The short-term effectiveness of the alternatives would be assessed by monitoring performed during, at the completion of, and after construction. Monitoring performed during construction would include perimeter and work space air monitoring, as well as worker health and safety monitoring. Construction quality control monitoring would be performed as part of all of the remedial alternatives to document that remedy construction was completed in accordance with the design specifications.

For the full excavation of RIM and partial excavation alternatives, measurements, sampling and laboratory analyses would be performed to guide the excavation activities and verify that the RIM above the respective cleanup levels was removed. Because thorium-230 (unlike gamma-emitting radium-226) cannot be detected using field survey instruments, excavation would have to be guided by collection and laboratory analyses of samples. In order to minimize the potential impacts on the excavation schedule, it is assumed that an on-site laboratory would be set up and operated to provide quick analyses of samples to guide excavation activities and initial confirmation that RIM to the specified cleanup level had been removed. A percentage of such samples would also be sent to an off-site laboratory for verification of the on-site laboratory results. Samples obtained for final confirmation that RIM has been removed from a particular area would also be subjected to off-site laboratory analyses. Potential impacts to the construction schedule could be addressed through use of an on-site laboratory to provide rapid turnaround of sample analyses, and through the relocation of excavation activities to other areas while waiting on the results of verification of confirmation sample analyses. However, even with these measures it is likely that some short-term delays to the construction work on the order of hours to days will likely occur due to waiting for sample results. Although it is anticipated that with proper excavation sequencing and scheduling the impact of such delays can be minimized to some extent, it is still likely that some delays will occur. Depending upon the number and duration of such delays, the impacts to the schedule may range from minimal to significant. Until detailed excavation and verification and confirmation sampling plans are developed and compared, the magnitude and potential impacts of such delays cannot be evaluated. No provisions for such delays have been included in the preliminary construction schedules developed for any of the alternatives.

Because radioactive materials would remain on the Site under the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives, measurements of gamma radiation levels and radon flux would be made on and around Areas 1 and 2 after all construction activities are completed to provide for final quantification of the cover effectiveness.

All of the alternatives include long-term groundwater and landfill gas monitoring along the perimeter of Areas 1 and 2 and, if necessary, at off-site locations.

Because RIM and solid wastes would remain in Areas 1 and 2 under the ROD-selected remedy, UMTRCA cover alternative, and the partial excavation alternatives, and solid wastes would remain in these areas under all of the alternatives, engineering measures and institutional controls intended to address the presence of solid wastes would be required for all of the alternatives. Engineering measures and institutional controls to address the presence of RIM would also be required for the ROD-selected remedy, UMTRCA cover alternative, and partial excavation alternatives. However, these are generally the same types of measures that would be used to address the solid waste materials remaining in Areas 1 and 2 under the full excavation of RIM alternative.

Unlike the ROD-selected remedy and UMTRCA cover alternative, the estimated schedules for construction of the full excavation of RIM and partial excavation alternatives are highly dependent upon the amount of expansion (the swell factor) the waste materials experience during excavation, handling and loading for shipment. Based on experience at the Mound Site, the Tulalip Landfill, and other landfill waste excavation projects (see section 6.1.7.2), it is likely that the actual volume expansion swell factor could be greater than what has been assumed in this FFS, and unlikely that it would be significantly less. To the extent that the swell factor is greater than what has been assumed during preparation of this FFS (factor of 1.5), the schedules for completion of construction—and consequently, the costs and risks associated with the full excavation of RIM and partial excavation alternatives—would increase. The swell factor does not apply to the ROD-selected remedy or UMTRCA cover alternative and therefore would not increase the costs and risks associated with these remedial alternatives.

The projected construction schedule and the cost estimate for the full excavation of RIM and partial excavation alternatives are also highly dependent on the number of containers that could be loaded with RIM and shipped off-site per day. The schedules and cost estimates developed in this FFS for these alternatives assume that a sufficient number of IM containers and rail cars can be made available, loaded, switched out, and replaced every day. If the actual rate is less than the projected rates of RIM excavation used to develop the construction schedules, the time required to complete construction—and consequently, the costs and risks for the full excavation of RIM or partial excavation alternatives—would increase.

Similarly, the schedule, costs and risks for the full excavation of RIM and partial excavation alternatives are sensitive to the rates at which soil and RIM can be relocated on site. These rates are a function of the capacity of the internal roads and road intersections, as well as the demands of the on-site truck traffic generated by the existing transfer station and asphalt plant operations. Since these estimates were based on an optimal number of trucks, it is possible that the number of off-road haul truck trips assumed for purposes of preparing this FFS may not be achievable. Conversely, it is unlikely that the number assumed could be greater. Consequently, the actual duration required for construction of the full excavation of RIM and partial excavation alternatives could be greater than that assumed in this FFS, resulting in increased time to complete, as well as increased costs and risks.

Summary of Short-Term Effectiveness – No unacceptable environmental (health) risks to the general public and surrounding community are expected from any of the alternatives. The two full excavation and two larger (52.9 pCi/g to 16 ft and 1000 pCi/g) partial excavation alternatives pose the greatest potential increased carcinogenic risks to workers, with projected potential risks above EPA's accepted risk range of 10^{-4} to 10^{-6} for the two full excavation and the 1,000 and 52.9 pCi/g partial excavation alternatives. All of the alternatives pose a potential for unacceptable toxic (non-carcinogenic) hazards to workers above EPA's accepted factor of 1.0. The potential total effective dose equivalent to workers under the 52.9 pCi/g and 1,000 pCi/g partial excavation and the two full excavation alternatives is projected to exceed the OSHA and NRC standards for radiation exposure. Although potential risks to workers exist, no remedial actions would be performed in a manner that could pose unacceptable risks to workers. Potential risks to workers would be addressed through training, development and implementation of health and safety and radiation safety plans, use of personal protective equipment, and work area and personal monitoring. Potential gamma radiation exposures under the full and partial excavation alternatives can only be addressed by monitoring and limiting worker exposure frequencies and durations, which could affect the progress of the remedial action, extending the schedule from what is currently estimated in Appendix J. No environmental impacts are expected to occur from any of the alternatives. The time to achieve RAOs is shortest for the OU-1 ROD-selected remedy (2.8 years) and UMTRCA cover alternative (2.8 years), greater for the partial excavation alternatives (5.0 and 8.3 years, respectively, for the 52.9 and 1,000 pCi/g alternatives), and greatest for the full excavation of RIM alternatives (14.6 years for Off-Site Disposal, and 14.8 years for On-Site Disposal). The greatest potential for increases to the construction schedule and delays are associated with the full excavation of RIM and partial excavation alternatives.

A screening-level analysis did not identify any environmental justice concerns relative to the Site. Because no such communities were identified, no long-term impacts to such communities would occur in conjunction with implementation of any of the alternatives.

7.2.4 Implementability

This criterion addresses the technical and administrative implementability of each alternative and the availability of the various services and materials required to implement each alternative.

Due to the development of the land to the north of Area 2 that occurred since the prior (2006) FS was prepared, placement of additional material along the toe of the Area 2 landfill slopes to reduce the grades is now considered to be less implementable due to potential difficulties and uncertainties regarding the ability to acquire the necessary land. In addition, even if the necessary property were available, slopes greater than 25% along other portions of Area 2 and along the east side of Area 1 could not be reduced by placement of additional material due to constraints imposed by surrounding features including St. Charles Rock Road and the perimeter stormwater drainage ditch between the landfill and St. Charles Rock Road, the Earth City Stormwater impoundment and the Site entrance road and stormwater ditch along the north side of Area 1 (Figures 7-1 and 7-2). Therefore, for purposes of this FFS, the evaluation of the ROD-Selected Remedy (as modified) is based on the assumption that the steeper slopes would be regraded by relocating some of the waste material to other parts of Areas 1 and 2 in order to achieve the maximum slope angles specified in the Missouri Solid Waste Regulations.

Installation of upgraded landfill covers to promote runoff and minimize infiltration, excavation and off-site disposal of waste materials, and implementation of institutional controls are all technically feasible, reliable, and established technologies that have been implemented and proven at other CERCLA landfill, FUSRAP, and DOE legacy management sites. Monitoring of landfill cover surfaces, landfill gas, radon, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of removal and containment actions and are easily implemented.

Uncertainty exists concerning the ability to remove all of the RIM included under the full excavation of RIM and partial excavation alternatives. The ability to remove RIM could be constrained by the depth of the RIM in some areas, the proximity of some of the RIM to other (OU-2) solid waste management units, including the North Quarry portion of the Bridgeton Landfill, closed construction and demolition waste landfill, and the inactive sanitary waste landfill, and the proximity of the existing solid waste transfer station to some of the RIM in Area 1.

Excavation of RIM would also present significant implementability concerns associated with the excavation and handling of contaminated materials, including:

- management of fugitive dust and potential odors;
- mitigation of bird hazards;
- management and treatment of stormwater exposed to RIM or other waste during excavation;
- prevention of oxygen intrusion into the exposed portion of the Bridgeton Landfill;

- management of RIM that fails the paint filter liquids test; and
- the identification, segregation, and disposal off-site of any hazardous wastes or regulated asbestos containing materials that may be encountered during RIM excavation.

These factors are discussed further in Section 6.

In addition, under the full excavation of RIM and partial excavation alternatives, directing and controlling the RIM excavation process using radiological scanning, sampling and laboratory analytical techniques would greatly impact (i.e., decrease) overburden and RIM excavation rates.

Implementability concerns specific to the off-site transport and disposal components of the Full Excavation with Off-Site Disposal Alternative and three partial excavation alternatives include the considerations listed below. The ROD-selected remedy, UMTRCA cover alternative, and the Full Excavation with On-Site Disposal Alternative would not pose such implementability concerns because they do not involve excavation and off-site disposal of waste.

- If a truck-to-rail transloading facility at an off-site rail spur location were to be used, a suitable location would have to be identified and a lease secured with the land/rail spur owner.

- If a rail spur were to be extended onto the West Lake Landfill property: (1) land located across St. Charles Rock Road would either need to be purchased or long-term leases would be needed with landowners, (2) it would be necessary to obtain state and local government, private landowner, facility occupant, and community approval to construct a rail spur across private property located to the east of St. Charles Rock Road, across St. Charles Rock Road, and along the Site access roads which serve the existing solid waste transfer station and asphalt plant operations, and (3) the long-term lease of the asphalt plant would likely need to be renegotiated or otherwise acquired.

- Switching of railcars either at a truck-to-rail transloading facility spur or an on-site rail spur would need to be coordinated with the railroad company that would be hauling the rail cars to the off-site disposal facility. The capacity to switch rail cars could affect the rate at which RIM could be excavated and removed from the Site.

- If a rail spur could be extended onto the West Lake Landfill property, dropping off empty and picking up loaded railcars would likely be possible only during late night hours due to the high traffic volume on St. Charles Rock Road during the day. The rail spur crossing at St. Charles Rock Road would need to meet appropriate state and local safety requirements.

- The EPA Region where the off-site disposal facility is located would need to be contacted every 60 days to obtain a compliance determination as to whether the disposal facility currently meets the criteria under the CERCLA Off-Site Rule. If, during RIM excavation, the contracted off-site disposal facility was found not to be in compliance for a period of time, excavation and transportation would need to cease until the facility became compliant, or RIM would need to be transported to another facility that EPA determined to be in compliance with all permit and regulatory requirements. Besides schedule delays, temporary stoppage of construction would present significant technical implementability concerns regarding open excavation areas.[82] Information regarding the past compliance history of the potential disposal facilities was outside the scope of, and therefore was not obtained as part of, preparation of this FFS. Therefore, information as to the frequency or duration of any periods when these facilities may have been out of compliance in the past (if any) has not been included here.

- If RIM were to be disposed at the Clean Harbors Deer Trail, CO facility, an application would have to be submitted to and accepted by the Rocky Mountain Low Level Radioactive Waste Compact.

All of the alternatives evaluated in this FFS include regrading (cutting and filling) and contouring of the existing waste materials in Areas 1 and 2 in order to achieve final grades. As discussed at the beginning of this section, the proximity of the landfill mass to the property boundaries and adjacent properties constrains the potential methods that can be utilized to regrade Areas 1 and 2. Specifically, the lack of space along the margins of Areas 1 and 2 dictates that regrading of these areas to achieve the desired slopes and to create space for stormwater retention basins, perimeter access roads, and environmental monitoring components along the margins of Areas 1 and 2 cannot be completed by placement of additional fill material alone. Relocation of a limited amount of existing waste materials would be necessary in some areas, and grading and contouring of existing waste would be required in other areas for all of the alternatives. Even so, the amount of waste relocation that may need to be performed for the ROD-selected remedy as modified and UMTRCA cover alternative (approximately 112,000 bcy, of which 33,000 bcy is estimated to be inert fill material) or the Risk-Based Partial Excavation Alternative (approximately 105,000 bcy) would be considerably less than the amount of waste excavation and movement that would be required for the two full excavation of RIM alternatives (approximately 1,821,000 bcy) or the other two partial excavation alternatives (274,000 and 684,000 bcy, respectively, for the 52.9 and 1,000 pCi/g alternatives), as these alternatives entail removal and stockpiling of substantial amounts of overburden waste, removal of substantial amounts of RIM, and replacement of the overburden waste material. The large volumes of overburden waste that would need to be excavated, stockpiled and replaced for the full excavation and the 1,000 pCi/g partial excavation alternatives indicate that these alternatives would pose difficulties for construction and increase the potential for technical problems to lead to delays. These alternatives therefore are considered to be less implementable than the two containment alternatives or the risk-based and 52.9 pCi/g partial excavation alternatives. Due to the higher activity limit targeted by the 1,000 pCi/g partial excavation alternative, and resultant

[82] For example, if such an event of non-compliance were to occur and could not be resolved quickly, excavation at the Site might be required to halt temporarily, and existing excavations may need to be backfilled in order to minimize potential RIM exposures.

anticipated higher gamma radiation levels associated with this material, radiological segregation of material in order to reduce the volume of material that would need to be disposed off-site is likely to be more effective and therefore has a potential to be more implementable for the 1,000 pCi/g alternative compared to the other alternatives.

Re-compaction of the regraded materials will be required under all of the alternatives to minimize the potential for differential settlement over time that could affect the integrity of the landfill cover. Placement of additional fill material to achieve the final slope requirements and for construction of the landfill covers over Areas 1 and 2 may result in further compaction and consolidation of the underlying waste materials, depending upon the nature, age, and amount of prior degradation of the waste materials. Placement of stockpiles of overburden waste and cover materials on portions of Areas 1 and 2 or on portions of the OU-2 landfill units would likely result in additional compaction, consolidation, and settlement of the underlying waste materials that would require additional fill material in order to achieve proposed surface grades and to maintain existing grades. The volumes of additional fill material that may be required to offset such additional consolidation have not been included in the volume estimates or cost estimates prepared for this FFS. Long-term maintenance, including inspection and repair, is typically required to address the potential for differential settlement or surface erosion of the landfill cover over time and is anticipated to be part of all alternatives. The level of effort for inspection and repair of the cover surfaces over Areas 1 and 2 would be the same for all alternatives.

Management and discharge of any leachate or contact stormwater that may be collected or generated during implementation of any of the remedial actions would require coordination with the Metropolitan Sewer District (MSD) with respect to acceptance and conditions for discharge of leachate to the sewer system. Design for and discharge of non-contact stormwater will require coordination with the Earth City Flood Control District. Removal of soil containing radionuclides above unrestricted use levels that may still remain on Lot 2A2 will require coordination with Crossroad Properties, LLC and AAA Trailer. A traffic control plan for, and possibly improvements to, the Site ingress and egress from St. Charles Rock Road may need to be developed and coordinated with the City of Bridgeton and/or the Missouri Department of Transportation.

Monitoring of the Area 1 and 2 landfill cover surfaces, perimeter landfill gas monitoring, and groundwater and surface water quality monitoring would be required for all of the alternatives in order to demonstrate the effectiveness of the remedy. Future groundwater monitoring activities could require acquisition and maintenance of access to off-site properties if off-site groundwater monitoring was required as part of the remedy. All of the monitoring activities are implementable.

Because Areas 1 and 2 exist within a larger Site with other landfill areas, the following activities impact one or more of the alternatives and would require coordination with the Site owner and operator:

- Regrading of Areas 1 and 2, installation of an upgraded landfill cover, and design of stormwater management structures under any of the remedial alternatives would need to be integrated with the grading, landfill covers, and stormwater controls that currently exist or that may be constructed on the adjacent OU-2 landfill units;

- Use of Site areas outside of Areas 1 and 2 to stockpile cover materials in order to facilitate cover construction under all of the remedial alternatives would need to be integrated with ongoing Site operations and/or implementation of remedial actions for OU-2;

- The flow of vehicles associated with remedy construction would need to be coordinated with the flow of vehicles associated with the on-site solid waste transfer station and asphalt plant operations;

- Excavation of RIM under the full excavation of RIM and partial excavation alternatives would need to be coordinated with remedial actions to be performed for OU-2;

- Truck hauling of RIM off site to a truck-to-rail transloading facility for the off-site disposal alternatives would need to be coordinated with vehicle activity associated with the existing Site operations;

- If a rail spur could be extended onto the Site for the off-site disposal alternatives, loading of railcars with RIM and switching of railcars would need to be coordinated with the Site owners and existing operations at the Site; and

- Truck delivery of rock, clay, and soil materials for cover construction over Areas 1 and 2 under all of the remedial alternatives would need to be coordinated with vehicle traffic associated with the existing Site activities.

Specialized personnel, equipment, and materials are expected to be readily available to implement the cover systems, institutional controls, and monitoring components of the remedial alternatives. The implementability and potential costs for all of the remedial alternatives will be influenced by the availability and location of clean fill materials and/or off-site soil borrow sources at the time the selected alternative is implemented. Potential vendors of rock, clay, and soil were contacted during the development of the SFS and during preparation of the Remedial Design Work Plan for the ROD-selected remedy. These vendors indicated that rock, clay, and soil material were readily available from sources close to the Site. However, if these local sources become exhausted prior to or during remedy implementation, cover materials would have to be obtained from suppliers at greater distances from the Site.

Materials, equipment and personnel required for excavation of RIM and transport of RIM to an off-site disposal facility are readily available. Only a limited number of off-site disposal facilities exist that can accept excavated RIM from the West Lake Landfill. All of the considered facilities currently anticipate having sufficient available capacity to accept the estimated volumes of RIM from the Site. However, there is no assurance that sufficient capacity at one or more of these facilities would be available in the future to serve the full excavation of RIM with off-site disposal or one of the partial excavation alternatives, if such an alternative were to be selected by EPA. At this time, it is difficult to evaluate which disposal facilities that can currently accept wastes from the West Lake Landfill may be available in the future, or what their respective future capacities or waste acceptance criteria may be. The volumetric rate of acceptance for all off-site disposal facilities would also be a function of the availability of IM containers and the number of railcars that could be made available and loaded at or near the Site, as well as the number of railcars that could be unloaded at or near the disposal facility. If a full excavation of RIM with off-site disposal or partial excavation alternative were to be selected, the facilities identified in Sections 3.1.4.3 and 4.3.5.4 and as further detailed in Appendix C are also permitted to (1) accept liquid wastes, should any stormwater accumulated in excavations during RIM excavation become contaminated and require disposal off-site, (2) accept mixed wastes, if mixed wastes are encountered during excavation, and (3) treat soil and/or debris that contains hazardous or mixed waste as needed to ensure the future integrity of capping systems that would be placed over the disposal cells at an off-site facility.

Summary of Implementability – All of the engineering and institutional control measures included with all of the alternatives are technically implementable, although the depth of the RIM and proximity of the RIM to other (OU-2) portions of the landfill and other facilities (*e.g.*, the existing solid waste transfer station) may constrain the ability to remove the all of the RIM associated with the full excavation of RIM or 1,000 pCi/g partial excavation alternatives. Sufficient capacity and capabilities currently exist for transport and disposal of RIM at permitted off-site disposal facilities; however, only four facilities have been identified that could potentially accept this material, and the capacity of these facilities in the future cannot be predicted. Due to a number of technical and administrative implementability issues that indicate that it will be difficult or impossible to extend a railroad spur to the Site, the evaluation of the full and partial excavation alternatives was based on an assumption that the waste material would be loaded onto trucks and transported to a truck-to-rail loading facility located near but off of the Site. Disposal of waste materials at an off-site facility under the full excavation of RIM and partial excavation alternatives would require ongoing determinations of compliance with the criteria under the CERCLA Off-Site Rule, which if not met could disrupt construction activities associated with excavation of RIM. Management of leachate and stormwater that contact waste material during remedy construction and implementation would need to be coordinated with MSD, and discharge of non-contact stormwater would need to be coordinated with Earth City Flood Control District. Investigation and removal of RIM from Lot 2A2 will require coordination with and approval from Crossroad Properties, LLC and AAA Trailer. Use of other areas of the Site for stockpiling of materials, scheduling and routing of trucks to haul RIM or deliver construction materials (*e.g.*, soil and rock) would require coordination with Bridgeton Landfill, LLC and the transfer station.

Overall, all of the alternatives are expected to be implementable and pose similar implementability concerns, to differing degrees. The primary differences between the various alternatives from an implementability perspective are:

- The greater depths and larger volumes of overburden and RIM to be excavated and handled for the two full excavation and the 1,000 pCi/g partial excavation alternatives pose greater difficulties and uncertainties for construction and a greater likelihood of technical problems that could lead to schedule delays, and therefore are considered to be less implementable than the two containment alternatives or the other two partial excavation alternatives.

- The proximity of the existing solid waste transfer station to the RIM located in the southwestern portion of Area 1 likely will require relocation of the transfer station in order to implement either of the full excavation alternatives or the 1,000 pCi/g or 52.9 pCi/g partial excavation alternatives. Due to the difficulty of permitting (if necessary) and constructing a new transfer station and removal of the existing transfer station, and because the only available space at the Site to relocate the transfer station is the area that is currently under long-term lease to another entity, relocation of the transfer station poses significant technical and administrative implementability issues. Therefore, these alternatives are less implementable than the two containment alternatives and the Risk-Based Partial Excavation Alternative.

- The higher radioactivity levels associated with the Partial Excavation to 1,000 pCi/g Alternative makes use of radiological screening to distinguish material to be excavated and disposed off-site to potentially to segregate this material from other waste materials likely to be more implementable for this alternative compared to the other excavation alternatives. Due to the predominance of thorium-230, which has a very weak gamma signature, field screening to identify RIM or application of radiological segregation for the full excavation alternatives, the Risk-Based Partial Excavation Alternative and potentially the Partial Excavation to 52.9 pCi/g Alternative are likely to be ineffective, requiring collection and analyses of samples to guide excavation and waste segregation activities. Therefore, these alternatives would pose additional difficulties and uncertainties during construction and therefore are less implementable than the 1,000 pCi/g partial excavation or the two containment alternatives. Because there would be no need to identify or segregate RIM for the ROD-Selected Remedy or UMTRCA Cover Alternative, landfill regrading activities could be performed with equipment that was guided by global positioning systems. This would eliminate the need for field technicians to work in Areas 1 and 2, which, in addition to better meeting the goals of ALARA, also makes these two alternatives more implementable.

7.2.5 Cost

The final primary balancing criterion is cost. Table 6-1 presents a summary of the anticipated costs associated with each alternative. The highest costs are associated with the Full Excavation of RIM with Off-Site Disposal Alternative, followed by the Full Excavation of RIM with On-

Site Disposal Alternative, the 1,000 pCi/g partial excavation alternative, and the 52.9 pCi/g partial excavation alternative, with the lowest costs associated with the UMTRCA Cover Alternative and the ROD-Selected Remedy (see listing below). Detailed information regarding the cost estimates for each alternative is presented in Appendix K.

- The ROD-Selected Remedy would result in the lowest overall estimated capital (design, construction, and environmental monitoring during construction) costs of all of the remedial alternatives at $75 million, with estimated annual OM&M costs ranging from $176,000 to $389,000.

- Capital costs for construction of the UMTRCA Cover Alternative are estimated to be $96 million, with estimated annual OM&M costs ranging from $176,000 to $389,000.

- Capital costs for construction of the 52.9 pCi/g Partial Excavation Alternative are estimated to be $274 million, with estimated annual operations, maintenance and monitoring costs of $176,000 to $389,000.

- Capital costs for construction of the 1,000 pCi/g Partial Excavation Alternative are projected to be $379 million, with estimated annual operations, maintenance and monitoring costs of $176,000 to $389,000.

- Capital costs for construction of the Risk-Based Partial Excavation Alternative are projected to be $187 million, with estimated annual operations, maintenance and monitoring costs of $176,000 to $389,000.

- Implementation of the Full Excavation of RIM with Off-Site Disposal Alternative would result in incurrence of the highest total estimated capital cost at $695 million, with estimated annual operations, maintenance and monitoring costs of $176,000 to $340,000.

- Implementation of the Full Excavation of RIM with On-Site Disposal Alternative would result in incurrence of the second highest total estimated capital cost at $591 million, with estimated annual operations, maintenance and monitoring costs of $182,100 to $444,100.

The cost estimates summarized above and provided elsewhere in this FFS are feasibility-level cost estimates. That is, they were developed to a level of accuracy such that the actual costs incurred to implement the alternatives are anticipated to be within a range bounded by 50% above and 30% below these estimates.

The ranges in values for the annual OM&M costs cited above result from variations in the specific activities that occur each year (*e.g.*, higher costs for years with additional environmental monitoring, years when landfill cover repairs may occur, and years when 5-year reviews are conducted).

Based on a 7% discount rate, the 30-year present worth costs of the alternatives are estimated to be:

- $71 million for the ROD-Selected Remedy,
- $90 million for the UMTRCA Cover Alternative,
- $236 million for the 52.9 pCi/g Partial Excavation Alternative,
- $287 million for the 1,000 pCi/g Partial Excavation Alternative,
- $165 million for the Rick-Based Partial Excavation Alternative,
- $455 million for the Full Excavation with Off-Site Disposal Alternative, and
- $391 million for the Full Excavation with On-Site Disposal Alternative.

Based on the Office of Management and Budget's current value (2017 value issued in November 2016) of 0.7% for the 30-year discount rate, the 30-year present worth costs of the alternatives are estimated to be:

- $79 million for the ROD-Selected Remedy,
- $100 million for the UMTRCA Cover Alternative,
- $275 million for the 52.9 pCi/g Partial Excavation Alternative,
- $372 million for the 1,000 pCi/g Partial Excavation Alternative,
- $189 million for the Risk-Based Partial Excavation Alternative,
- $667 million for the Full Excavation with Off-Site Disposal Alternative, and
- $568 million for the Full Excavation with On-Site Disposal Alternative.

Finally, the total non-discounted costs over the same 30-year period are estimated to be:

- $80 million for the ROD-Selected Remedy,
- $102 million for the UMTRCA Cover Alternative,
- $280 million for the 52.9 pCi/g Partial Excavation Alternative,
- $384 million for the 1,000 pCi/g Partial Excavation Alternative,

- $192 million for the Risk-Based Partial Excavation Alternative,
- $699 million for the Full Excavation with Off-Site Disposal Alternative and
- $596 million for the Full Excavation with On-Site Disposal Alternative.

Present worth costs for 200 years and 1,000 years were also evaluated and are summarized on Tables 6-1 and 7-1.

As discussed in Section 6.1.7.2, variable scope contingency factors were developed and applied to each of the major construction activities including excavation (55%), off-site disposal (15%), geosynthetic cover (20%), and soil cover construction (10%). Scope contingency addresses unknown costs due to scope changes that may occur during RD and represents project risks associated with an incomplete design, because design concepts are not typically developed enough during preparation of an FS to identify all project components or quantities. This type of contingency represents costs unforeseeable at the time the FFS and conceptual design cost estimate were prepared, both of which are likely to become better known as the RD phase progresses.

The greatest source of uncertainty is associated with RIM excavation, and results from uncertainties associated with (1) the volume, configuration and composition of the RIM; (2) the volume and configuration of the overburden material; (3) excavation rates; (4) the material swell factors; (5) available areas for stockpiling overburden; (6) the nature and degree of nuisance factors (*e.g.,* odors, weather, stormwater management, bird control, etc.) and the associated management techniques; and (7) changes or additions to the construction and management procedures that may be requested or required by the regulatory agencies or other parties, among other factors. Among the alternatives, the greater the amount of RIM excavated, the greater the degree of uncertainty. Due to the limited number of off-site disposal facilities that could accept the waste materials, the greatest degree of uncertainty with the capital costs is associated with the off-site disposal component of the full excavation of RIM and partial excavation alternatives. There also are uncertainties regarding the specification and cost of the rock that would be used for the biointrusion layer included in the ROD-selected remedy, UMTRCA cover alternative, the partial excavation alternatives, and on-site cell alternative, as well as the source and unit costs for acquisition and delivery of the clay and soil to be used to construct the low permeability and vegetative layers of the final landfill covers over Areas 1 and 2 that are included in all of the remedial alternatives.

A 20% bid contingency was also included in the capital costs for all of the remedial alternatives to address unknowns that might occur after a construction contract is awarded. The ROD-selected remedy and UMTRCA cover alternative are expected to have a lower potential for significant cost growth after construction begins because these alternatives are based on use of demonstrated technologies with fewer uncertainties in cost-determining factors. In contrast, the full excavation of RIM and partial excavation alternatives have the potential for significant cost growth due to the unknowns associated with excavation of the RIM, including, among other factors: (1) the configuration and volume of the RIM; (2) the swell resulting from RIM excavation; (3) the amount of overburden; (4) potential occurrences of hazardous wastes or RACM; and (5) actual production rates of excavation and disposal activities, especially under difficult or severe weather conditions.

As an example, at OU-1 of the Mound CERCLA site in Miamisburg, OH, the remediation of landfilled contaminated soil/debris that contained radionuclides cost significantly more than anticipated. Review of available documents (ARC, 2009 and ARC, 2010) and discussions with regulatory agency representatives for this project indicate that one reason for the significant increase in costs was "variations with respect to waste location and waste type from those modeled by the project team in the original Remedial Action Work Plan were encountered during excavation" (ARC, 2009). Specific factors that resulted in the increased costs included:

- Uncertainty regarding the locations, extents, depths, configurations, volumes, types, and characteristics of the waste deposits;

- No data, or only limited characterization data, for the waste materials prior to initiation of the removal action;

- The presence of unanticipated and undocumented waste materials and waste types, including (but not limited to) mercury, PCBs, previously unidentified VOCs, Pu-239, and Am-241;

- The presence of a substantial amount of both mixed radioactive and hazardous wastes/debris and hazardous waste/debris, with both the hazardous wastes/debris and the mixed wastes requiring off-site incineration and chemical oxidation;

- The necessity of transporting materials to four different off-site disposal or waste processing facilities (rather than only one facility, as was anticipated during project planning) because of the variability in types of wastes encountered;

- The impacts of weather (heat, cold, rain, lightning) on implementability, employee productivity rates, equipment operation, and progress of the excavation activities;

- Excessive water ponding in trenches and limited operations during backfilling activities caused by severe precipitation; and

- Delayed and complicated backfill and soil cover compaction due to excessive precipitation and frozen soil.

Excavation of waste materials from OU-1 Areas 1 and 2 is likely to encounter many of the same complications encountered at the Mound OU-1 Landfill Area. In addition to the cost overrun issues listed above, experience with waste excavation at other landfill sites indicates that the following additional factors could also contribute to increased costs for the full excavation of RIM or partial excavation alternatives:

- Unanticipated variations in the volume-weight relationships for the wastes that could result in variability in costs charged on either a volumetric or weight-based unit price;
- Increased fuel and resultant transportation costs over time;
- Loss of the availability of one or more of the currently available off-site disposal facilities in the future;
- Potential increases in the off-site transportation and disposal pricing over time;
- Potential for encountering leachate containing hazardous substances that may require treatment;
- Potential for stormwater accumulation in depressions created by waste excavation and resultant potential for generation of contaminated stormwater requiring treatment; and
- Decreased availability and/or increased pricing for local fill material required to regrade the Area 1 and 2 surfaces and perimeter slopes following completion of the waste excavation activities.

The nature of the activities and the longer duration required for implementation of the full excavation of RIM and, to a lesser extent, partial excavation alternatives, significantly increases the potential for occurrence of cost increases over time.

Modifying Criteria

The two NCP modifying criteria are: (1) state acceptance; and (2) community acceptance. Comparison of the alternatives with respect to modifying criteria will be performed by EPA as part of the FFS review and decision process.

8 REFERENCES

Accelerated Remediation Company (ARC), 2010, Operable Unit 1 Landfill Area Closeout Report, Final, DOE Contract No. DE-AM09-05SR22399, Prepared for USDOE, October 12.

ARC, 2009, Operable Unit 1 Closeout Report, DOE Contract No. DE-AM09-05SR22399, Prepared for USDOE, April.

Arcadis, 2015a, Memorandum in Support of Further Characterization of Extent of Radiologically Impacted Material in Areas 1 and 2 – West Lake Landfill Operable Unit-1, Bridgeton, Missouri, May 18.

Arcadis, 2015b, Work Plan for Further Characterization of Extent of Radiologically Impacted Material in Areas 1 and 2, West Lake Landfill Operable Unit-1, Bridgeton, Missouri, July31.

Auxier & Associates, Inc. (Auxier), 2017, Updated Baseline Risk Assessment, West Lake Landfill Operable Unit 1, DRAFT, December 20.

Auxier, 2016, Draft Risk to Industrial User of Operable Unit 1 at West Lake Landfill Superfund Site, May.

Auxier, 2000, Baseline Risk Assessment, West Lake Landfill Operable Unit 1, April 24.

Auxier and EMSI, 2017a, West Lake Landfill Perimeter Air Monitoring Report, Year Two Quarter Two Report, August, September, and October 2016, July.

Auxier and EMSI, 2017b, West Lake Landfill Perimeter Air Monitoring Report, Year Two Quarter One Report, May, June and July 2016, May.

Auxier and EMSI, 2017c, West Lake Landfill Perimeter Air Monitoring Report, February, March and April, 2016, March.

Auxier and EMSI, 2016a, West Lake Landfill Perimeter Air Monitoring Report, May, June and July 2015, April.

Auxier and EMSI, 2016b, West Lake Landfill Perimeter Air Monitoring Report, August, September and October 2015, April.

Auxier and EMSI, 2016c, West Lake Landfill Perimeter Air Monitoring Report, November and December, 2015, and January, 2016, April.

Auxier and EMSI, 2016d, Final Supplemental Radon Flux Analysis from the Area South of the Proposed Isolation Barrier, West Lake Landfill Superfund Site, prepared for Bridgeton Landfill, LLC, March.

Auxier and EMSI, 2016e, Final Particulate Emission Analysis from Area South of Proposed Isolation Barrier, West Lake Landfill Superfund Site, prepared for Bridgeton Landfill, LLC, March.

Auxier and EMSI, 2014, Air Monitoring, Sampling and QA/QC Plan, West Lake Landfill Superfund Site Operable Unit 1, October.

Bridgeton Landfill, LLC, 2013, Bridgeton Landfill North Quarry Contingency Plan – Part 1, June 27.

Benson, Craig H., 2016, Predicting Service Life of Geomembranes in Low-Level and Mixed Waste Disposal Facilities, CRESP/University of Virginia Webinar: Performance & Risk Assessment Community of Practice, May 16.

Bush, Rich, 2010, Design Basis of UMTRCA Disposal Cells, presentation at Workshop on Engineered Barrier Performance Related to Low-Level Radioactive Waste, Decommissioning, and Uranium Mill Tailings Facilities, August 3.

Caldwell, Jack, A. and Reith, Charles, C., 1994, Cover Design for Uranium Mill Tailings Piles: A Standard for the Future, Chapter 26.

Caldwell, Jack, A. and Shepherd, Thomas, A., 1989, Pile Stabilization and Groundwater Protection at Title I and Title II UMTRA Project Sites.

Caldwell, Jack, A. and Truett, Duane, 1989, Technical Approaches on the UMTRA Project Relevant to Superfund Projects.

Caterpillar, Inc, 2016, Caterpillar Performance Handbook, Edition 46, January.

Cornerstone Environmental, 2016, EVOH Cover System Work Plan, North Quarry Bridgeton Landfill, Revised October 2016.

Council on Environmental Quality (CEQ), 1997, Environmental Justice: Guidance Under the National Environmental Policy Act, Washington, D.C.: Executive Office of the President. Retrieved from http://www3.epa.gov/environmentaljustice/resources/policy/el_guidance_nepa_ceq1297.pdf.

City of St. Louis, Missouri, 2010, Letter to Daniel Gravatt of USEPA Region 7 RE: West Lake Landfill: Comments on Work Plan for Supplemental Feasibility Study, September 20.

City of St. Louis, Missouri, 2005, Negative Easement and Declaration of Restrictive Covenants Agreement, by and among Grantors: Bridgeton Landfill, LLC, Rock Road Industries, Inc., and Bridgeton Transfer Station, LLC and Grantee: The City of St. Louis, MO, April 6.

Cummings, Mark, and Booth, Steven R., 1996, Remediation of Uranium-Contaminated Soil Using the Segmented Gate System and Containerized Vat Leaching Techniques: A Cost Effectiveness Study, Los Alamos National Laboratory, Technology and Safety Assessment Division, LA-UR-96-2663.

Deutsch, C.V. and Journel, A. G., 1992, GSLIB: Geostatistical Software Library and User's Guide, New York, Oxford University Press.

Engineering Management Support, Inc. (EMSI), 2017a, Remedial Investigation Addendum, West Lake Landfill Operable Unit 1, Bridgeton, Missouri, November 28.

EMSI, 2017b, Draft Stormwater Monitoring Plan, West Lake Landfill Operable Unit 1, Bridgeton, Missouri, March 22.

EMSI, 2016a, Abbreviated Work Plan for Remedial Investigation Addendum and Final Feasibility Study, West Lake Landfill Operable Unit 1, Final, March 14.

EMSI, 2015a, Letter to Bradley Vann of USEPA Region VII, Subject: Responses to EPA’s and Other Agencies’ Comments on the Isolation Barrier Alternatives Analysis, West Lake Landfill Superfund Site, Bridgeton, Missouri, October 6.

EMSI, 2015b, Phase 1D Investigation – Additional Characterization of Extent of Radiologically-Impacted Material in Area 1: Revised Addendum to Phase 1 Work Plans for Isolation Barrier Investigation, West Lake Landfill Operable Unit-1, Bridgeton, Missouri, May 1.

EMSI, 2015c, Evaluation of Alternative Landfill Cover Designs, West Lake Landfill Operable Unit-1, January 22.

EMSI, 2015d, Responses to EPA (D. Kappleman) Comments on Preliminary Volume Estimates for EPA’s Partial Excavation Options, West Lake Landfill OU-1, February 13.

EMSI, 2015e, Revised Work Plan Partial Excavation Alternative, West Lake Landfill Operable Unit-1, July 23.

EMSI, 2014a, Groundwater Monitoring Report, October 2013 Additional Groundwater Sampling Event, West Lake Landfill Operable Unit-1, February 21.

EMSI, 2014b, Memorandum: Additional Present Value Cost Estimates, October 31.

EMSI, 2014c, Revised Work Plan – Evaluation of Alternative Landfill Cover Design, West Lake Landfill Operable Unit 1, Bridgeton, Missouri, February 7.

EMSI, 2014d, Estimated Volumes for Partial Excavation Options Identified by EPA, West Lake Landfill Operable Unit-1, October 31.

EMSI, 2014e, Evaluation of Possible Impacts of a Potential Subsurface Smoldering Event on the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill, January 14.

EMSI, 2013a, Groundwater Monitoring Report, April 2013 Additional Groundwater Sampling Event, West Lake Landfill Operable Unit-1, July 8.

EMSI, 2013b, Groundwater Monitoring Report, July 2013 Additional Groundwater Sampling Event, West Lake Landfill Operable Unit-1, December 1.

EMSI, 2013c, Work Plan Additional Present Value Cost Estimates, October 15.

EMSI, 2013d, Work Plan Evaluation of the Use of Apatite/Phosphate Treatment Technologies, October 31.

EMSI, 2013e, Work Plan, Evaluation of Potential Impacts of a Tornado on the ROD-Selected Remedy for the West Lake Landfill OU-1, July 24.

EMSI, 2013f, Evaluation of Possible Effects of a Tornado on the Integrity of the Record of Decision – Selected Remedy for Operable Unit-1 at the West Lake Landfill, October 11.

EMSI, 2013g, Work Plan – Evaluation of the Potential Impacts to the ROD-Selected Remedy from a Possible Subsurface Smoldering Event, July 16.

EMSI, 2012a, Groundwater Monitoring Report, July/August 2012 Additional Groundwater Sampling Event, West Lake Landfill Operable Unit-1, December 14.

EMSI, 2012b, Work Plan Partial Excavation Alternative, December 4.

EMSI, 2010, Work Plan for Supplemental Feasibility Study – Radiological-Impacted Material Excavation Alternatives Analysis, West Lake Landfill Operable Unit 1, June 4.

EMSI, 2008, Remedial Design Work Plan, West Lake Landfill Operable Unit 1, November 25.

EMSI, 2006, Feasibility Study Report, West Lake Landfill Operable Unit 1, May 8.

EMSI, 2000, Remedial Investigation Report, West Lake Landfill Operable Unit 1, April 10.

EMSI, 1997, Amended Sampling and Analysis Plan (ASAP), West Lake Landfill Operable Unit 1, February.

EMSI, FEI, and Auxier, 2011, Supplemental Feasibility Study, West Lake Landfill OU-1, December 16.

EMSI, FEI, P. J. Carey & Associates, P.C., and Auxier, 2016, Comprehensive Phase 1 Report, Investigation of Radiological Area 1, West Lake Landfill Operable Unit-1, April 5.

EMSI, FEI, P. J. Carey & Associates, P.C., and Auxier, 2014, Isolation Barrier Alternatives Analysis, West Lake Landfill Superfund Site, October 10.

Federal Aviation Administration (FAA), U.S. Department of Transportation, 2007, Advisory Circular AC 150/5200-33B, "Hazardous Wildlife Attractants On or Near Airports", August 28.

FAA, 1998, Record of Decision for Lambert-ST. Louis International Airport, St. Louis, MO, September 30.

Federal Emergency Management Agency (FEMA), 2015, FIRM Flood Insurance Rate Map, St. Louis County, Missouri and Incorporated Areas, Panel 39 of 445, Map Number 29189C0039K, February 4.

Federal Remediation Technologies Roundtable (FRTR), 2002, Remediation Technologies Screening Matrix and Reference Guide, Version 4.0: Chemical Extraction http://www.frtr.gov/matrix2/section4/4-15.html, Separation http://www.frtr.gov/matrix2/section4/4-18.html, and Phytoremediation http://www.frtr.gov/matrix2/section4/4-3.html

Feezor Engineering, Inc. (FEI), 2017, North Quarry Subsurface Temperature Monitoring Probes (TMPs) Work Plan, Administrative Settlement Agreement and Order on Consent for Removal Action, Revised August 2017.

FEI, 2016, Record Drawings for Seventeen Additional and Two Replacement Temperature Monitoring Probe Installation in North Quarry, Bridgeton Landfill, December.

FEI, and P. J. Carey & Associates, 2016, As-Built Drawings for Neck Heat Extraction System, November 2016.

FEI and P. J. Carey & Associates, 2015, Technical Evaluation of a Heat Extraction Barrier, Bridgeton Landfill, Bridgeton, St. Louis County, MO, November.

FEI, P. J. Carey & Associates, EMSI, and Auxier, 2014, Bridgeton Landfill Thermal Isolation Barrier Investigation Phase 1 Report prepared on behalf of Bridgeton Landfill, LLC., December 19.

Fischer, Timothy, 2011, USEPA Region 5 Remedial Project Manager for USDOE Mound Plant, Personal Communication, March 23.

Focazio, Michael, J., Szabo, Zoltan, Kraemer, Thomas, F., Mullin, Ann, H., Barringer, Thomas, H. and DePaul, Vincent, T., 2000, Occurrence of Selected Radionuclides in Groundwater Used for Drinking Water in the United States: A Reconnaissance Survey, 1998, U.S. Geological Survey Water Resources Investigation Report 00-4273.

FOX 2 News, 2013, EF3 Tornado Hits Madison County, IL, June 1, available at http://fox2now.com/2013/06/01/ef3-tornado-hits-metro-east/

Foth & Van Dyke, 1989, Letter from Rodney Bloese to Joseph Homsy re: West Lake Landfill CERCLA, dated December 12, 1989.

Gailey, David, 2002, Maryland Department of Natural Resources-Forest Service, Tornado Damage Assessment Report, May 23, available at http://dnr.maryland.gov/forests/publications/tornado_report.pdf

Glass, Fred, undated, Good Friday Tornadoes 22 April 2011, PowerPoint Presentation Providing Overview of Event: Lead Forecaster Fred Glass, NOAA National Weather Service, St. Charles, Missouri, available at http://www.crh.noaa.gov/images/lsx/presentations/goodfridayfred.ppt

Herst & Associates, 2005, Remedial Investigation Report, West Lake Landfill Operable Unit 2, Bridgeton, Missouri, September 16.

Kavazanjian, E., Dixon, N., Katsumi, T., Kortegast, A., Legg, P., and Zanzinger, H., 2006, Geosynthetic Barriers for Environmental Protection at Landfills, 8th International Conference on Geosynthetics, Arizona State University Fulton School of Engineering.

Lee, Chris, 2010, Vice President of Government Business Development – Energy Solutions, Personal communication, June 28.

LGL, Ltd., 2015, Bird Management and Control Plans for Various Barrier Options at West Lake Site, Bridgeton Landfill, St. Louis, MO, LGL Report FA0030-1, October 6.

Lommler, John, C., Chen, Ping, K., Artiglia, Edward, Guros, Frank, B., Bridgeman, Barbara, and Cox, Steven, 1999, DOE UMTRA Project Disposal Cell Design Summary, WM'99 Conference, February 28 – March 4, 1999.

Lucas, Paul, 2011, USDOE Office of Environmental Management, Miamisburg, OH, Personal Communication, March 25.

Marr, W. Allen, and Christopher, Barry, 2003, Geotechnical Fabrics Report, October/November.

McCarthy, Daniel, Ruthi, Larry and Hutton, Jeff, 2007, The Greensburg, KS Tornado, 22nd Conference on Weather Analysis and Forecasting/18th Conference on Numerical Weather Prediction, 25 – 29, June, available at https://ams.confex.com/ams/pdfpapers/126927.pdf

McLaren/Hart, 1996, Soil Boring/Surface Soil Investigation Report, West Lake Landfill Areas 1 & 2, November 26.

Marshall, Timothy, P., McCarthy, Daniel, LaDue, James, Wurman, J., Alexander, C., Robinson, P. and Kosiba, K., 2008, Damage Survey of the Greensburg, KS Tornado, American Meteorological Society 24th Conference on Severe Local Storms (27-31 October 2008) Savannah, GA, available at https://ams.confex.com/ams/pdfpapers/141534.pdf

Merritt, Frederick S., Loftin, M. Kent, and Ricketts, Jonathan T., Eds, 1996, Standard Handbook for Civil Engineers, 4th ed.

Missouri Department of Natural Resources (MDNR), 2015, Letter to Brian Power of Bridgeton Landfill, LLC, RE: Technical Evaluation of a Heat Extraction Barrier Submittal, Bridgeton Sanitary Landfill, Permit Number 0118912, St. Louis County, December 4.

MDNR, 2014, Letter to Lynn Slugantz of USEPA Region 7, RE: Comments on Isolation Barrier Alternatives Analysis, West Lake Superfund Site, dated October 10, 2014, November 24.

National Oceanic and Atmospheric Administration *(*NOAA*)*, 2011, August-Saint Louis Weather Calendar at http://www.crh.noaa.gov/lsx/climate/normals/aug.php.

National Research Council of the National Acadamies, 2007, Assessment of the Performance of Engineered Waste Containment Barriers, http://www.nap.edu/catalog/11930.html

National Wildlife Research Center (NWRC), 2008, New Technologies to Deter Wildlife from Airports and Aircraft, USDA Animal and Plant Health Inspection Service.

Patteson, Ray, 2000, The Accelerated Site Technology Deployment Program/Segmented Gate System Project, Sandia National Laboratories, presented at the Spectrum 2000 Conference, Chattanooga, TN, September 24-28.

Patteson, Ray, Maynor, Doug, and Callan, Connie, 2000, The Accelerated Site Technology Deployment Program Presents the Segmented Gate System, WM2K Conference, February 27 – March 3, 2000, Abstract #559, Session 12, Paper #6.

Pivetz, B., 2001, Ground Water Issue: Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites, Prepared for U.S. EPA, Office of Solid Waste and Emergency Response, EPA/540/S-01 /500, February.

Radiation Management Corporation (RMC), 1981, Report on Site Visit - West Lake Landfill, St. Louis County, Missouri.

Reed, P., T. Ellsworth, and B.S. Minsker, 2004, Spatial Interpolation Methods for Nonstationary Plume Data. Ground Water, 42(2): pp. 190-202.

RMC, 1982, Radiological Survey of the West Lake Landfill, St. Louis County, Missouri.

Richtel, Steve, 2010, Program Manager, Closed Sites Management Group – Waste Management, Personal communication, June 28.

Reith, Charles, C., and Caldwell, Jack, A., 1990, Vegetative Covers for Uranium Mill Tailings, February.

Robertson, Thomas and Dunbar, Josh, 2005, Guidance for Evaluating Landfill Gas Emissions from Closed or Abandoned Facilities, EPA-600/R-05/123a, September.

Rowe, R. K., and Islam, M. Z., 2009, Impact of landfill liner time-temperature history on service life of geomembranes, in *International Journal of Integrated Waste Management*, pages 2689-2699.

Rowe, R.K., and Jones, C.J.F.P., 2015, Geosynthetics: Innovative Materials and Rational Design, https://www.researchgate.net/publication/265668747.

Rowe, R. K., and Rimal, S. 2008, Ageing and Long-term Performance of Geomembrane Liners, The First Pan American Geosynthetics Conference & Exhibition, March 2-5.

Rowe, R. K., Rimal, S., and Sangam, H., 2009, Ageing of HDPE geomembrane exposed to air, water and leachate at different temperatures, in *Geotextiles and Geomembranes*, 27, 137-151.

R.S. Means Data Online, 2017, Online Estimating with RSMeans Data from Gordian, https://www.rsmeansonline.com, Data for 2016 Q2.

SCS Engineers, 2016, Corrective Action Measures – Inert Gas Injection Work Plan for Hot Spot Remediation, Bridgeton Landfill, Revised December 16.

Smith, Gregory, M., 1999, Evolution of Disposal Cell Cover Design Used for Uranium Mill Tailings Long-Term Containment, WM’99 Conference, February 28 – March 4, 1999.a

S.S. Papadopulos & Associates, Inc. (SSP&A), 2017, Estimated Three-Dimensional Extent of Radiologically Impacted Material, West Lake Landfill Operable Unit-1, Bridgeton, Missouri, December.

SSP&A, 2016, Fate-and-Transport Evaluation for Radiologically Impacted Material, West Lake Landfill Operable Unit 1, Bridgeton, Missouri, DRAFT, November 2.

Stark, T.D., Jafari, N.H., and Rowe, R.K., 2012, Service Life of a Landfill Liner System Subjected to Elevated Temperatures, A paper to be submitted for review and possible publication in the ASCE Journal of Hazardous, Toxic, and Radioactive Waste Management, April 14.

The Weather Channel, 2012d, In pictures: Joplin, MO. Tornado Devastation, by Johnathan Erdman, Sr. Meteorologist, available at http://www.weather.com/outlook/weather-news/news/articles/joplin-mo-incredible-devastation-photos_2011-05-23

terra technologies, 2004, Letter to Ms. Cheryle Micinski, USEPA from David Heinze, terra technologies re: Clarifications to Information Request, West Lake Landfill Site, September 10, 2004.

TetraTech, Inc., 2016, Quality Assurance Project Plan for Soil/Sediment Sampling of Drainage Features, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, EPA Region 7, START 4, Contract No. EP-S7-13-06, Task Order No. 0007, February 2 (revised May 19, 2016).

TetraTech, 2015a, Interim Data Summary of Ongoing Baseline Off-Site Air Monitoring Volatile Organic Compounds, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, Superfund Technical Assessment and Response Team (START) 4, Contract No. EP-S7-13-06, Task Order No. 0058, Prepared for U.S. Environmental Protection Agency Region 7, January 19.

TetraTech, 2015b, Interim Data Summary of Ongoing Baseline Off-Site Air Monitoring Radiological Parameters, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, Superfund Technical Assessment and Response Team (START) 4, Contract No. EP-S7-13-06, Task Order No. 0058, Prepared for U.S. Environmental Protection Agency Region 7, January 19.

TetraTech, 2015c, Interim Data Summary of Ongoing Baseline Off-Site Air Monitoring for Carbon Monoxide, Hydrogen Sulfide, and Sulfur Dioxide Measurements, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, Superfund Technical Assessment and Response Team (START) 4, Contract No. EP-S7-13-06, Task Order No. 0058, Prepared for U.S. Environmental Protection Agency Region 7, March 6.

TetraTech, 2015d, Interim Data Summary of Ongoing Baseline Off-Site Air Monitoring via Sampling for Volatile Organic Compounds and Hydrogen Sulfide by Application of Passive/Diffusive Sampling Methods, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, Superfund Technical Assessment and Response Team (START) 4, Contract No. EP-S7-13-06, Task Order No. 0058, Prepared for U.S. Environmental Protection Agency Region 7, March 26.

TetraTech, 2015e, Interim Data Summary of Ongoing Baseline Off-Site Air Monitoring Radiological Parameters, West Lake Landfill Site, Bridgeton, Missouri, CERCLIS ID: MOD079900932, Superfund Technical Assessment and Response Team (START) 4, Contract No. EP-S7-13-06, Task Order No. 0058, Prepared for U.S. Environmental Protection Agency Region 7, March 16.

TetraTech, 2014, Quality Assurance Project Plan for Baseline Off-Site Air Monitoring and Sampling, West Lake Landfill Site, Bridgeton Missouri.

TetraTech EM, Inc., 2009, Cost Evaluation for Excavation Remedial Alternative, Revision 01, West Lake Landfill Site, Bridgeton, Missouri, Operable Unit 1, START 3 Contract No, EP-S7-06-01, Task Order No. 0142, September 3.

Thermo Nutech, 1998, Segmented Gate System, ER Site 228A Remediation Project, Sandia National Laboratories, December 15.

Thompson, K.M., and Wellman, Dawn M., 2012, personnel communication, July 23.

Union Pacific Railroad (UPRR), 2007, Environmental Facts.

United Press International, Inc, undated, photograph of Home Depot in Joplin, MO, available at http://ph.cdn.photos.upi.com/collection/upi/sb/5141/2a8ab12a6ee3bf3492db02a1b25e66f8/Tornado-hits-Joplin-Missouri_4.jpg

U.S. Army Corps of Engineers (USACE), 2015, Isolation Barrier Alignment Alternatives Assessment, Amendment 1, West Lake Landfill, Bridgeton, Missouri, November 24.

USACE, 2014, Isolation Barrier Alignment Alternatives Assessment, West Lake Landfill, Bridgeton, Missouri, August 14.

USACE, 1998, Record of Decision for the St. Louis Downtown Site, October.

United States Department of Agriculture (USDA), 2008, Innovative Solutions to Human-Wildlife Conflicts, National Wildlife Research Center Accomplishments, Miscellaneous Publication No. 1603.

United States Department of Commerce (USDC), National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), 2013, Joplin Tornado Event Summary, May 22, 2011, May 21, available at http://www.crh.noaa.gov/sgf/?n=event_2011may22_summary

USDC-NOAA-NWS, 2012, Storm Event Pictures – May 22, 2011, May 16 available at http://www.crh.noaa.gov/sgf/?n=event_2011may22_pictures

USDC-NOAA-NWS, 2011a, Service Assessment: The Historic Tornadoes of April 2011, December, available at http://www.nws.noaa.gov/os/assessments/pdfs/historic_tornadoes.pdf

USDC-NOAA-NWS, 2011c, NWS Central Region Service Assessment, Joplin, Missouri, Tornado – May 22, 2011, July, available at http://www.nws.noaa.gov/os/assessments/pdfs/Joplin_tornado.pdf

USDC-NOAA-NWS, 2003, Service Assessment: Record Tornado Outbreaks of May 4-10, 2003, December, available at http://www.nws.noaa.gov/om/assessments/pdfs/record-may.pdf

U.S. Department of Energy (DOE), 1999, Cost and Performance Report: Thermo Nutech's Segmented Gate System, Sandia National Laboratories, ER Site 16, Albuquerque, N.M. Prepared by Sandia National Laboratories, January.

DOE, 1998, Technology Deployment: Segmented Gate System (SGS), Accelerated Site Technology Deployment Program, August.

DOE, 1989, Technical Approach Document, DOE/UMTRA- - 050425-0002, DE91 –5807, December.

United States Environmental Protection Agency (EPA), 2017, Letter from Alyse Stoy (EPA) to William Beck, Esq., John McGahren, Esq., Steven Miller, Esq., and Phil Dupre, Esq. RE: In the Matter of Cotter Corporation (NSL), and Laidlaw Waste Systems (Bridgeton), Inc. and Rock Road Industries, Inc., and the U.S. Department of Energy, Administrative Order on Consent, EPA Docket No. VII-93-F-0005, November 28.

EPA, 2017, LFG Energy Project Development Handbook, https://www.epa.gov/lmop/landfill-gas-energy-project-development-handbook

EPA, 2016, Letter from Bradley Vann to Paul Rosasco of EMSI regarding overview of status of various studies' work plans and related deliverables developed to support EPA's evaluation of the remedy decision for the West Lake Landfill Operable Unit-1, Bridgeton, Missouri, August 8.

EPA2016a, Letter from Bradley Vann to Paul Rosasco of EMSI regarding approving and accepting as final the revised Abbreviated Work Plan for a Remedial Investigation Addendum and Final Feasibility Study for OU-1 of the West Lake Landfill, May 18.

EPA, 2016b, Letter from Tom Mahler to Paul Rosasco of EMSI regarding preliminary laboratory data (Test America Reports J15607, J15609, J16191, and J16964), June 21.

EPA, 2016c, Letter from Bradley Vann to Paul Rosasco of EMSI regarding an overview of the status of various studies' work plans and related deliverables, August 4.

EPA, 2016d, Technical Guidance for Assessing Environmental Justice in Regulatory Analysis, June.

EPA, 2016e, Administrative Settlement Agreement and Order on Consent for Removal Actions, CERCLA Docket No. 07-2016-0005, In the Matter of West Lake Landfill Superfund Site, Bridgeton, St. Louis Co., Missouri (MOD079900932), Bridgeton landfill, LLC, April.

EPA, 2016f, Considering a Noncancer Oral Reference Does for Uranium for Superfund Human Health Risk Assessments, December 21.

EPA, 2015, Letter from Alyse Stoy (EPA) to William Beck, Esq., John McGahren, Esq., Steven Miller, Esq., and Phil Dupre, Esq. RE: In the Matter of Cotter Corporation (NSL), and Laidlaw Waste Systems (Bridgeton), Inc. and Rock Road Industries, Inc., and the U.S. Department of Energy, Administrative Order on Consent, EPA Docket No. VII-93-F-0005, April 20.

EPA, 2015a, Letter from Alyse Stoy (EPA) to William Beck, Esq., John McGahren, Esq., Steven Miller, Esq., and Phil Dupre, Esq. RE: In the Matter of Cotter Corporation (NSL), and Laidlaw Waste Systems (Bridgeton), Inc. and Rock Road Industries, Inc., and the U.S. Department of Energy, Administrative Order on Consent, EPA Docket No. VII-93-F-0005, October 9.

EPA, 2015b, Statement of Work for Remedial Investigation Addendum, Final Feasibility Study, and Perimeter Air Monitoring Program, West Lake Landfill OU1, attachment to EPA, 2015a, October 9.

EPA, 2015c, Letter from Alyse Stoy (EPA) to William Beck, Esq. and Jessica Merrigan, Esq., John McGahren, Esq., Steven Miller, Esq., and Phil Dupre, Esq. RE: In the Matter of Cotter Corporation (NSL), and Laidlaw Waste Systems (Bridgeton), Inc. and Rock Road Industries, Inc., and the U.S. Department of Energy, Administrative Order on Consent, EPA Docket No. VII-93-F-0005, December 9.

EPA, 2015d, Letter from Brad Vann to Joseph Benco of Republic Services providing comments on the "Isolation Barrier Alternatives Analysis" from EPA, USACE, Lambert-St. Louis International Airport, MDNR and MDHSS, March 10.

EPA, 2015e, Guidance on Considering Environmental Justice During the Development of Regulatory Actions, May.

EPA, 2015f, EJSCREEN, Environmental Justice Mapping and Screening Tool, Technical Documentation, May.

EPA, 2014a, Climate Change Adaptation Technical Fact Sheet: Landfills and Containment as an Element of Site Remediation, Office of Superfund Remediation Technology, EPA 542-F-14-001, May.

EPA, 2014b, Region 7 Change Adaption Implementation Plan, Publication Number: EPA-100-K-14-001M, June.

EPA, 2014c, Policy on Environmental Justice for Working with Federally Recognized Tribes and Indigenous Peoples, Washington, D.C.: U.S. EPA, Retrieved from http://www3.epa.gov/sites/production/files/2015-02/documents/ej_indigenous-policy.pdf

EPA, 2014d, Emission Factors for Greenhouse Gas inventories, April 4 at http://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

EPA, 2014e, Memorandum: "Distribution of Radiation Risk Assessment Guidance at CERCLA Sites: Q&A", OSWER Directive 9285.6-20, June 13.

EPA, 2012, Letter from Audrey Asher (EPA) to William Beck, Esq. and Jessica Merrigan, Esq., Lathrop and Gage, LLP, RE: In the Matter of Cotter Corporation (NSL), and Laidlaw Waste Systems (Bridgeton), Inc. and Rock Road Industries, Inc., and the U.S. Department of Energy Administrative Order on Consent, EPA Docket No. VII-93-F-0005, October 12.

EPA, 2011, Plan EJ 2014, Office of Environmental Justice, September.

EPA, 2010a, Letter dated January 11, 2010 from Cecilia Tapia, Region 7 Director Superfund Division to Michael Hockley (Spencer Fane Britt & Browne, LLP), Charlotte Neitzel (Holme, Roberts & Owen, LLP), and Christina Richmond (U.S. Department of Justice) Re: West Landfill Site, Bridgeton, Missouri Administrative Order on Consent, Docket No.: 93-F-0005 and Statement of Work for Supplemental Feasibility Study, West Lake Landfill Site (attachment to EPA's January 11, 2010 letter).

EPA, 2010b, NPL Fact Sheet, Mound Plant (USDOE), EPA ID# OH6890008984, May 19.

EPA, 2009a, National Oil and Hazardous Substances Pollution Contingency Plan, 59 FR 47416, September 15.

EPA, 2009b, Office of Superfund Remediation and Technology Innovation (OSTRI) Memorandum from Elizabeth Sutherland to Cecilia Tapia re: West Lake Landfill Site: Recommendations, May 21, 2009.

EPA, 2008, Record of Decision – West Lake Landfill Site, Bridgeton, Missouri, Operable Unit 1, May.

EPA, 2007, Technology Reference Guide for Radioactively Contaminated Media, EPA 402 R-07-004, October.

EPA, 2006a, Proposed Plan – West Lake Landfill Site Operable Units 1 and 2, Bridgeton, Missouri, June.

EPA, 2006b, Mineralogical Preservation of Solid Samples Collected from Anoxic Subsurface Environments, USEPA-600-R-06-112, October.

EPA, 2005, EPA Superfund Record of Decision: St. Louis Airport/Hazelwood Interim Storage/Futura Coatings Co., EPA ID: MOD980633176 OU 1, St. Louis, MO, EPA/ROD/R07-05/045, September 2.

EPA, 2004a, Multi-Agency Radiological Laboratory Analytical Procedures Manual [MARLAP], NUREG-1576, EPA 402-B-04-001B, July.

EPA, 2004b, (Draft) Technical Guidance for RCRA/CERCLA Final Covers, EPA 540-R-04-007, April.

EPA, 2003, Superfund Innovative Technology Evaluation Program, Technology Profiles, Eleventh Edition, EPA/540/R-03/009.

EPA, 2002, Role of Background in the CERCLA Cleanup Program, OSWER 9285.6-07P, April 26.

EPA, 2001a, Memorandum: Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA sites, OSWER Directive no. 9283.1-14, November 6.

EPA, 2001b, Abstracts of Remediation Case Studies, Volume 5, Federal Remediation Technologies Roundtable, EPA 542-R-01-008, May.

EPA, 2000a, Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6)", OSWER Directive 9200.4-35P, April 2000.

EPA, 2000b, Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups, OSWER Directive 9355.0-74FS-P, EPA 540-F-00-005, September.

EPA, 2000c, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July.

EPA, 1998, Memorandum: Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites, OSWER Directive no. 9200.4-25, February 12.

EPA, 1997a, Memorandum: Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, OSWER Directive no. 9200.4-18, August 22.

EPA, 1997b, Memorandum: Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA, OSWER Directive 9200.4-23, August 22.

EPA, 1995, Contaminants and Remedial Options at Selected Metal-Contaminated Sites, EPA/540/R-95/512.

EPA, 1994, National Oil and Hazardous Substances Pollution Contingency Plan, 59 FR 47416, September 15.

EPA, 1993a, Administrative Order on Consent for Remedial Investigation/Feasibility Study in the Matter of: Cotter Corporation (N.S.L.), and Laidlaw Waste Systems (Bridgeton), Inc., and Rock Road Industries, Inc., and United States Department of Energy, Respondents, Docket No: VII-93-F-005, March 3.

EPA, 1993b, Presumptive Remedy for CERCLA Municipal Landfill Sites, Office of Solid Waste and Emergency Response Directive 9355.0-49FS, EPA 540-F-93-035, September.

EPA, 1993c, Memorandum: Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis, OSWER Directive No. 9355.3-20, June 25.

EPA, 1992a, Guidance for Data Useability in Risk Assessment; OSWER Directive 9285.7-09A, April.

EPA, 1992b, Engineering Bulletin: Slurry Walls, EPA/540/S-92/008.

EPA, 1991a, Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives), Interim, Publication 9285.7-01C, October.

EPA, 1991b, Conducting Remedial Investigation/Feasibility Studies for CERCLA Municipal Landfill Sites, EPA/540/P-91/001, February.

EPA, 1991c, Risk Assesssment Guidance for Superfund Volume I: Human Health Evaluation Manual – Supplemental Guidance "standard Default Exposure Factors" Interim Final, OSWER Directive 9285.6-03, March 25.

EPA, 1989a, Aerial Photographic Analysis of the West Lake Landfill Site, Bridgeton, MO, TC-PIC-89787, October.

EPA, 1989b, RCRA ARARs: Focus on Closure Requirements, OSWER Directive 9234.2-04FS, October.

EPA, 1989c, Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, EPA 530-SW-89-047, July.

EPA, 1988a, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA 540/G-89/004, October 1988.

EPA, 1988b, CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006, August.

EPA, 1988c, Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites, EPA/540/2-88/002.

EPA, DOE, NRC, and U.S. Department of Defense, 1997, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, December.

U.S. Department of Homeland Security (DHS)-Federal Emergency Management Agency (FEMA), 2012, Mitigation Assessment Team Report – Spring 2011 Tornadoes: April 25 – 28 and May 22, Building Performance Observations, Recommendations, and Technical Guidance, FEMA P-908, May, available at http://www.fema.gov/media-library/assets/documents/25810?id=5633

DHS-FEMA, 2010, Pre-Mitigation Assessment Team Report – Mississippi Tornado Outbreak, April 23rd – 24th, Damage and Safe Room Performance Observations, Recommendations and Conclusions, July, available at http://www.fema.gov/media-library/assets/documents/19420?id=4286

DHS-FEMA, 2007a, Tornado Damage Investigation, Greensburg, Kansas, Final Report 1699 DR KS, October 24, 2007, http://www.fema.gov/media-library/assets/documents/15280?id=3566

DHS-FEMA, 1999, Building Assessment Report: Midwest Tornadoes of May 3, 1999 – Observations, Recommendations and Technical Guidance, October, FEMA 342, available at http://www.fema.gov/media-library/assets/documents/647?id=1423

United States Geological Survey (USGS), 2014, Background Groundwater Quality, Review of 2012-14 Groundwater Data, and Potential Origin of Radium at the West Lake Landfill Site, St. Louis County, Missouri, Administrative Report Prepared by the U.S. Geological Survey Missouri Water Science Center for the U.S. EPA, Region 7, Interagency Agreement DW-14-92380501, December 17.

U.S. Nuclear Regulatory Commission (NRC), 1988, Office of Nuclear Material Safety and Safeguards, Radioactive Material in the West Lake Landfill, Summary Report, NUREG-1308-Rev. 1, TI88 012946, June.

NRC, 1976, Office of Inspection and Enforcement Region III, IE Investigation Report No. 76-01, Subject: Cotter Corporation, Hazelwood, Missouri, License No. SUB-1022 (Terminated).

University of Missouri – Missouri Climate Center, 2016, Climate of Missouri, at http://climate.missouri.edu/climate.php#precip.

TABLES

Table 1-1: Summary of West Lake Landfill OU-1 Remedial Alternatives Evaluated in the 2006 FS, 2011 SFS and 2018 FFS

No.	Prior No.	Description	Evaluated in	Conclusion Reached	Status for this FFS
1	L1	No Action	2006 FS; 2011 SFS and 2018 FFS	Not protective	Retained per the NCP
2	L2	Cover repair & maintenance, additional access restrictions, institutional controls, and monitoring	2006 FS	Not protective	Not retained
3	L3	Soil Cover to Address Gamma Exposure and Erosion Potential	2006 FS	Protective but did not comply with solid waste ARARs	Not retained
4	L4	Regrading of Areas 1 and 2 (to 2% minimum slope) and Installation of Subtitle D landfill Cover System	2006 FS; 2011 SFS and 2018 FFS	Protective and complied with ARARs	ROD-selected remedy; retained
5	L5	Regrading of Areas 1 and 2 (to 5% minimum slope) and Installation of Subtitle D landfill Cover System	2006 FS	Protective and complied with ARARs	Not retained
6	L6	Excavation of "hot spots" from Area 2, regrading and installation of a Subtitle D landfill cover	2006 FS and 2018 FFS	Protective and complied with ARARs	Not retained in 2008 but re-evaluated in 2018 FFS
	F1	Buffer Zone/Lot 2A2 - No Action	2006 FS	Not protective	
	F2	Buffer Zone/Lot 2A2 - Institutional and Access Controls	2006 FS	Not protective	
	F3	Buffer Zone/Lot 2A2 - Capping and Institutional and Access Controls	2006 FS	Protective but did not comply with UMTRCA ARARs	
	F4	Buffer Zone/Lot 2A2 - Soil excavation and consolidation in Area 2	2006 FS, 2011 SFS and 2018 FFS	Protective and complied with ARARs	ROD-selected remedy; retained
7	none	ROD-selected remedy	2011 SFS and 2018 FFS	Protective and complied with	ROD-selected remedy;
8	none	"Complete rad removal" with off-site disposal	2011 SFS and 2018 FFS	Protective and complied with ARARs	Retained
9	none	"Complete rad removal" with on-site disposal	2011 SFS and 2018 FFS	Protective and complied with ARARs	Originally not retained but added in Nov. 2017
10	1a	Partial excavation of RIM >1,000 pCi/g (also no. 6)	2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
11	1b	Partial excavation of RIM >52.9 pCi/g within 16 ft of the 2005 topographic surface	2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
12	1c	Partial excavation to risk-based criteria consistent with an industrial land use	2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
13	2	Full excavation with off-site disposal (same as no. 8)	2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
14	3	Leaving all RIM in-place on-site - No Action (also no. 1)	2006 FS; 2011 SFS and 2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
15	4	2008 ROD-selected remedy (same as nos. 4 & 7)	2006 FS; 2011 SFS and 2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*
16		Full excavation with on-site disposal (same as no. 9)	2018 FFS	*to be evaluated in the FFS*	*Evaluated in the FFS*

Notes: 2006 FS - EMSI, 2006, Feasibility Study Report, West Lake Landfill Operable Unit 1, May 8.
2011 SFS - EMSI, 2011, Supplemental Feasibility Study, West Lake Landfill OU-1, December 16.
2018 FFS - this document

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
NRC (1981)																								
PVC-24-MH	1069234.280	516312.810	469.570	BKGD									No						-	NA	NA	NA	NA	NA
PVC-25-MH	1069345.420	516406.580	467.650	72,000	9	458.7							Yes	7	460.7	11	456.7	4.0	X	NA	NA	-	-	-
PVC-26-MH	1069464.450	516376.130	465.220	86,000	5	460.2							Yes	3	462.2	10	455.2	7.0	X	NA	NA	-	-	-
PVC-27-MH	1069460.560	516510.300	469.140	BKGD									No						-	NA	NA	NA	NA	NA
PVC-28-MH	1069255.020	516488.890	473.110	132,000	14	459.1							Yes	12	461.1	17	456.1	5.0	X	NA	NA	-	-	-
PVC-36-MH	1069217.890	516193.840	466.800	15,780	7.8	459.0							Yes	6	460.8	9.5	457.3	3.5	X	NA	NA	-	-	-
PVC-37-MH	1069146.480	516421.570	473.430	BKGD									No						-	NA	NA	NA	NA	NA
PVC-38-MH	1069315.550	516580.410	470.520	1,298,000	10	460.5							Yes	0	470.5	15	455.5	15.0	X	NA	NA	-	-	-
PVC-41-MH	1069213.330	516701.180	474.060	BKGD									No						-	NA	NA	NA	NA	NA
NRC-29	1069125.900	516607.450	473.460	2,000	9	464.46							No						-	NA	NA	NA	NA	NA
McLaren/Hart RI																								
WL-101-MH	1069549.550	516317.210	456.500	BKGD									No						-	NA	NA	-	-	-
WL-102-MH	1069260.460	515974.050	462.800	60,000	3.25	459.6							Yes	0	462.8	6	456.8	6.0	X	NA	NA	-	-	-
WL-103-MH	1069407.360	516737.060	450.900	BKGD									Yes	9	441.9	11	439.9	2.0	-	NA	NA	-	X	-
WL-104-MH	1069575.470	516602.770	449.800	BKGD									No						-	NA	NA	-	-	-
WL-105A-MH	1069136.260	515871.620	467.200	180,000	9	458.2							Yes	5.5	461.7	12	455.2	6.5	X	NA	NA	X	X	-
WL-105B-MH	1069148.420	515889.500	466.000	263,000	6.5	459.5							Yes	5.5	460.5	10.5	455.5	5.0	X	NA	NA	-	-	-
WL-105C-MH	1069155.840	515901.030	465.700	386,000	3.5	462.2							Yes	2	463.7	5	460.7	3.0	X	NA	NA	-	-	-
WL-106A-MH	1069317.250	516061.920	462.800	25,000	4	458.8							Yes	0	462.8	6	456.8	6.0	-	NA	NA	X	X	X
WL-106-MH	1069301.640	516082.180	465.400	25,000	4	461.4							Yes	1	464.4	5.5	459.9	4.5	X	NA	NA	-	-	-
WL-107-MH	1068909.520	516254.310	486.000	BKGD									No						-	NA	NA	-	-	-
WL-108-MH	1069144.210	516379.680	456.500	BKGD									No						-	NA	NA	-	-	-
WL-109A-MH	1068932.920	516509.670	485.500	BKGD									No						-	NA	NA	-	-	-
WL-109B-MH	1068947.160	516523.170	484.500	BKGD									No						-	NA	NA	-	-	-
WL-109C-MH	1068961.120	516528.430	483.900	BKGD									No						-	NA	NA	-	-	-
WL-109D-MH	1068947.380	516504.970	485.600	BKGD									No						-	NA	NA	-	-	-
WL-110-MH	1068852.431	516664.579	484.410	BKGD									No						-	NA	NA	-	-	-
WL-111-MH	1069187.350	516583.610	474.500	BKGD									No						-	NA	NA	-	-	-
WL-112-MH	1069379.450	516628.220	467.600	10,000	5.5	462.1							Yes	4	463.6	7	460.6	3.0	X	NA	NA	-	X	-
WL-113-MH	1069483.190	516469.950	467.000	14,000	3.75	463.3							Yes	3	464.0	5	462.0	2.0	X	NA	NA	-	-	-
WL-114-MH	1069391.530	516338.570	468.300	14,000	5	463.3							Yes	0	468.3	6	462.3	6.0	X	NA	NA	X	X	X
WL-115-MH	1069298.980	516395.130	468.900	BKGD									No						-	NA	NA	-	-	-
WL-116-MH	1069083.490	516160.600	474.300	BKGD									No						-	NA	NA	-	-	-
WL-117-MH	1069237.400	516221.330	467.600	16,000	6.5	461.1							Yes	3	464.6	11	456.6	8.0	X	NA	NA	-	X	-
WL-118-MH	1069411.090	516304.950	465.800	12,000	0	465.8							Yes	0	465.8	7	458.8	7.0	X	NA	NA	X	X	-
WL-119-MH	1069031.140	516289.260	477.400	BKGD									No						-	NA	NA	-	-	-
WL-120-MH	1069053.640	516846.570	474.700	BKGD									No						-	NA	NA	-	-	-
WL-121-MH	1068762.531	516241.324	523.210	BKGD									No						-	NA	NA	-	-	-
WL-122-MH	1068774.622	516110.181	507.192	BKGD									No						-	NA	NA	-	-	-
WL-123-MH	1068792.759	515934.652	480.135	BKGD									No						-	NA	NA	-	-	-
WL-124-MH	1069050.704	515857.983	470.484	BKGD									No						-	NA	NA	-	-	-
Phase 1A																								
GCPT 1-1	1068826.649	515829.017	471.003	6,258	1.1	469.9							No						-	NA	NA	NA	NA	NA
GCPT 1-1A	1068820.373	515835.155	470.952	7,464	32.5	438.5							No						-	NA	NA	NA	NA	NA
GCPT 1-2	1068777.662	515870.573	471.709	67,878	24.4	447.3							Yes	23.5	448.2	25.2	446.5	1.7	X	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 2-1	1068905.795	515882.108	472.776	5,610	3.3	469.5							No						-	NA	NA	NA	NA	NA
GCPT 2-2	1068879.341	515916.514	474.933	6,294	1.5	473.4							No						-	NA	NA	NA	NA	NA
GCPT 2-2A	1068874.348	515928.265	475.273	5,766	1.5	473.8							No						-	NA	NA	NA	NA	NA
GCPT 2-3	1068819.102	515941.573	476.607	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 2-3A	1068819.102	515941.573	476.607	34,722	35.6	441.0							Yes	35	441.6	36.8	439.8	1.8	X	NA	NA	NA	NA	NA
GCPT 2-2B	1068874.348	515928.265	475.273	96,000	34	441.3							Yes	33.2	442.1	34.7	440.6	1.5	X	NA	NA	NA	NA	NA
GCPT 2-2C	1068878.507	515931.137	475.300	18,906	32.5	442.8							Yes	31.8	443.5	32.7	442.6	0.9	X	NA	NA	NA	NA	NA
GCPT 2-4	1068863.196	515948.689	476.643	10,320	29.4	447.2							No						-	NA	NA	NA	NA	NA
GCPT 3-1	1068944.022	515949.289	474.936	5,724	4.4	470.5							No						-	NA	NA	NA	NA	NA
GCPT 3-1A	1068944.022	515949.289	474.936	78,810	27.7	447.2							Yes	27	447.9	28.5	446.4	1.5	X	NA	NA	NA	NA	NA
GCPT 3-2	1068866.409	516005.995	479.012	6,186	1	478.0							No						-	NA	NA	NA	NA	NA
GCPT 4-1	1068941.601	516007.654	474.382	488,196	28.9	445.5							Yes	27.5	446.9	31	443.4	3.5	X	NA	NA	NA	NA	NA
GCPT 4-2	1068880.888	516037.985	479.036	40,644	34	445.0							Yes	33.5	445.5	34.5	444.5	1.0	X	NA	NA	NA	NA	NA
GCPT 5-1	1069052.620	516101.781	473.644	126,738	25.1	448.5							Yes	23.2	450.4	25.8	447.8	2.6	X	NA	NA	NA	NA	NA
GCPT 5-2	1069012.133	516040.892	473.341	114,684	26.2	447.1							Yes	25.2	448.1	27	446.3	1.8	X	NA	NA	NA	NA	NA
GCPT 5-3	1068985.452	516093.331	474.679	631,662	29.4	445.3							Yes	25.5	449.2	33	441.7	7.5	X	NA	NA	NA	NA	NA
GCPT 5-4	1068925.017	516116.619	478.216	5,310	1.3	476.9							No						-	NA	NA	NA	NA	NA
GCPT 5-4A	1068931.178	516116.457	477.965	8,820	11.8	466.2							No						-	NA	NA	NA	NA	NA
GCPT 5-5	1068953.892	516113.219	476.700	450,360	32.2	444.5							Yes	30.1	446.6	34.4	442.3	4.3	X	NA	NA	NA	NA	NA
GCPT 5-6	1068998.386	516126.377	474.700	405,864	27.4	447.3							Yes	25.5	449.2	29	445.7	3.5	X	NA	NA	NA	NA	NA
GCPT 6-2	1069108.868	516196.534	472.997	6,258	13.3	459.7							No						-	NA	NA	NA	NA	NA
GCPT 6-3	1069036.469	516180.777	474.043	103,218	27.9	446.1							Yes	27.2	446.8	28.8	445.2	1.6	X	NA	NA	NA	NA	NA
GCPT 6-4	1068976.421	516208.637	482.702	4,434	3.1	479.6							No						-	NA	NA	NA	NA	NA
GCPT 6-5	1068969.612	516218.253	482.621	6,108	3.3	479.3							No						-	NA	NA	NA	NA	NA
GCPT 6-6	1069012.482	516193.425	475.200	191,856	28.1	447.1							Yes	26	449.2	29	446.2	3.0	X	NA	NA	NA	NA	NA
GCPT 7-1	1069155.521	516310.797	470.865	6,204	7.9	463.0							No						-	NA	NA	NA	NA	NA
GCPT 7-2	1069085.747	516269.321	472.588	6,012	4.9	467.7							No						-	NA	NA	NA	NA	NA
GCPT 7-3	1069013.045	516308.254	479.220	12,558	40	439.2							No						-	NA	NA	NA	NA	NA
GCPT 8-1	1069039.242	516366.519	479.726	19,854	29	450.7							Yes	27.5	452.2	30	449.7	2.5	X	NA	NA	NA	NA	NA
GCPT 9-1	1069152.039	516357.317	470.278	8,280	6.2	464.1							No						-	NA	NA	NA	NA	NA
GCPT 9-2	1069098.604	516379.609	472.123	5,826	16.9	455.2							No						-	NA	NA	NA	NA	NA
GCPT 9-3	1069055.624	516401.053	479.625	3,642	1.8	477.8							No						-	NA	NA	NA	NA	NA
GCPT 9-3A	1069049.417	516404.583	479.231	6,228	15.3	463.9							No						-	NA	NA	NA	NA	NA
GCTP 9-4	1069113.505	516407.046	471.412	5,622	2.1	469.3							No						-	NA	NA	NA	NA	NA
GCPT 10-1	1069190.539	516433.004	471.077	6,828	1.6	469.5							No						-	NA	NA	NA	NA	NA
GCPT 10-2	1069140.593	516449.840	472.326	6,486	7.5	464.8							No						-	NA	NA	NA	NA	NA
GCPT 10-3	1069074.641	516465.592	485.347	4,074	1.6	483.7							No						-	NA	NA	NA	NA	NA
GCPT 10-3A	1069075.419	516462.854	485.373	4,890	3.4	482.0							No						-	NA	NA	NA	NA	NA
GCPT 10-4	1069060.422	516474.665	483.551	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 10-4A	1069061.187	516477.897	483.556	6,642	14.9	468.7							No						-	NA	NA	NA	NA	NA
GCPT 11-1	1069222.929	516503.558	479.814	9,210	0.2	479.6							No						-	NA	NA	NA	NA	NA
GCPT 11-2	1069167.995	516518.208	474.796	7,614	15.4	459.4							No						-	NA	NA	NA	NA	NA
GCPT 11-3	1069137.542	516551.085	476.620	6,858	6.1	470.5							No						-	NA	NA	NA	NA	NA
GCPT 11-4	1069072.777	516565.515	482.682	9,792	45.9	436.8							No						-	NA	NA	NA	NA	NA
GCPT 12-1	1069249.275	516567.619	479.376	308,106	24.1	455.3							Yes	22	457.4	24.9	454.5	2.9	X	NA	NA	NA	NA	NA
GCPT 12-2	1069198.102	516592.800	476.014	6,546	1.3	474.7							No						-	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

																			Basis for RIM Interval					
Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 12-3	1069163.456	516608.867	475.910	7,476	4.1	471.8							No						-	NA	NA	NA	NA	NA
GCPT 12-4	1069124.740	516619.657	476.420	7,374	38.5	437.9							No						-	NA	NA	NA	NA	NA
GCPT 12-5	1069091.157	516638.742	478.450	6,432	7.5	471.0							No						-	NA	NA	NA	NA	NA
GCPT 12-6	1069031.297	516650.636	478.965	6,378	23.1	455.9							No						-	NA	NA	NA	NA	NA
GCPT 13-1	1069279.353	516642.002	470.898	28,302	15.4	455.5							Yes	15	455.9	16.3	454.6	1.3	X	NA	NA	NA	NA	NA
GCPT 13-2	1069258.075	516646.324	471.546	2,490	0.8	470.7							No						-	NA	NA	NA	NA	NA
GCPT 13-2A	1069256.406	516650.406	471.769	3,162	1.6	470.2							No						-	NA	NA	NA	NA	NA
GCPT 13-3	1069242.473	516658.268	472.195	2,520	1.3	470.9							No						-	NA	NA	NA	NA	NA
GCPT 13-4	1069194.628	516676.493	474.034	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 13-4S	1069195.799	516675.988	474.100	6,120	36.6	437.5							No						-	NA	NA	NA	NA	NA
GCPT 13-5	1069148.378	516695.025	475.365	1,872	0.3	475.1							No						-	NA	NA	NA	NA	NA
GCPT 13-5S	1069148.524	516697.133	475.500	5,682	11.5	464.0							No						-	NA	NA	NA	NA	NA
GCPT 13-6	1069094.279	516722.059	475.910	5,802	3.4	472.5							No						-	NA	NA	NA	NA	NA
GCPT 13-6S	1069094.328	516722.082	476.000	6,552	23.8	452.2							No						-	NA	NA	NA	NA	NA
GCPT 13-7	1069028.275	516764.522	474.263	5,964	1.6	472.7							No						-	NA	NA	NA	NA	NA
GCPT 13-7S	1069028.451	516763.208	474.200	6,366	20.8	453.4							No						-	NA	NA	NA	NA	NA
GCPT 14-1	1069289.841	516676.946	474.151	29,640	18.9	455.3							Yes	18.3	455.9	19.6	454.6	1.3	X	NA	NA	NA	NA	NA
GCPT 14-2	1069248.776	516702.985	474.471	3,600	1.1	473.4							No						-	NA	NA	NA	NA	NA
GCPT 14-3	1069218.180	516720.735	473.680	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 14-3S	1069218.942	516719.904	473.700	6,708	36.6	437.1							No						-	NA	NA	NA	NA	NA
GCPT 14-4	1069177.042	516745.043	474.597	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 14-5	1069125.940	516777.935	473.330	5,772	1.6	471.7							No						-	NA	NA	NA	NA	NA
GCPT 14-5S	1069125.781	516777.333	473.300	5,880	15.4	457.9							No						-	NA	NA	NA	NA	NA
GCPT 14-6	1069077.338	516811.126	472.680	6,654	7.4	465.3							No						-	NA	NA	NA	NA	NA
GCPT 14-6S	1069077.339	516809.484	472.800	6,330	14.9	457.9							No						-	NA	NA	NA	NA	NA
GCPT 14-7	1069029.001	516850.785	473.149	1,338	0.2	472.9							No						-	NA	NA	NA	NA	NA
GCPT 15-1	1069362.505	516757.424	453.830	11,940	20.3	433.5							No						-	NA	NA	NA	NA	NA
GCPT 15-2	1069277.200	516767.371	477.333	3,222	1.6	475.7							No						-	NA	NA	NA	NA	NA
GCPT 15-3	1069247.590	516788.341	473.986	9,828	30.5	443.5							No						-	NA	NA	NA	NA	NA
GCPT 15-4	1069209.876	516811.939	473.090	8,400	29.4	443.7							No						-	NA	NA	NA	NA	NA
GCPT 15-5	1069166.487	516848.251	469.170	7,098	57.7	411.5							No						-	NA	NA	NA	NA	NA
GCPT 15-6	1069125.130	516878.774	468.775	7,098	2.6	466.2							No						-	NA	NA	NA	NA	NA
GCPT 15-7	1069083.743	516906.231	472.113	6,444	2.5	469.6							No						-	NA	NA	NA	NA	NA
GCPT 15-8	1069045.994	516931.453	473.775	8,724	2.3	471.5							No						-	NA	NA	NA	NA	NA
GCPT 16-1	1069393.686	516784.741	451.150	9,228	7.2	444.0							No						-	NA	NA	NA	NA	NA
GCPT 16-2	1069364.966	516787.054	453.091	6,948	1.8	451.3							No						-	NA	NA	NA	NA	NA
GCPT 16-3	1069262.220	516837.666	471.257	6,744	2.3	469.0							No						-	NA	NA	NA	NA	NA
GCPT 16-4	1069234.210	516866.371	472.459	7,446	3	469.5							No						-	NA	NA	NA	NA	NA
GCPT 16-5	1069196.904	516903.898	474.011	6,864	4.8	469.2							No						-	NA	NA	NA	NA	NA
GCPT 16-6	1069158.015	516935.268	476.777	6,600	13.6	463.2							No						-	NA	NA	NA	NA	NA
GCPT 16-7	1069114.104	516970.890	479.817	6,414	2.6	477.2							No						-	NA	NA	NA	NA	NA
GCPT 16-8	1069073.911	517002.539	481.927	6,648	20.7	461.2							No						-	NA	NA	NA	NA	NA
Phase 1C (2014)																								
GCPT 1C-1	1068771.644	515837.945	463.703	5,256	3	460.7							No						-	NA	NA	NA	NA	NA
GCPT 1C-1A	1068766.648	515841.442	463.588	5,988	3.1	460.5							No						-	NA	NA	NA	NA	NA
GCPT 1C-2	1068737.758	515904.377	472.318	BKGD									No						-	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

																			Basis for RIM Interval					
Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 1C-2R	1068733.913	515907.223	472.500	31,290	30.3	442.2							Yes	29.6	442.9	32	440.5	2.4	**X**	NA	NA	NA	NA	NA
GCPT 1C-3	1068778.999	515991.398	486.422	6,576	22	464.4							No						-	NA	NA	NA	NA	NA
GCPT 1C-4	1068832.903	516068.813	486.098	1,851	27.7								No						-	NA	NA	NA	NA	NA
GPCT 1C-4R	1068835.119	516070.919	486.000	22,638	43.8	442.2							Yes	43.4	442.6	44	442.0	0.6	**X**	NA	NA	NA	NA	NA
GCPT 1C-5	1068986.634	516413.538	478.999	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 1C-5A	1068986.634	516413.538	478.999	6,516	15.1	463.9							No						-	NA	NA	NA	NA	NA
GCPT 1C-6	1068691.769	515934.812	468.800	84,810	22.1	446.7							Yes	21.4	447.4	23.2	445.6	1.8	**X**	NA	NA	NA	NA	NA
GCPT 1C-6T	1068685.948	515938.701	468.900	90,390	22.8	446.1							Yes	22	446.9	24	444.9	2.0	**X**	NA	NA	NA	NA	NA
GCPT 1C-6T1	1068684.148	515939.610	468.900	171,774	23.5	445.4							Yes	22.5	446.4	23.6	445.3	1.1	**X**	NA	NA	NA	NA	NA
GCPT 1C-7	1068646.890	515958.200	468.599	6,978	4.3	464.3							No						-	NA	NA	NA	NA	NA
GCPT 1C-8	1068728.323	516014.864	491.227	6,144	3	488.2							No						-	NA	NA	NA	NA	NA
GCPT 1C-9	1068746.456	516049.886	495.235	6,360	10.4	484.8							No						-	NA	NA	NA	NA	NA
GCPT 1C-10	1068797.838	516095.938	496.493	6,276	11.8	484.7							No						-	NA	NA	NA	NA	NA
GCPT 1C-11	1068838.882	516151.875	496.895	6,516	3	493.9							No						-	NA	NA	NA	NA	NA
GCPT 1C-12	1068865.907	516200.860	500.100	57,414	56.3	443.8							Yes	55.7	444.4	57	443.1	1.3	**X**	NA	NA	NA	NA	NA
GCPT 1C-13	1068982.241	516321.892	480.072	6,438	34.1	446.0							No						-	NA	NA	NA	NA	NA
GCPT-108	1069142.077	516388.988	470.448	6,408	2	468.4							No						-	NA	NA	NA	NA	NA
GCPT-111A	1069183.707	516592.402	475.656	9,564	25.9	449.8							No						-	NA	NA	NA	NA	NA
GCPT-119	1069021.032	516294.161	478.577	14,616	45.6	433.0							No						-	NA	NA	NA	NA	NA
GCPT-28A	1069253.583	516490.663	480.478	82,512	24.9	455.6							Yes	24.2	456.3	25.6	454.9	1.4	**X**	NA	NA	NA	NA	NA
GCPT-36	1069217.918	516193.669	464.969	19,470	8.5	456.5							Yes	7.8	457.2	8.8	456.2	1.0	**X**	NA	NA	NA	NA	NA
GCPT-25	1069345.436	516405.360	465.274	74,880	8.4	456.9							Yes	7.3	458.0	9.8	455.5	2.5	**X**	NA	NA	NA	NA	NA
PVC-25R	1069345.436	516405.360	465.300	74,562	9.5	455.8							Yes	8.3	457.0	10.9	454.4	2.6	**X**	NA	NA	NA	NA	NA
1-2	1068783.142	515878.536	472.600	4,271	33	439.6	11,838	2	470.6				No						-	-	NA	-	-	-
2-2	1068876.813	515926.163	475.200	4,354	32	443.2	14,862	22	453.2				No						-	-	NA	-	-	-
5-3	1068986.832	516093.839	474.400	336,937	29.5	444.9	368,717	28	446.4				Yes	26	448.4	34	440.4	8.0	**X**	**X**	NA	**X**	**X**	**X**
5-3	1068986.832	516093.839	474.400	44,163	51.5	422.9							Yes	49	425.4	53?	421.4?	4?	**X**	-	NA	-	-	-
8-1	1069041.228	516368.555	479.800	4,821	28	451.8	15,541	44	435.8				No						-	-	NA	-	-	-
12-5	1069087.130	516641.299	478.900	3,864	14	464.9	13,053	49	429.9				No						-	-	NA	-	-	-
13-3	1069232.054	516662.275	472.600	3,607	16.5	456.1	13,869	43	429.6				No						-	-	NA	-	-	-
13-6	1069093.452	516723.784	475.900	3,902	24.5	451.4	12,293	21	454.9				No						-	-	NA	-	-	-
14-2	1069250.965	516701.546	474.600	4,008	27.5	447.1	16,548	29	445.6				No						-	-	NA	-	-	-
14-4	1069179.619	516743.234	474.400	3,888	9	465.4	11,662	40	434.4				No						-	-	NA	-	-	-
14-5	1069122.899	516777.908	472.900	3,454	13.5	459.4	11,457	12	460.9				No						-	-	NA	-	-	-
14-7	1069027.735	516848.642	473.300	3,637	31.5	441.8	13,227	31	442.3				No						-	-	NA	-	-	-
15-2	1069281.151	516768.917	476.500	5,184	26	450.5	13,899	24	452.5				Yes	22	454.5	27	449.5	5.0	-	-	NA	-	**X**	-
16-3	1069267.110	516837.299	470.700	4,118	20	450.7	13,165	10	460.7				No						-	-	NA	-	-	-
16-6	1069155.378	516938.746	477.100	3,841	14	463.1	13,051	21	456.1				No						-	-	NA	-	-	-
1C-6	1068688.971	515936.009	469.200	53,732	22.5	446.7	15,025	26	443.2				Yes	20	449.2	27	442.2	7.0	**X**	-	NA	**X**	**X**	-
WL-119	1069017.400	516296.369	479.200	7,941	32.5	446.7	13,679	1	478.2				Yes	31.5	447.7	33	446.2	1.5	**X**	-	NA	-	-	-
1-2-Geoprobe	1068779.843	515869.22	472.859	NA									No						NA	NA	NA	-	-	-
2-2-Geoprobe	1068870.734	515929.287	475.250	NA									Yes	30	445.250	34	441.250	4.0	NA	NA	NA	**X**	**X**	-
2-3-Geoprobe	1068815.973	515943.908	476.459	NA									Yes	33	443.459	38	438.459	5.0	NA	NA	NA	**X**	**X**	-
8-1B-Geoprobe	1069041.054	516363.853	479.703	NA									No						NA	NA	NA	-	-	-
1C-12-Geoprobe	1068867.887	516204.389	500.064	NA									No						NA	NA	NA	-	-	-
1C-12B-Geoprobe	1068863.729	516197.682	499.723	NA									Yes	54	445.723	56	443.723	2.0	NA	NA	NA	-	**X**	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

																			Basis for RIM Interval					
Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
1C-12C-Geoprobe	1068862.939	516203.039	500.161	NA									Yes	53	447.161	58	442.161	5.0	NA	NA	NA	X	X	-
1C-2RA-Geoprobe	1068730.068	515908.919	472.398	NA									No						NA	NA	NA	-	-	-
1C-4R-Geoprobe	1068835.529	516073.369	486.107	NA									No						NA	NA	NA	-	-	-
1C-4RB-Geoprobe	1068837.644	516076.741	485.970	NA									No						NA	NA	NA	-	-	-
1C-6T1-Geoprobe	1068681.573	515937.074	468.930	NA									No						NA	NA	NA	-	-	-
WL-119-Geoprobe	1069018.294	516291.964	478.594	NA									No						NA	NA	NA	-	-	-
WL-119B-Geoprobe	1069013.907	516287.796	479.244	NA									No						NA	NA	NA	-	-	-
WL-119C-Geoprobe	1069012.752	516291.905	479.148	NA									No						NA	NA	NA	-	-	-
Phase 1D (2015)																								
1D-1	1069085.157	515745.035	462.487	6,288	8.9	453.6	13,570	8	454.5	3 (m)	16	446.5	No						-	NA	NA	NA	NA	NA
1D-2	1068999.089	515778.193	468.382	5,142	5.9	462.5	13,261	36	432.4	7	3	465.4	No						-	NA	NA	NA	NA	NA
1D-3	1068972.272	515874.232	472.064	390,720	27.4	444.7	67,177	28	444.1	125	28	444.1	Yes	25.5	446.6	29.5	442.6	4.0	X	NA	NA	NA	NA	NA
1D-4	1068794.546	516092.056	496.410	14,154	55.8	440.6	15,010	11	485.4	3 (m)	14	482.4	No						-	NA	NA	NA	NA	NA
1D-5	1068649.773	516043.497	487.632	143,724	55.1	432.5	20,707	51	436.6	33	51	436.6	Yes	54.1	433.5	56.2	431.4	2.1	X	NA	NA	NA	NA	NA
1D-6	1068727.516	516153.004	512.509	6,834	3.9	508.6	20,707	51	461.5	33	51	461.5	No						-	NA	NA	NA	NA	NA
1D-7	1068647.213	516155.853	512.790	775,560	82.8	430.0	1,995,300	83	429.8	3270	82	430.8	Yes	80.2	432.6	85.5	427.3	5.3	X	NA	NA	NA	NA	NA
1D-8	1068818.180	516243.565	517.157	44,028	75.3	441.9	19,108	75	442.2	6	85	432.2	Yes	74.7	442.5	75.6	441.6	0.9	X	NA	NA	NA	NA	NA
1D-8A	1068820.740	516250.571	517.322	6,318	2.6	514.7							No						-	NA	NA	NA	NA	NA
1D-9	1068667.863	516221.690	518.577	13,236	58.6	460.0	18,794	87	431.6	10 (m)	84	434.6	No						-	NA	NA	NA	NA	NA
1D-9A	1068662.945	516220.860	518.595	14,508	56.8	461.8							No						-	NA	NA	NA	NA	NA
1D-10	1068897.481	516306.812	503.702	7,554	38.9	464.8	12,827	6	497.7	3	48	455.7	No						-	NA	NA	NA	NA	NA
1D-11	1068732.965	516319.191	522.966	5,970	1.8	521.2	24,281	85	438.0	38	85	438.0	No						-	NA	NA	NA	NA	NA
1D-11A	1068728.093	516324.559	522.829	6,648	1.6	521.2							No						-	NA	NA	NA	NA	NA
1D-12	1068878.274	516446.247	505.566	6,054	29.4	476.2	13,843	61	444.6	4	59	446.6	No						-	NA	NA	NA	NA	NA
1D-13	1068807.791	516405.192	520.176	7,980	36.4	483.8	13,515	93	427.2	2	53	467.2	No						-	NA	NA	NA	NA	NA
1D-13A	1068807.910	516397.463	520.165	5,934	2.1	518.1							No						-	NA	NA	NA	NA	NA
1D-13B	1068807.560	516392.053	520.392	5,964	7.1	513.3							No						-	NA	NA	NA	NA	NA
1D-13C	1068808.169	516414.237	519.931	6,432	2.5	517.4							No						-	NA	NA	NA	NA	NA
1D-14	1068737.296	516389.489	522.027	5,952	2.5	519.5	14,725	54	468.0	2 (m)	46	476.0	No						-	NA	NA	NA	NA	NA
1D-15	1068600.173	516194.976	516.672	16,194	89.6	427.1	13,352	85	431.7	15	85	431.7	Yes	89.4	427.3	89.7	427.0	0.3	X	NA	NA	NA	NA	NA
1D-16	1068604.580	516049.511	484.823	68,700	46.9	437.9	24,411	50	434.8	17	50	434.8	Yes	46	438.8	48	436.8	2.0	X	NA	NA	NA	NA	NA
1D-16A	1068611.344	516048.677	485.168	17,712	49.9	435.3							Yes	49.7	435.5	49.9	435.3	0.2	X	NA	NA	NA	NA	NA
1D-17	1068872.427	515830.991	472.494	4,938	4.1	468.4	13,040	18	454.5	4	45	427.5	No						-	NA	NA	NA	NA	NA
1D-17A	1068870.009	515836.352	472.546	5,496	17.7	454.8							No						-	NA	NA	NA	NA	NA
1D-18	1068551.103	516059.874	480.990	7,224	10.2	470.8	13,803	12	469.0	4 (m)	19	462.0	No						-	NA	NA	NA	NA	NA
1D-18A	1068545.369	516060.390	480.524	6,984	41.3	439.2							No						-	NA	NA	NA	NA	NA
1D-1S	1069074.230	515747.359	462.568	3,382	6.5	456.1							No						-	-	-	-	-	-
1D-2S	1068990.154	515784.257	468.561	4,001	19.5	449.1							No						-	-	-	-	-	-
1D-3S	1068968.601	515882.929	472.250	204,471	27	445.3							Yes	23	449.3	31	441.3	8.0	X	X	X	X	X	-
1D-4S	1068804.861	516101.296	496.422	4,349	12.5	483.9							No						-	-	-	-	-	-
1D-5S	1068657.730	516040.319	487.751	12,059	53	434.8							Yes	51	436.8	56	431.8	5.0	X	X	X	X	X	-
1D-6S	1068732.994	516160.954	512.707	3,749	11	501.7							No						-	-	-	-	-	-
1D-7S	1068653.591	516157.910	513.346	1,503,082	82.5	430.8							Yes	76	437.3	93	420.3	17.0	X	X	X	X	X	-
1D-8S	1068810.599	516238.029	516.742	6,869	73	443.7							Yes	72	444.7	74	442.7	2.0	X	-	-	-	-	-
1D-9S	1068678.246	516223.760	518.893	16,313	71.5	447.4							Yes	70	448.9	72.5	446.4	2.5	X	-	-	-	-	-
1D-9S	1068678.246	516223.760	518.893	1,174,844	87.5	431.4							Yes	82	436.9	96	422.9	14.0	X	X	X	X	X	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
1D-10S	1068898.786	516318.538	503.074	3,942	37.5	465.6							No						-	-	-	-	-	-
1D-11S	1068739.042	516311.220	522.303	16,554	84	438.3							Yes	82	440.3	86	436.3	4.0	X	X	X	X	X	-
1D-12S	1068880.804	516434.947	505.890	4,173	29.5	476.4							No						-	-	-	-	-	-
1D-13S	1068786.080	516399.333	520.512	4,304	42	478.5							No						-	-	-	-	-	-
1D-14S	1068730.267	516381.884	522.532	4,010	43.5	479.0							No						-	-	-	-	-	-
1D-15S	1068611.681	516196.257	516.098	20,523	85	431.1							Yes	83.5	432.6	86	430.1	2.5	X	X	X	X	X	-
1D-16S	1068620.165	516047.598	485.581	11,886	50	435.6							Yes	49.5	436.1	51.5	434.1	2.0	X	X	X	X	X	-
1D-17S	1068865.421	515846.051	472.920	3,650	16	456.9							No						-	-	-	-	-	-
1D-18S	1068573.847	516056.126	482.022	4,480	48.5	433.5							No						-	-	-	-	-	-
1D-19S	1068620.714	516259.114	521.112	3,437	44	477.1							No						-	-	-	-	-	-
1D-20S	1068540.263	516226.617	517.696	1,576	2.5	515.2							No						-	-	-	-	-	-
Area 1 - Additional																								
AC-1a	1069120.740	516017.324	466.725	824,868	10.5	456.2	1,128,112	10	456.7	2596	10	456.7	Yes	4.5	462.2	22	444.7	17.5	X	X	X	X	X	X
AC-1b	1069120.740	516017.324	466.725	3,686	29.0	437.7							Yes	29	437.7	32	434.7	3.0	-	X	X	X	X	-
AC-1c	1069120.740	516017.324	466.725	20,364	38.5	428.2							Yes	35	431.7	41	425.7	6.0	X	-	-	-	-	-
AC-2Ba	1069151.417	515831.894	466.165	7,931	4.5	461.7	21,345	10	456.2	11	10	456.2	Yes	2	464.2	6.5	459.7	4.5	X	-	-	-	-	-
AC-2Bb	1069151.417	515831.894	466.165	15,570	10.0	456.2							Yes	9.5	456.7	13.5	452.7	4.0	X	X	X	X	X	-
AC-3a	1069183.583	516040.675	466.425	906,839	4.0	462.4	979,494	5	461.4	1013	3	463.4	Yes	0	466.4	19	447.4	19.0	X	X	X	X	X	X
AC-3b	1069183.583	516040.675	466.425	46,921	38.5	427.9							Yes	32.5	433.9	39.5	426.9	7.0	X	-	-	-	-	-
AC-4B	1069555.665	516492.941	464.661	5,114	5.0	459.7	13,302	32	432.7	4	25	439.7	No						-	-	-	-	-	-
AC-5	1069483.755	516657.795	451.372	4,656	12.5	438.9	15,408	11	440.4	5	11	440.4	No						-	-	-	-	-	-
AC-6	1069420.320	516222.713	464.254	4,857	26.0	438.3	14,908	23	441.3	4 (m)	7	457.3	No						-	-	-	-	-	-
AC-7	1069315.677	516025.425	461.529	24,727	2.5	459.0	17,700	32	429.5	4	32	429.5	Yes	0.5	461.0	5	456.5	4.5	X	-	-	-	-	-
Cotter (2015)																								
WL-102-CT	1069271.265	515974.528	461.697	4,379	3.0	458.7	13,625	12	449.7	10 (m)	2	459.7	No						-	-	X	-	-	-
WL-106A-CT	1069300.779	516090.264	463.803	27,546	4.5	459.3	30,545	10	453.8	54	11	452.8	Yes	2	461.8	12	451.8	10.0	X	X	X	X	X	-
WL-114-CT	1069381.076	516352.442	467.381	5,669	5.0	462.4	14,300	6	461.4	14	32	435.4	Yes	2	465.4	6	461.4	4.0	-	X	-	-	-	-

Notes:

amsl = above mean sea level   cpm = counts per minute

NA - Data were not collected or are otherwise not available.

X - Data support the presence of RIM in the indicated interval

- Data do not indicate the presence of RIM at this location/interval

(m) - multiple intervals with same detections; see Appendix L for details; only uppermost elevation shown

See Borehole Summary Sheets in Appendix L and Appendix D-1 for the NRC data for supporting documentation for this table

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
NRC (1981)																								
PVC-24-MH	1069234.280	516312.810	469.570	BKGD									No						-	NA	NA	NA	NA	NA
PVC-25-MH	1069345.420	516406.580	467.650	72,000	9	458.7							Yes	7	460.7	11	456.7	4.0	X	NA	NA	-	-	-
PVC-26-MH	1069464.450	516376.130	465.220	86,000	5	460.2							Yes	3	462.2	10	455.2	7.0	X	NA	NA	-	-	-
PVC-27-MH	1069460.560	516510.300	469.140	BKGD									No						-	NA	NA	NA	NA	NA
PVC-28-MH	1069255.020	516488.890	473.110	132,000	14	459.1							Yes	12	461.1	17	456.1	5.0	X	NA	NA	-	-	-
PVC-36-MH	1069217.890	516193.840	466.800	15,780	7.8	459.0							Yes	6	460.8	9.5	457.3	3.5	X	NA	NA	-	-	-
PVC-37-MH	1069146.480	516421.570	473.430	BKGD									No						-	NA	NA	NA	NA	NA
PVC-38-MH	1069315.550	516580.410	470.520	1,298,000	10	460.5							Yes	0	470.5	15	455.5	15.0	X	NA	NA	-	-	-
PVC-41-MH	1069213.330	516701.180	474.060	BKGD									No						-	NA	NA	NA	NA	NA
NRC-29	1069125.900	516607.450	473.460	2,000	9	464.46							No						-	NA	NA	NA	NA	NA
McLaren/Hart RI																								
WL-101-MH	1069549.550	516317.210	456.500	BKGD									No						-	NA	NA	-	-	-
WL-102-MH	1069260.460	515974.050	462.800	60,000	3.25	459.6							Yes	0	462.8	6	456.8	6.0	X	NA	NA	-	-	-
WL-103-MH	1069407.360	516737.060	450.900	BKGD									Yes	9	441.9	11	439.9	2.0	-	NA	NA	-	X	-
WL-104-MH	1069575.470	516602.770	449.800	BKGD									No						-	NA	NA	-	-	-
WL-105A-MH	1069136.260	515871.620	467.200	180,000	9	458.2							Yes	5.5	461.7	12	455.2	6.5	X	NA	NA	X	X	-
WL-105B-MH	1069148.420	515889.500	466.000	263,000	6.5	459.5							Yes	5.5	460.5	10.5	455.5	5.0	X	NA	NA	-	-	-
WL-105C-MH	1069155.840	515901.030	465.700	386,000	3.5	462.2							Yes	2	463.7	5	460.7	3.0	X	NA	NA	-	-	-
WL-106A-MH	1069317.250	516061.920	462.800	25,000	4	458.8							Yes	0	462.8	6	456.8	6.0	-	NA	NA	X	X	X
WL-106-MH	1069301.640	516082.180	465.400	25,000	4	461.4							Yes	1	464.4	5.5	459.9	4.5	X	NA	NA	-	-	-
WL-107-MH	1068909.520	516254.310	486.000	BKGD									No						-	NA	NA	-	-	-
WL-108-MH	1069144.210	516379.680	456.500	BKGD									No						-	NA	NA	-	-	-
WL-109A-MH	1068932.920	516509.670	485.500	BKGD									No						-	NA	NA	-	-	-
WL-109B-MH	1068947.160	516523.170	484.500	BKGD									No						-	NA	NA	-	-	-
WL-109C-MH	1068961.120	516528.430	483.900	BKGD									No						-	NA	NA	-	-	-
WL-109D-MH	1068947.380	516504.970	485.600	BKGD									No						-	NA	NA	-	-	-
WL-110-MH	1068852.431	516664.579	484.410	BKGD									No						-	NA	NA	-	-	-
WL-111-MH	1069187.350	516583.610	474.500	BKGD									No						-	NA	NA	-	-	-
WL-112-MH	1069379.450	516628.220	467.600	10,000	5.5	462.1							Yes	4	463.6	7	460.6	3.0	X	NA	NA	-	X	-
WL-113-MH	1069483.190	516469.950	467.000	14,000	3.75	463.3							Yes	3	464.0	5	462.0	2.0	X	NA	NA	-	-	-
WL-114-MH	1069391.530	516338.570	468.300	14,000	5	463.3							Yes	0	468.3	6	462.3	6.0	X	NA	NA	X	X	X
WL-115-MH	1069298.980	516395.130	468.900	BKGD									No						-	NA	NA	-	-	-
WL-116-MH	1069083.490	516160.600	474.300	BKGD									No						-	NA	NA	-	-	-
WL-117-MH	1069237.400	516221.330	467.600	16,000	6.5	461.1							Yes	3	464.6	11	456.6	8.0	X	NA	NA	-	X	-
WL-118-MH	1069411.090	516304.950	465.800	12,000	0	465.8							Yes	0	465.8	7	458.8	7.0	X	NA	NA	X	X	-
WL-119-MH	1069031.140	516289.260	477.400	BKGD									No						-	NA	NA	-	-	-
WL-120-MH	1069053.640	516846.570	474.700	BKGD									No						-	NA	NA	-	-	-
WL-121-MH	1068762.531	516241.324	523.210	BKGD									No						-	NA	NA	-	-	-
WL-122-MH	1068774.622	516110.181	507.192	BKGD									No						-	NA	NA	-	-	-
WL-123-MH	1068792.759	515934.652	480.135	BKGD									No						-	NA	NA	-	-	-
WL-124-MH	1069050.704	515857.983	470.484	BKGD									No						-	NA	NA	-	-	-
Phase 1A																								
GCPT 1-1	1068826.649	515829.017	471.003	6,258	1.1	469.9							No						-	NA	NA	NA	NA	NA
GCPT 1-1A	1068820.373	515835.155	470.952	7,464	32.5	438.5							No						-	NA	NA	NA	NA	NA
GCPT 1-2	1068777.662	515870.573	471.709	67,878	24.4	447.3							Yes	23.5	448.2	25.2	446.5	1.7	X	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 2-1	1068905.795	515882.108	472.776	5,610	3.3	469.5							No						-	NA	NA	NA	NA	NA
GCPT 2-2	1068879.341	515916.514	474.933	6,294	1.5	473.4							No						-	NA	NA	NA	NA	NA
GCPT 2-2A	1068874.348	515928.265	475.273	5,766	1.5	473.8							No						-	NA	NA	NA	NA	NA
GCPT 2-3	1068819.102	515941.573	476.607	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 2-3A	1068819.102	515941.573	476.607	34,722	35.6	441.0							Yes	35	441.6	36.8	439.8	1.8	X	NA	NA	NA	NA	NA
GCPT 2-2B	1068874.348	515928.265	475.273	96,000	34	441.3							Yes	33.2	442.1	34.7	440.6	1.5	X	NA	NA	NA	NA	NA
GCPT 2-2C	1068878.507	515931.137	475.300	18,906	32.5	442.8							Yes	31.8	443.5	32.7	442.6	0.9	X	NA	NA	NA	NA	NA
GCPT 2-4	1068863.196	515948.689	476.643	10,320	29.4	447.2							No						-	NA	NA	NA	NA	NA
GCPT 3-1	1068944.022	515949.289	474.936	5,724	4.4	470.5							No						-	NA	NA	NA	NA	NA
GCPT 3-1A	1068944.022	515949.289	474.936	78,810	27.7	447.2							Yes	27	447.9	28.5	446.4	1.5	X	NA	NA	NA	NA	NA
GCPT 3-2	1068866.409	516005.995	479.012	6,186	1	478.0							No						-	NA	NA	NA	NA	NA
GCPT 4-1	1068941.601	516007.654	474.382	488,196	28.9	445.5							Yes	27.5	446.9	31	443.4	3.5	X	NA	NA	NA	NA	NA
GCPT 4-2	1068880.888	516037.985	479.036	40,644	34	445.0							Yes	33.5	445.5	34.5	444.5	1.0	X	NA	NA	NA	NA	NA
GCPT 5-1	1069052.620	516101.781	473.644	126,738	25.1	448.5							Yes	23.2	450.4	25.8	447.8	2.6	X	NA	NA	NA	NA	NA
GCPT 5-2	1069012.133	516040.892	473.341	114,684	26.2	447.1							Yes	25.2	448.1	27	446.3	1.8	X	NA	NA	NA	NA	NA
GCPT 5-3	1068985.452	516093.331	474.679	631,662	29.4	445.3							Yes	25.5	449.2	33	441.7	7.5	X	NA	NA	NA	NA	NA
GCPT 5-4	1068925.017	516116.619	478.216	5,310	1.3	476.9							No						-	NA	NA	NA	NA	NA
GCPT 5-4A	1068931.178	516116.457	477.965	8,820	11.8	466.2							No						-	NA	NA	NA	NA	NA
GCPT 5-5	1068953.892	516113.219	476.700	450,360	32.2	444.5							Yes	30.1	446.6	34.4	442.3	4.3	X	NA	NA	NA	NA	NA
GCPT 5-6	1068998.386	516126.377	474.700	405,864	27.4	447.3							Yes	25.5	449.2	29	445.7	3.5	X	NA	NA	NA	NA	NA
GCPT 6-2	1069108.868	516196.534	472.997	6,258	13.3	459.7							No						-	NA	NA	NA	NA	NA
GCPT 6-3	1069036.469	516180.777	474.043	103,218	27.9	446.1							Yes	27.2	446.8	28.8	445.2	1.6	X	NA	NA	NA	NA	NA
GCPT 6-4	1068976.421	516208.637	482.702	4,434	3.1	479.6							No						-	NA	NA	NA	NA	NA
GCPT 6-5	1068969.612	516218.253	482.621	6,108	3.3	479.3							No						-	NA	NA	NA	NA	NA
GCPT 6-6	1069012.482	516193.425	475.200	191,856	28.1	447.1							Yes	26	449.2	29	446.2	3.0	X	NA	NA	NA	NA	NA
GCPT 7-1	1069155.521	516310.797	470.865	6,204	7.9	463.0							No						-	NA	NA	NA	NA	NA
GCPT 7-2	1069085.747	516269.321	472.588	6,012	4.9	467.7							No						-	NA	NA	NA	NA	NA
GCPT 7-3	1069013.045	516308.254	479.220	12,558	40	439.2							No						-	NA	NA	NA	NA	NA
GCPT 8-1	1069039.242	516366.519	479.726	19,854	29	450.7							Yes	27.5	452.2	30	449.7	2.5	X	NA	NA	NA	NA	NA
GCPT 9-1	1069152.039	516357.317	470.278	8,280	6.2	464.1							No						-	NA	NA	NA	NA	NA
GCPT 9-2	1069098.604	516379.609	472.123	5,826	16.9	455.2							No						-	NA	NA	NA	NA	NA
GCPT 9-3	1069055.624	516401.053	479.625	3,642	1.8	477.8							No						-	NA	NA	NA	NA	NA
GCPT 9-3A	1069049.417	516404.583	479.231	6,228	15.3	463.9							No						-	NA	NA	NA	NA	NA
GCTP 9-4	1069113.505	516407.046	471.412	5,622	2.1	469.3							No						-	NA	NA	NA	NA	NA
GCPT 10-1	1069190.539	516433.004	471.077	6,828	1.6	469.5							No						-	NA	NA	NA	NA	NA
GCPT 10-2	1069140.593	516449.840	472.326	6,486	7.5	464.8							No						-	NA	NA	NA	NA	NA
GCPT 10-3	1069074.641	516465.592	485.347	4,074	1.6	483.7							No						-	NA	NA	NA	NA	NA
GCPT 10-3A	1069075.419	516462.854	485.373	4,890	3.4	482.0							No						-	NA	NA	NA	NA	NA
GCPT 10-4	1069060.422	516474.665	483.551	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 10-4A	1069061.187	516477.897	483.556	6,642	14.9	468.7							No						-	NA	NA	NA	NA	NA
GCPT 11-1	1069222.929	516503.558	479.814	9,210	0.2	479.6							No						-	NA	NA	NA	NA	NA
GCPT 11-2	1069167.995	516518.208	474.796	7,614	15.4	459.4							No						-	NA	NA	NA	NA	NA
GCPT 11-3	1069137.542	516551.085	476.620	6,858	6.1	470.5							No						-	NA	NA	NA	NA	NA
GCPT 11-4	1069072.777	516565.515	482.682	9,792	45.9	436.8							No						-	NA	NA	NA	NA	NA
GCPT 12-1	1069249.275	516567.619	479.376	308,106	24.1	455.3							Yes	22	457.4	24.9	454.5	2.9	X	NA	NA	NA	NA	NA
GCPT 12-2	1069198.102	516592.800	476.014	6,546	1.3	474.7							No						-	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 12-3	1069163.456	516608.867	475.910	7,476	4.1	471.8							No						-	NA	NA	NA	NA	NA
GCPT 12-4	1069124.740	516619.657	476.420	7,374	38.5	437.9							No						-	NA	NA	NA	NA	NA
GCPT 12-5	1069091.157	516638.742	478.450	6,432	7.5	471.0							No						-	NA	NA	NA	NA	NA
GCPT 12-6	1069031.297	516650.636	478.965	6,378	23.1	455.9							No						-	NA	NA	NA	NA	NA
GCPT 13-1	1069279.353	516642.002	470.898	28,302	15.4	455.5							Yes	15	455.9	16.3	454.6	1.3	X	NA	NA	NA	NA	NA
GCPT 13-2	1069258.075	516646.324	471.546	2,490	0.8	470.7							No						-	NA	NA	NA	NA	NA
GCPT 13-2A	1069256.406	516650.406	471.769	3,162	1.6	470.2							No						-	NA	NA	NA	NA	NA
GCPT 13-3	1069242.473	516658.268	472.195	2,520	1.3	470.9							No						-	NA	NA	NA	NA	NA
GCPT 13-4	1069194.628	516676.493	474.034	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 13-4S	1069195.799	516675.988	474.100	6,120	36.6	437.5							No						-	NA	NA	NA	NA	NA
GCPT 13-5	1069148.378	516695.025	475.365	1,872	0.3	475.1							No						-	NA	NA	NA	NA	NA
GCPT 13-5S	1069148.524	516697.133	475.500	5,682	11.5	464.0							No						-	NA	NA	NA	NA	NA
GCPT 13-6	1069094.279	516722.059	475.910	5,802	3.4	472.5							No						-	NA	NA	NA	NA	NA
GCPT 13-6S	1069094.328	516722.082	476.000	6,552	23.8	452.2							No						-	NA	NA	NA	NA	NA
GCPT 13-7	1069028.275	516764.522	474.263	5,964	1.6	472.7							No						-	NA	NA	NA	NA	NA
GCPT 13-7S	1069028.451	516763.208	474.200	6,366	20.8	453.4							No						-	NA	NA	NA	NA	NA
GCPT 14-1	1069289.841	516676.946	474.151	29,640	18.9	455.3							Yes	18.3	455.9	19.6	454.6	1.3	X	NA	NA	NA	NA	NA
GCPT 14-2	1069248.776	516702.985	474.471	3,600	1.1	473.4							No						-	NA	NA	NA	NA	NA
GCPT 14-3	1069218.180	516720.735	473.680	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 14-3S	1069218.942	516719.904	473.700	6,708	36.6	437.1							No						-	NA	NA	NA	NA	NA
GCPT 14-4	1069177.042	516745.043	474.597	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 14-5	1069125.940	516777.935	473.330	5,772	1.6	471.7							No						-	NA	NA	NA	NA	NA
GCPT 14-5S	1069125.781	516777.333	473.300	5,880	15.4	457.9							No						-	NA	NA	NA	NA	NA
GCPT 14-6	1069077.338	516811.126	472.680	6,654	7.4	465.3							No						-	NA	NA	NA	NA	NA
GCPT 14-6S	1069077.339	516809.484	472.800	6,330	14.9	457.9							No						-	NA	NA	NA	NA	NA
GCPT 14-7	1069029.001	516850.785	473.149	1,338	0.2	472.9							No						-	NA	NA	NA	NA	NA
GCPT 15-1	1069362.505	516757.424	453.830	11,940	20.3	433.5							No						-	NA	NA	NA	NA	NA
GCPT 15-2	1069277.200	516767.371	477.333	3,222	1.6	475.7							No						-	NA	NA	NA	NA	NA
GCPT 15-3	1069247.590	516788.341	473.986	9,828	30.5	443.5							No						-	NA	NA	NA	NA	NA
GCPT 15-4	1069209.876	516811.939	473.090	8,400	29.4	443.7							No						-	NA	NA	NA	NA	NA
GCPT 15-5	1069166.487	516848.251	469.170	7,098	57.7	411.5							No						-	NA	NA	NA	NA	NA
GCPT 15-6	1069125.130	516878.774	468.775	7,098	2.6	466.2							No						-	NA	NA	NA	NA	NA
GCPT 15-7	1069083.743	516906.231	472.113	6,444	2.5	469.6							No						-	NA	NA	NA	NA	NA
GCPT 15-8	1069045.994	516931.453	473.775	8,724	2.3	471.5							No						-	NA	NA	NA	NA	NA
GCPT 16-1	1069393.686	516784.741	451.150	9,228	7.2	444.0							No						-	NA	NA	NA	NA	NA
GCPT 16-2	1069364.966	516787.054	453.091	6,948	1.8	451.3							No						-	NA	NA	NA	NA	NA
GCPT 16-3	1069262.220	516837.666	471.257	6,744	2.3	469.0							No						-	NA	NA	NA	NA	NA
GCPT 16-4	1069234.210	516866.371	472.459	7,446	3	469.5							No						-	NA	NA	NA	NA	NA
GCPT 16-5	1069196.904	516903.898	474.011	6,864	4.8	469.2							No						-	NA	NA	NA	NA	NA
GCPT 16-6	1069158.015	516935.268	476.777	6,600	13.6	463.2							No						-	NA	NA	NA	NA	NA
GCPT 16-7	1069114.104	516970.890	479.817	6,414	2.6	477.2							No						-	NA	NA	NA	NA	NA
GCPT 16-8	1069073.911	517002.539	481.927	6,648	20.7	461.2							No						-	NA	NA	NA	NA	NA
Phase 1C (2014)																								
GCPT 1C-1	1068771.644	515837.945	463.703	5,256	3	460.7							No						-	NA	NA	NA	NA	NA
GCPT 1C-1A	1068766.648	515841.442	463.588	5,988	3.1	460.5							No						-	NA	NA	NA	NA	NA
GCPT 1C-2	1068737.758	515904.377	472.318	BKGD									No						-	NA	NA	NA	NA	NA

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
GCPT 1C-2R	1068733.913	515907.223	472.500	31,290	30.3	442.2							Yes	29.6	442.9	32	440.5	2.4	X	NA	NA	NA	NA	NA
GCPT 1C-3	1068778.999	515991.398	486.422	6,576	22	464.4							No						-	NA	NA	NA	NA	NA
GCPT 1C-4	1068832.903	516068.813	486.098	1,851	27.7								No						-	NA	NA	NA	NA	NA
GPCT 1C-4R	1068835.119	516070.919	486.000	22,638	43.8	442.2							Yes	43.4	442.6	44	442.0	0.6	X	NA	NA	NA	NA	NA
GCPT 1C-5	1068986.634	516413.538	478.999	BKGD									No						-	NA	NA	NA	NA	NA
GCPT 1C-5A	1068986.634	516413.538	478.999	6,516	15.1	463.9							No						-	NA	NA	NA	NA	NA
GCPT 1C-6	1068691.769	515934.812	468.800	84,810	22.1	446.7							Yes	21.4	447.4	23.2	445.6	1.8	X	NA	NA	NA	NA	NA
GCPT 1C-6T	1068685.948	515938.701	468.900	90,390	22.8	446.1							Yes	22	446.9	24	444.9	2.0	X	NA	NA	NA	NA	NA
GCPT 1C-6T1	1068684.148	515939.610	468.900	171,774	23.5	445.4							Yes	22.5	446.4	23.6	445.3	1.1	X	NA	NA	NA	NA	NA
GCPT 1C-7	1068646.890	515958.200	468.599	6,978	4.3	464.3							No						-	NA	NA	NA	NA	NA
GCPT 1C-8	1068728.323	516014.864	491.227	6,144	3	488.2							No						-	NA	NA	NA	NA	NA
GCPT 1C-9	1068746.456	516049.886	495.235	6,360	10.4	484.8							No						-	NA	NA	NA	NA	NA
GCPT 1C-10	1068797.838	516095.938	496.493	6,276	11.8	484.7							No						-	NA	NA	NA	NA	NA
GCPT 1C-11	1068838.882	516151.875	496.895	6,516	3	493.9							No						-	NA	NA	NA	NA	NA
GCPT 1C-12	1068865.907	516200.860	500.100	57,414	56.3	443.8							Yes	55.7	444.4	57	443.1	1.3	X	NA	NA	NA	NA	NA
GCPT 1C-13	1068982.241	516321.892	480.072	6,438	34.1	446.0							No						-	NA	NA	NA	NA	NA
GCPT-108	1069142.077	516388.988	470.448	6,408	2	468.4							No						-	NA	NA	NA	NA	NA
GCPT-111A	1069183.707	516592.402	475.656	9,564	25.9	449.8							No						-	NA	NA	NA	NA	NA
GCPT-119	1069021.032	516294.161	478.577	14,616	45.6	433.0							No						-	NA	NA	NA	NA	NA
GCPT-28A	1069253.583	516490.663	480.478	82,512	24.9	455.6							Yes	24.2	456.3	25.6	454.9	1.4	X	NA	NA	NA	NA	NA
GCPT-36	1069217.918	516193.669	464.969	19,470	8.5	456.5							Yes	7.8	457.2	8.8	456.2	1.0	X	NA	NA	NA	NA	NA
GCPT-25	1069345.436	516405.360	465.274	74,880	8.4	456.9							Yes	7.3	458.0	9.8	455.5	2.5	X	NA	NA	NA	NA	NA
PVC-25R	1069345.436	516405.360	465.300	74,562	9.5	455.8							Yes	8.3	457.0	10.9	454.4	2.6	X	NA	NA	NA	NA	NA
1-2	1068783.142	515878.536	472.600	4,271	33	439.6	11,838	2	470.6				No						-	-	NA	-	-	-
2-2	1068876.813	515926.163	475.200	4,354	32	443.2	14,862	22	453.2				No						-	-	NA	-	-	-
5-3	1068986.832	516093.839	474.400	336,937	29.5	444.9	368,717	28	446.4				Yes	26	448.4	34	440.4	8.0	X	X	NA	X	X	X
5-3	1068986.832	516093.839	474.400	44,163	51.5	422.9							Yes	49	425.4	53?	421.4?	4?	X	-	NA	-	-	-
8-1	1069041.228	516368.555	479.800	4,821	28	451.8	15,541	44	435.8				No						-	-	NA	-	-	-
12-5	1069087.130	516641.299	478.900	3,864	14	464.9	13,053	49	429.9				No						-	-	NA	-	-	-
13-3	1069232.054	516662.275	472.600	3,607	16.5	456.1	13,869	43	429.6				No						-	-	NA	-	-	-
13-6	1069093.452	516723.784	475.900	3,902	24.5	451.4	12,293	21	454.9				No						-	-	NA	-	-	-
14-2	1069250.965	516701.546	474.600	4,008	27.5	447.1	16,548	29	445.6				No						-	-	NA	-	-	-
14-4	1069179.619	516743.234	474.400	3,888	9	465.4	11,662	40	434.4				No						-	-	NA	-	-	-
14-5	1069122.899	516777.908	472.900	3,454	13.5	459.4	11,457	12	460.9				No						-	-	NA	-	-	-
14-7	1069027.735	516848.642	473.300	3,637	31.5	441.8	13,227	31	442.3				No						-	-	NA	-	-	-
15-2	1069281.151	516768.917	476.500	5,184	26	450.5	13,899	24	452.5				Yes	22	454.5	27	449.5	5.0	-	-	NA	-	X	-
16-3	1069267.110	516837.299	470.700	4,118	20	450.7	13,165	10	460.7				No						-	-	NA	-	-	-
16-6	1069155.378	516938.746	477.100	3,841	14	463.1	13,051	21	456.1				No						-	-	NA	-	-	-
1C-6	1068688.971	515936.009	469.200	53,732	22.5	446.7	15,025	26	443.2				Yes	20	449.2	27	442.2	7.0	X	-	NA	X	X	-
WL-119	1069017.400	516296.369	479.200	7,941	32.5	446.7	13,679	1	478.2				Yes	31.5	447.7	33	446.2	1.5	X	-	NA	-	-	-
1-2-Geoprobe	1068779.843	515869.22	472.859	NA									No						NA	NA	NA	-	-	-
2-2-Geoprobe	1068870.734	515929.287	475.250	NA									Yes	30	445.250	34	441.250	4.0	NA	NA	NA	X	X	-
2-3-Geoprobe	1068815.973	515943.908	476.459	NA									Yes	33	443.459	38	438.459	5.0	NA	NA	NA	X	X	-
8-1B-Geoprobe	1069041.054	516363.853	479.703	NA									No						NA	NA	NA	-	-	-
1C-12-Geoprobe	1068867.887	516204.389	500.064	NA									No						NA	NA	NA	-	-	-
1C-12B-Geoprobe	1068863.729	516197.682	499.723	NA									Yes	54	445.723	56	443.723	2.0	NA	NA	NA	-	X	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
1C-12C-Geoprobe	1068862.939	516203.039	500.161	NA									Yes	53	447.161	58	442.161	5.0	NA	NA	NA	X	X	-
1C-2RA-Geoprobe	1068730.068	515908.919	472.398	NA									No						NA	NA	NA	-	-	-
1C-4R-Geoprobe	1068835.529	516073.369	486.107	NA									No						NA	NA	NA	-	-	-
1C-4RB-Geoprobe	1068837.644	516076.741	485.970	NA									No						NA	NA	NA	-	-	-
1C-6T1-Geoprobe	1068681.573	515937.074	468.930	NA									No						NA	NA	NA	-	-	-
WL-119-Geoprobe	1069018.294	516291.964	478.594	NA									No						NA	NA	NA	-	-	-
WL-119B-Geoprobe	1069013.907	516287.796	479.244	NA									No						NA	NA	NA	-	-	-
WL-119C-Geoprobe	1069012.752	516291.905	479.148	NA									No						NA	NA	NA	-	-	-
Phase 1D (2015)																								
1D-1	1069085.157	515745.035	462.487	6,288	8.9	453.6	13,570	8	454.5	3 (m)	16	446.5	No						-	NA	NA	NA	NA	NA
1D-2	1068999.089	515778.193	468.382	5,142	5.9	462.5	13,261	36	432.4	7	3	465.4	No						-	NA	NA	NA	NA	NA
1D-3	1068972.272	515874.232	472.064	390,720	27.4	444.7	67,177	28	444.1	125	28	444.1	Yes	25.5	446.6	29.5	442.6	4.0	X	NA	NA	NA	NA	NA
1D-4	1068794.546	516092.056	496.410	14,154	55.8	440.6	15,010	11	485.4	3 (m)	14	482.4	No						-	NA	NA	NA	NA	NA
1D-5	1068649.773	516043.497	487.632	143,724	55.1	432.5	20,707	51	436.6	33	51	436.6	Yes	54.1	433.5	56.2	431.4	2.1	X	NA	NA	NA	NA	NA
1D-6	1068727.516	516153.004	512.509	6,834	3.9	508.6	20,707	51	461.5	33	51	461.5	No						-	NA	NA	NA	NA	NA
1D-7	1068647.213	516155.853	512.790	775,560	82.8	430.0	1,995,300	83	429.8	3270	82	430.8	Yes	80.2	432.6	85.5	427.3	5.3	X	NA	NA	NA	NA	NA
1D-8	1068818.180	516243.565	517.157	44,028	75.3	441.9	19,108	75	442.2	6	85	432.2	Yes	74.7	442.5	75.6	441.6	0.9	X	NA	NA	NA	NA	NA
1D-8A	1068820.740	516250.571	517.322	6,318	2.6	514.7							No						-	NA	NA	NA	NA	NA
1D-9	1068667.863	516221.690	518.577	13,236	58.6	460.0	18,794	87	431.6	10 (m)	84	434.6	No						-	NA	NA	NA	NA	NA
1D-9A	1068662.945	516220.860	518.595	14,508	56.8	461.8							No						-	NA	NA	NA	NA	NA
1D-10	1068897.481	516306.812	503.702	7,554	38.9	464.8	12,827	6	497.7	3	48	455.7	No						-	NA	NA	NA	NA	NA
1D-11	1068732.965	516319.191	522.966	5,970	1.8	521.2	24,281	85	438.0	38	85	438.0	No						-	NA	NA	NA	NA	NA
1D-11A	1068728.093	516324.559	522.829	6,648	1.6	521.2							No						-	NA	NA	NA	NA	NA
1D-12	1068878.274	516446.247	505.566	6,054	29.4	476.2	13,843	61	444.6	4	59	446.6	No						-	NA	NA	NA	NA	NA
1D-13	1068807.791	516405.192	520.176	7,980	36.4	483.8	13,515	93	427.2	2	53	467.2	No						-	NA	NA	NA	NA	NA
1D-13A	1068807.910	516397.463	520.165	5,934	2.1	518.1							No						-	NA	NA	NA	NA	NA
1D-13B	1068807.560	516392.053	520.392	5,964	7.1	513.3							No						-	NA	NA	NA	NA	NA
1D-13C	1068808.169	516414.237	519.931	6,432	2.5	517.4							No						-	NA	NA	NA	NA	NA
1D-14	1068737.296	516389.489	522.027	5,952	2.5	519.5	14,725	54	468.0	2 (m)	46	476.0	No						-	NA	NA	NA	NA	NA
1D-15	1068600.173	516194.976	516.672	16,194	89.6	427.1	13,352	85	431.7	15	85	431.7	Yes	89.4	427.3	89.7	427.0	0.3	X	NA	NA	NA	NA	NA
1D-16	1068604.580	516049.511	484.823	68,700	46.9	437.9	24,411	50	434.8	17	50	434.8	Yes	46	438.8	48	436.8	2.0	X	NA	NA	NA	NA	NA
1D-16A	1068611.344	516048.677	485.168	17,712	49.9	435.3							Yes	49.7	435.5	49.9	435.3	0.2	X	NA	NA	NA	NA	NA
1D-17	1068872.427	515830.991	472.494	4,938	4.1	468.4	13,040	18	454.5	4	45	427.5	No						-	NA	NA	NA	NA	NA
1D-17A	1068870.009	515836.352	472.546	5,496	17.7	454.8							No						-	NA	NA	NA	NA	NA
1D-18	1068551.103	516059.874	480.990	7,224	10.2	470.8	13,803	12	469.0	4 (m)	19	462.0	No						-	NA	NA	NA	NA	NA
1D-18A	1068545.369	516060.390	480.524	6,984	41.3	439.2							No						-	NA	NA	NA	NA	NA
1D-1S	1069074.230	515747.359	462.568	3,382	6.5	456.1							No						-	-	-	-	-	-
1D-2S	1068990.154	515784.257	468.561	4,001	19.5	449.1							No						-	-	-	-	-	-
1D-3S	1068968.601	515882.929	472.250	204,471	27	445.3							Yes	23	449.3	31	441.3	8.0	X	X	X	X	X	-
1D-4S	1068804.861	516101.296	496.422	4,349	12.5	483.9							No						-	-	-	-	-	-
1D-5S	1068657.730	516040.319	487.751	12,059	53	434.8							Yes	51	436.8	56	431.8	5.0	X	X	X	X	X	-
1D-6S	1068732.994	516160.954	512.707	3,749	11	501.7							No						-	-	-	-	-	-
1D-7S	1068653.591	516157.910	513.346	1,503,082	82.5	430.8							Yes	76	437.3	93	420.3	17.0	X	X	X	X	X	-
1D-8S	1068810.599	516238.029	516.742	6,869	73	443.7							Yes	72	444.7	74	442.7	2.0	X	-	-	-	-	-
1D-9S	1068678.246	516223.760	518.893	16,313	71.5	447.4							Yes	70	448.9	72.5	446.4	2.5	X	-	-	-	-	-
1D-9S	1068678.246	516223.760	518.893	1,174,844	87.5	431.4							Yes	82	436.9	96	422.9	14.0	X	X	X	X	X	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

DRAFT

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Downhole Gamma Value (cpm)	Depth to Max Gamma (ft)	Elevation of Max Gamma (ft amsl)	Maximum Core Gamma (cpm)	Depth to Max Core Gamma (ft)	Elevation of Max Core Gamma (ft amsl)	Maximum Core Alpha (cpm)	Depth to Max Core Alpha (ft)	Elevation of Max Core Alpha (ft amsl)	RIM Present ?	Depth to Top of RIM Interval (ft)	Elevation Top of RIM Interval (ft amsl)	Depth to Bottom of RIM Interval (ft)	Elevation of Bottom of RIM Interval (ft amsl)	Thickness of RIM (ft)	Basis for RIM Interval: Down-hole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
1D-10S	1068898.786	516318.538	503.074	3,942	37.5	465.6							No						-	-	-	-	-	-
1D-11S	1068739.042	516311.220	522.303	16,554	84	438.3							Yes	82	440.3	86	436.3	4.0	X	X	X	X	X	-
1D-12S	1068880.804	516434.947	505.890	4,173	29.5	476.4							No						-	-	-	-	-	-
1D-13S	1068786.080	516399.333	520.512	4,304	42	478.5							No						-	-	-	-	-	-
1D-14S	1068730.267	516381.884	522.532	4,010	43.5	479.0							No						-	-	-	-	-	-
1D-15S	1068611.681	516196.257	516.098	20,523	85	431.1							Yes	83.5	432.6	86	430.1	2.5	X	X	X	X	X	-
1D-16S	1068620.165	516047.598	485.581	11,886	50	435.6							Yes	49.5	436.1	51.5	434.1	2.0	X	X	X	X	X	-
1D-17S	1068865.421	515846.051	472.920	3,650	16	456.9							No						-	-	-	-	-	-
1D-18S	1068573.847	516056.126	482.022	4,480	48.5	433.5							No						-	-	-	-	-	-
1D-19S	1068620.714	516259.114	521.112	3,437	44	477.1							No						-	-	-	-	-	-
1D-20S	1068540.263	516226.617	517.696	1,576	2.5	515.2							No						-	-	-	-	-	-
Area 1 - Additional																								
AC-1a	1069120.740	516017.324	466.725	824,868	10.5	456.2	1,128,112	10	456.7	2596	10	456.7	Yes	4.5	462.2	22	444.7	17.5	X	X	X	X	X	X
AC-1b	1069120.740	516017.324	466.725	3,686	29.0	437.7							Yes	29	437.7	32	434.7	3.0	-	X	X	X	X	-
AC-1c	1069120.740	516017.324	466.725	20,364	38.5	428.2							Yes	35	431.7	41	425.7	6.0	X	-	-	-	-	-
AC-2Ba	1069151.417	515831.894	466.165	7,931	4.5	461.7	21,345	10	456.2	11	10	456.2	Yes	2	464.2	6.5	459.7	4.5	X	-	-	-	-	-
AC-2Bb	1069151.417	515831.894	466.165	15,570	10.0	456.2							Yes	9.5	456.7	13.5	452.7	4.0	X	X	X	X	X	-
AC-3a	1069183.583	516040.675	466.425	906,839	4.0	462.4	979,494	5	461.4	1013	3	463.4	Yes	0	466.4	19	447.4	19.0	X	X	X	X	X	X
AC-3b	1069183.583	516040.675	466.425	46,921	38.5	427.9							Yes	32.5	433.9	39.5	426.9	7.0	X	-	-	-	-	-
AC-4B	1069555.665	516492.941	464.661	5,114	5.0	459.7	13,302	32	432.7	4	25	439.7	No						-	-	-	-	-	-
AC-5	1069483.755	516657.795	451.372	4,656	12.5	438.9	15,408	11	440.4	5	11	440.4	No						-	-	-	-	-	-
AC-6	1069420.320	516222.713	464.254	4,857	26.0	438.3	14,908	23	441.3	4 (m)	7	457.3	No						-	-	-	-	-	-
AC-7	1069315.677	516025.425	461.529	24,727	2.5	459.0	17,700	32	429.5	4	32	429.5	Yes	0.5	461.0	5	456.5	4.5	X	-	-	-	-	-
Cotter (2015)																								
WL-102-CT	1069271.265	515974.528	461.697	4,379	3.0	458.7	13,625	12	449.7	10 (m)	2	459.7	No						-	-	X	-	-	-
WL-106A-CT	1069300.779	516090.264	463.803	27,546	4.5	459.3	30,545	10	453.8	54	11	452.8	Yes	2	461.8	12	451.8	10.0	X	X	X	X	X	-
WL-114-CT	1069381.076	516352.442	467.381	5,669	5.0	462.4	14,300	6	461.4	14	32	435.4	Yes	2	465.4	6	461.4	4.0	-	X	-	-	-	-

Notes:

amsl = above mean sea level cpm = counts per minute

NA - Data were not collected or are otherwise not available.

X - Data support the presence of RIM in the indicated interval

\- Data do not indicate the presence of RIM at this location/interval

(m) - multiple intervals with same detections; see Appendix L for details; only uppermost elevation shown

See Borehole Summary Sheets in Appendix L and Appendix D-1 for the NRC data for supporting documentation for this table

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D GCPT Soundings and Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result	Radium-226 Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result	Radium-228 Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228	Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230 Result	Thorium-230 Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result	Thorium-232 Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234 Result	Uranium-234 Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result	Uranium-235 Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result	Uranium-238 Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238	Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
McLaren/Hart RI Data																																												
WL-101-MH	5	5	pCi/g	1.04		0.22		0.33	0.95	U			0.95	1.52 *	Less than Criteria	2.18		0.57		0.07	0.89				0.07	3.07	Less than Criteria	1.54		0.44		0.13	0.72	U			0.72	0.88		0.31		0.11	2.78 *	Less than Criteria
WL-101-MH	20	20	pCi/g	0.91		0.19		0.35	1.08	U			1.08	1.45 *	Less than Criteria	1.99		0.63		0.25	1.51		0.53		0.20	3.50	Less than Criteria	1.47		0.46		0.17	0.54	U			0.54	1.63		0.49		0.13	3.37 *	Less than Criteria
WL-102-MH	5	5	pCi/g	1.17		0.22		0.26	0.99	U			0.99	1.67 *	Less than Criteria	4.18		1.02		0.23	0.90		0.38		0.14	5.08	Less than Criteria	1.06		0.37		0.11	0.49	U			0.49	0.88		0.33		0.12	2.19 *	Less than Criteria
WL-102-MH	15	15	pCi/g	0.98		0.23		0.35	1.07	U			1.07	1.52 *	Less than Criteria	1.53		0.56		0.25	1.11		0.46		0.17	2.64	Less than Criteria	1.24		0.41		0.11	0.83	U			0.83	1.34		0.43		0.10	3.00 *	Less than Criteria
WL-103-MH	5	5	pCi/g	1.17		0.26		0.34	1.19	U			1.19	1.77 *	Less than Criteria	1.42		0.51		0.22	0.78		0.36		0.17	2.20	Less than Criteria	1.95		0.55		0.20	0.73	U			0.73	1.60		0.48		0.16	3.92 *	Less than Criteria
WL-103-MH	10	10	pCi/g	0.81		0.34		0.53	1.26	U			1.26	1.44 *	Less than Criteria	7.52		1.65		0.16	0.77				0.09	8.29	Exceeds Criteria	1.41		0.39		0.19	1.41	U			1.41	1.12		0.34		0.14	3.24 *	Less than Criteria
WL-104-MH	5	5	pCi/g	0.78		0.18		0.30	0.84	U			0.84	1.20 *	Less than Criteria	3.08		0.85		0.21	0.94		0.41		0.19	4.02	Less than Criteria	1.19		0.37		0.15	0.55	U			0.55	0.70		0.27		0.14	2.17 *	Less than Criteria
WL-104-MH	20	20	pCi/g	0.39		0.19		0.34	0.92	U			0.92	0.85 *	Less than Criteria	0.98		0.42		0.18	0.71		0.35		0.16	1.69	Less than Criteria	0.52		0.19		0.10	0.56	U			0.56	0.32		0.14		0.11	1.12 *	Less than Criteria
WL-105A-MH	10	10	pCi/g	40.8		2.10		0.60	1.59	U			1.59	41.6 *	Exceeds Criteria	522		95.0		0.09	4.61		0.99		0.06	527	Exceeds Criteria	6.64		1.23		0.16	3.95		0.73		1.97	6.94		1.28		0.14	17.5	Less than Criteria
WL-105A-MH	30	30	pCi/g	0.99		0.23		0.34	1.18	U			1.18	1.58 *	Less than Criteria	1.59		0.56		0.31	1.04		0.42		0.15	2.63	Less than Criteria	1.16		0.36		0.10	0.73	U			0.73	1.10		0.34		0.08	2.63 *	Less than Criteria
WL-106A-MH	0	0	pCi/g	906		37.0		2.00	5.86	U			5.86	909 *	Exceeds Criteria	9,700		1,800		11.8	35.2				11.2	9,735	Exceeds Criteria	105		22.0		3.00	75.5		8.50		8.70	105		22.0		2.00	286	Exceeds Criteria
WL-106A-MH	5	5	pCi/g	18.8		1.30		0.40	1.42		0.66		1.07	20.2	Exceeds Criteria	731		135		0.21	3.22				0.20	734	Exceeds Criteria	11.5		4.80		4.00	2.10		0.43		1.12	6.69		3.50		2.73	20.3	Less than Criteria
WL-106A-MH_FD	5	5	pCi/g	128		6.00		1.00	2.69	U			2.69	129 *	Exceeds Criteria	766		142		0.14	4.71				0.12	771	Exceeds Criteria	31.5	U	17.1		35.3	12.1		1.70		3.40	26.4		10.1		17.2	54.3 *	Exceeds Criteria
WL-106A-MH	25	25	pCi/g	1.26		0.25		0.40	1.18	U			1.18	1.85 *	Less than Criteria	2.38		0.55		0.14	0.56				0.09	2.94	Less than Criteria	2.70		0.53		0.06	0.78	U			0.78	2.89		0.56		0.06	5.98 *	Less than Criteria
WL-106A-MH_FD	25	25	pCi/g	2.92		0.35		0.31	1.16	U			1.16	3.50 *	Less than Criteria	6.49		1.37		0.12	0.47				0.09	6.96	Less than Criteria	1.90		0.42		0.18	1.14	U			1.14	2.08		0.45		0.17	4.55 *	Less than Criteria
WL-107-MH	5	5	pCi/g	0.80		0.21		0.29	0.91		0.38		0.68	1.71	Less than Criteria	0.89		0.34		0.13	0.89		0.34		0.09	1.78	Less than Criteria	1.30		0.43		0.11	0.58	U			0.58	0.89		0.34		0.11	2.48 *	Less than Criteria
WL-107-MH	51	51	pCi/g	0.71		0.21		0.36	0.98	U			0.98	1.20 *	Less than Criteria	0.56		0.27		0.15	0.14		0.12		0.09	0.70	Less than Criteria	0.54		0.24		0.08	0.63	U			0.63	0.33		0.18		0.08	1.19 *	Less than Criteria
WL-108-MH	5	5	pCi/g	0.95		0.25		0.37	1.34	U			1.34	1.62 *	Less than Criteria	1.21		0.42		0.16	0.79		0.32		0.12	2.00	Less than Criteria	0.74		0.31		0.10	0.67	U			0.67	1.05		0.38		0.12	2.13 *	Less than Criteria
WL-109D-MH	5	5	pCi/g	0.90		0.21		0.31	1.18		0.40		0.62	2.08	Less than Criteria	0.67		0.30		0.13	0.21		0.16		0.11	0.88	Less than Criteria	0.66		0.25		0.08	0.61	U			0.61	0.66		0.24		0.07	1.63 *	Less than Criteria
WL-109D-MH	50	50	pCi/g	0.95		0.21		0.30	1.36		0.48		0.71	2.31	Less than Criteria	1.10		0.36		0.20	0.58		0.25		0.21	1.68	Less than Criteria	0.57		0.27		0.11	0.77	U			0.77	0.99		0.38		0.12	1.95 *	Less than Criteria
WL-110-MH	5	5	pCi/g	0.87		0.25		0.40	1.27	U			1.27	1.51 *	Less than Criteria	0.66		0.35		0.23	0.37		0.25		0.16	1.03	Less than Criteria	1.25		0.41		0.09	0.84	U			0.84	0.87		0.33		0.09	2.54 *	Less than Criteria
WL-110-MH	50	50	pCi/g	1.01		0.21		0.31	1.02	U			1.02	1.52 *	Less than Criteria	0.87		0.29		0.12	0.87		0.28		0.08	1.74	Less than Criteria	1.17		0.40		0.20	0.74	U			0.74	1.14		0.39		0.23	2.68 *	Less than Criteria
WL-111-MH	0	0	pCi/g	0.91		0.22		0.33	1.05	U			1.05	1.44 *	Less than Criteria	2.12		0.72		0.29	0.68		0.36		0.20	2.80	Less than Criteria	1.70		0.63		0.25	0.70	U			0.70	1.04		0.46		0.18	3.09 *	Less than Criteria
WL-111-MH	5	5	pCi/g	0.61		0.21		0.42	1.02	U			1.02	1.12 *	Less than Criteria	2.76		0.90		0.77	0.38	U	0.39		0.70	2.95 *	Less than Criteria	3.37		1.08		0.97	0.70	U			0.70	1.16		0.65		0.90	4.88 *	Less than Criteria
WL-111-MH	51	51	pCi/g	0.48		0.18		0.33	1.10	U			1.10	1.03 *	Less than Criteria	2.47		1.26		0.79	0.41	U	0.49		0.58	2.68 *	Less than Criteria	0.75		0.47		0.58	0.64	U			0.64	0.33	U	0.32		0.48	1.24 *	Less than Criteria
WL-112-MH	0	0	pCi/g	1.32		0.24		0.41	1.18	U			1.18	1.91 *	Less than Criteria	60.5		11.70		11.70	0.91		0.41		0.39	61.41	Exceeds Criteria	1.45		0.48		0.13	0.85	U			0.85	1.22		0.43		0.12	3.10 *	Less than Criteria
WL-112-MH	5	5	pCi/g	4.66		0.46		0.42	1.20	U			1.20	5.26 *	Less than Criteria	296.0		64.0		0.23	32.9	U	7.30		0.14	312.5 *	Exceeds Criteria	2.92		1.46		0.89	0.99	U			0.99	3.44		1.58		0.42	6.86 *	Less than Criteria
WL-112-MH	42	42	pCi/g	0.76		0.20		0.34	1.31		0.44		0.58	2.07	Less than Criteria	0.92		0.44		0.42	0.68		0.37		0.30	1.60	Less than Criteria	1.74		1.15		1.06	0.56	U			0.56	1.62		1.09		0.88	3.64 *	Less than Criteria
WL-113-MH	5	5	pCi/g	0.97		0.08		0.06	1.06		0.14		0.13	2.03	Less than Criteria	0.33		0.15		0.11	0.19		0.11		0.08	0.52	Less than Criteria	1.40		0.59		0.32	0.23	U			0.23	1.25		0.54		0.26	2.77 *	Less than Criteria
WL-113-MH_FD	5	5	pCi/g	1.06		0.08		0.06	0.98		0.13		0.13	2.04	Less than Criteria	0.58		0.23		0.15	0.15		0.11		0.08	0.73	Less than Criteria	0.76		0.34		0.16	0.17	U			0.17	0.62		0.30		0.08	1.47 *	Less than Criteria
WL-113-MH	10	10	pCi/g	1.53		0.15		0.12	0.98		0.22		0.24	2.51	Less than Criteria	8.43		2.00		0.29	0.78		0.35		0.31	9.21	Exceeds Criteria	1.20		0.48		0.22	0.42	U			0.42	1.06		0.44		0.09	2.47 *	Less than Criteria
WL-114-MH	0	0	pCi/g	109		5.00		0.90	2.50	U			2.50	110 *	Exceeds Criteria	7,850		1,470		0.92	18.1		4.60		0.78	7,868	Exceeds Criteria	154		40.0		1.00	17.6		2.10		3.00	147		38.0		0.90	319	Exceeds Criteria
WL-114-MH	5	5	pCi/g	2.59		0.17		0.06	0.39		0.12		0.16	2.98	Less than Criteria	68.7		14.2		0.16	1.83		0.56		0.11	69.6 *	Exceeds Criteria	3.43		1.35		0.63	0.32		0.06		0.27	3.54		1.38		0.51	7.29	Less than Criteria
WL-114-MH	15	15	pCi/g	0.98		0.08		0.07	1.04		0.15		0.14	2.02	Less than Criteria	1.08		0.46		0.28	0.14	U	0.16		0.20	1.15 *	Less than Criteria	1.29		0.74		0.56	0.24	U			0.24	1.60		0.82		0.23	3.01 *	Less than Criteria
WL-115-MH	5	5	pCi/g	1.00		0.08		0.06	0.93		0.13		0.12	1.93	Less than Criteria	0.84		0.29		0.18	0.21		0.13		0.11	1.05	Less than Criteria	1.30		0.52		0.29	0.15	U			0.15	1.22		0.49		0.21	2.60 *	Less than Criteria
WL-115-MH	40	40	pCi/g	0.58		0.05		0.05	0.69		0.10		0.10	1.27	Less than Criteria	0.29		0.16		0.12	0.27		0.15		0.09	0.56	Less than Criteria	0.35		0.21		0.16	0.13	U			0.13	0.33		0.20		0.11	0.75 *	Less than Criteria
WL-116-MH	0	0	pCi/g	0.94		0.21		0.33	1.19	U			1.19	1.54 *	Less than Criteria	1.94		0.69		0.52	0.52		0.34		0.46	2.46	Less than Criteria	1.04		0.38		0.20	1.02	U			1.02	0.88		0.34		0.15	2.43 *	Less than Criteria
WL-116-MH	5	5	pCi/g	1.11		0.08		0.06	0.94		0.13		0.14	2.05	Less than Criteria	0.51		0.21		0.13	0.25		0.14		0.04	0.76	Less than Criteria	1.15		0.49		0.36	0.17	U			0.17	1.18		0.50		0.41	2.42 *	Less than Criteria
WL-116-MH_FD	5	5	pCi/g	1.18		0.13		0.13	1.00		0.23		0.28	2.18	Less than Criteria	0.35		0.17		0.11	0.21		0.13		0.07	0.56	Less than Criteria	0.64		0.39		0.28	0.44	U			0.44	1.03		0.51		0.20	1.89 *	Less than Criteria
WL-116-MH	10	10	pCi/g	1.00		0.07		0.05	0.76		0.11		0.11	1.76	Less than Criteria	0.36		0.20		0.21	0.33		0.18		0.13	0.69	Less than Criteria	1.14		0.37		0.17	0.13	U			0.13	1.32		0.41		0.05	2.53 *	Less than Criteria
WL-117-MH	10	10	pCi/g	3.15		0.19		0.07	0.64		0.14		0.16	3.79	Less than Criteria	36.6		7.40		0.13	1.00		0.35		0.12	37.6	Exceeds Criteria	1.72		0.61		0.25	0.30		0.06		0.27	2.90		0.86		0.16	4.92	Less than Criteria
WL-117-MH	25	25	pCi/g	0.62		0.06		0.05	0.64		0.12		0.12	1.26	Less than Criteria	0.70		0.28		0.15	0.20		0.14		0.12	0.90	Less than Criteria	0.56		0.31		0.17	0.20	U			0.20	0.56		0.31		0.10	1.22 *	Less than Criteria
WL-118-MH	5	5	pCi/g	18.4		1.00		0.30	0.73	U			0.73	18.8 *	Exceeds Criteria	425		87.0		2.50	10.3		3.50		2.22	435	Exceeds Criteria	15.6		3.60		0.20	2.40		0.37		1.41	17.8		4.10		0.20	35.8	Less than Criteria
WL-118-MH	10	10	pCi/g	1.31		0.10		0.05	0.49		0.09		0.14	1.80	Less than Criteria	7.19		1.88		0.20	0.35		0.23		0.20	7.54	Less than Criteria	1.18		0.48		0.18	0.18		0.03		0.15	1.14		0.47		0.17	2.50	Less than Criteria
WL-119-MH	5	5	pCi/g	0.89		0.07		0.06	0.73		0.12		0.12	1.62	Less than Criteria	0.60		0.28		0.22	0.26		0.17		0.13	0.86	Less than Criteria	0.51		0.29		0.21	0.15	U			0.15	0.72		0.35		0.17	1.31 *	Less than Criteria
WL-119-MH	50	50	pCi/g	0.46		0.05		0.04	0.41		0.09		0.10	0.87	Less than Criteria	0.67		0.35		0.41	0.32	U	0.26		0.41	0.83 *	Less than Criteria	0.85		0.53		0.50	0.12	U			0.12	0.34	U	0.36		0.58	1.08 *	Less than Criteria
WL-119-MH_FD	50	50	pCi/g	0.45		0.05		0.06	0.50		0.10		0.12	0.95	Less than Criteria	0.22		0.13		0.11	0.10		0.08		0.09	0.32	Less than Criteria	0.57		0.29		0.19	0.13	U			0.13	0.36		0.23		0.25	1.00 *	Less than Criteria
WL-120-MH	5	5	pCi/g	1.00		0.09		0.07	1.08		0.15		0.16	2.08	Less than Criteria	0.48		0.18		0.12	0.14		0.09		0.09	0.62	Less than Criteria	1.15		0.43		0.26	0.24	U			0.24	0.95		0.38		0.18	2.22 *	Less than Criteria
WL-120-MH	50	50	pCi/g	0.92		0.10		0.11	0.91		0.21		0.22	1.83	Less than Criteria	0.32		0.19		0.15	0.23		0.16		0.13	0.55	Less than Criteria	0.46		0.23		0.14	0.37	U			0.37	0.52		0.25		0.12	1.17 *	Less than Criteria
WL-120-MH_FD	50	50	pCi/g	1.07		0.09		0.09	1.04		0.18		0.17	2.11	Less than Criteria	0.38		0.19		0.21	0.25		0.15		0.15	0.63	Less than Criteria	0.98		0.47		0.35	0.25	U			0.25	0.92		0.46		0.38	2.03 *	Less than Criteria
WL-121-MH	0	0	pCi/g	7.28	U			7.28	2.14	U			2.14	Non-detect *	Non-detect	1.57		0.36		0.10	0.87		0.23		0.09	2.44	Less than Criteria	0.78		0.24		0.13						0.94		0.27		0.17	1.72	Less than Criteria
WL-122-MH	0	0	pCi/g	5.44	U			5.44	1.69	U			1.69	Non-detect *	Non-detect	1.93		0.43		0.12	1.02		0.26		0.10	2.95	Less than Criteria	0.94		0.26		0.10						0.87		0.25		0.09	1.81	Less than Criteria
WL-123-MH	0	0	pCi/g	5.98	U			5.98	1.82	U			1.82	Non-detect *	Non-detect	1.45		0.34		0.07	1.06		0.27		0.05	2.51	Less than Criteria	2.94		0.65		0.07						2.33		0.54		0.12	5.27	Less than Criteria
WL-124-MH	0	0	pCi/g	5.22	U			5.22	1.79	U			1.79	Non-detect *	Non-detect	2.16		0.49		0.07	1.16		0.30		0.07	3.32	Less than Criteria	1.50		0.34		0.06						1.02		0.26		0.06	2.52	Less than Criteria
Phase 1C data (and Cotter samples from Core of Phase 1C borings)																																												
01-2	8	9	pCi/g	1.38		0.20	0.11	0.22	1.31	J	0.22	0.24	0.50	2.69	Less than Criteria	0.68		0.25	0.02	0.10	0.38		0.17	0.10	0.10	1.05	Less than Criteria	0.47		0.16	0.01	0.06	0.04	U	0.06	0.00	0.09	0.43		0.15	0.00	0.05	0.95 *	Less than Criteria
01-2	18	19	pCi/g	1.32		0.20	0.09	0.19	1.34		0.25	0.20	0.43	2.65	Less than Criteria	0.62		0.22	0.00	0.08	0.34		0.15	0.07	0.05	0.96	Less than Criteria	0.40		0.14	0.02	0.06	0.05	U	0.06	0.01	0.08	0.41		0.14	0.00	0.05	0.87 *	Less than Criteria
01-2	20	21	pCi/g	1.22		0.22	0.13	0.27	1.05		0.25	0.23	0.50	2.28	Less than Criteria	0.84		0.27	0.01	0.06	0.57		0.20	0.07	0.08	1.41	Less than Criteria	0.46		0.16	0.01	0.05	0.01	U	0.03	0.01	0.08	0.40		0.15	0.00	0.05	0.86 *	Less than Criteria
01-2	22	23	pCi/g	0.23	UJ	0.33	0.27	0.58	0.44	UJ	0.41	0.39	0.90	Non-detect *	Non-detect	0.13		0.08	0.00	0.07	0.06	U	0.06	0.06	0.07	0.19 *	Less than Criteria	0.15		0.08	0.02	0.06	0.00	U	0.03	0.01	0.07	0.06	U	0.06	0.02	0.07	0.21 *	Less than Criteria
01-2	23	24	pCi/g	1.35		0.32	0.19	0.40	1.21	J	0.43	0.38	0.81	2.56	Less than Criteria	0.94		0.30	0.01	0.07	0.56		0.21	0.07	0.08	1.51	Less than Criteria	0.44		0.17	0.02	0.07	0.10		0.09	0.00	0.11	0.36		0.16	0.01	0.09	0.89	Less than Criteria
01-2	24	25	pCi/g	1.36		0.20	0.10	0.21	1.13		0.20	0.16	0.34	2.50	Less than Criteria	3.41		0.84	0.01	0.09	1.34		0.38	0.08	0.06	4.74	Less than Criteria	0.76		0.23	0.01	0.06	0.14		0.10	0.00	0.07	1.20		0.30	0.01	0.07	2.09	Less than Criteria
01-2	28	29	pCi/g	0.61		0.16	0.12	0.24	0.35	U	0.20	0.23	0.50	0.97 *	Less than Criteria	1.38		0.46	0.02	0.12	0.71		0.29	0.15	0.15	2.10	Less than Criteria	0.73		0.22	0.01	0.06	0.09		0.09	0.00	0.11	0.57		0.19	0.01	0.09	1.38	Less than Criteria
01-2	33	34	pCi/g	0.62		0.13	0.09	0.18	0.26	U	0.19	0.16	0.33	0.88 *	Less than Criteria	0.28		0.12	0.00	0.06	0.11	U	0.07	0.06	0.05	0.39 *	Less than Criteria	0.50		0.15	0.01	0.05	0.02	U	0.03	0.00	0.05	0.30		0.11	0.00	0.04	0.82 *	Less than Criteria
01-2	38	39	pCi/g	1.02		0.19	0.11	0.24	0.95	J	0.32	0.47	0.76	1.97	Less than Criteria	0.28		0.13	0.01	0.06	0.29		0.13	0.07	0.06	0.57	Less than Criteria	0.31		0.13	0.01	0.05	0.07		0.06	0.00	0.06	0.26		0.11	0.01	0.06	0.65	Less than Criteria
01-2_FD	38	39	pCi/g	1.05		0.25	0.16	0.34	1.20	J	0.42	0.40	0.84	2.25	Less than Criteria	0.40		0.16	0.02	0.08	0.13	U	0.08	0.07	0.06	0.53 *	Less than Criteria	0.30		0.12	0.01	0.05	0.16		0.10	0.00	0.07	0.32		0.13	0.01	0.06	0.79	Less than Criteria
01-2	39	40	pCi/g	4.98		0.48	0.12	0.25	1.28	J	0.37	0.35	0.71	6.26	Less than Criteria	417	QJ	123	0.05	0.80	5.23	QJ	2.46	0.81	0.72	422	Exceeds Criteria	3.56		0.67	0.02	0.06	0.34		0.16	0.00	0.08	3.84		0.71	0.01	0.07	7.74	Less than Criteria
01-2	40	41	pCi/g	0.39		0.10	0.08	0.16	0.44		0.17	0.15	0.32	0.83	Less than Criteria	0.06	U	0.06	0.02	0.08	0.05	U	0.05	0.07	0.05	Non-Detect *	Non-detect	0.17		0.09	0.01	0.05	0.07	U	0.06	0.01	0.07	0.20		0.10	0.01	0.06	0.44 *	Less than Criteria
01-2GP	23	24	pCi/g	1.45		0.26	0.17	0.35	1.27	J	0.33	0.26	0.55	2.72	Less than Criteria	1.09		0.29	0.00	0.03	0.54		0.16	0.04	0.04	1.63	Less than Criteria	0.53		0.12	0.01	0.04	0.04		0.04	0.00	0.03	0.37		0.10	0.00	0.03	0.94	Less than Criteria
01-2GP	28	29	pCi/g	0.85		0.24	0.16	0.33	0.23	UJ	0.29	0.24	0.53	1.08 *	Less than Criteria	0.64		0.19	0.01	0.04	0.06	U	0.05	0.04	0.04	0.70 *	Less than Criteria	0.22		0.08	0.01	0.03	0.01	U	0.02	0.00	0.03	0.16		0.06	0.00	0.02	0.40 *	Less than Criteria
02-2	5	6	pCi/g	0.99		0.16	0.10	0.20	1.14		0.19	0.10	0.22	2.14	Less than Criteria	1.24		0.39	0.03	0.12	0.89		0.29	0.09	0.08	2.13	Less than Criteria	0.98		0.25	0.01	0.05	0.10		0.08	0.00	0.09	0.87		0.23	0.00	0.07	1.95	Less than Criteria
02-2	19	20	pCi/g	0.96		0.20	0.13	0.28	0.84		0.27	0.19	0.41	1.79	Less than Criteria	0.16		0.08	0.01	0.06	0.13	U	0.08	0.07	0.08	0.29 *	Less than Criteria	0.36		0.12	0.01	0.04	0.01	U	0.02	0.00	0.05	0.31		0.11	0.00	0.05	0.68 *	Less than Criteria

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D GCPT Soundings and Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228	Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230 Result Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234 Result Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238	Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
02-2	20	21	pCi/g	0.32 U	0.18	0.17	0.36	0.66 UJ	0.41	0.36	0.80	Non-detect *	Non-detect	0.66	0.22	0.00	0.07	0.46	0.17	0.08	0.08	1.12	Less than Criteria	0.32	0.13	0.01	0.06	0.07	0.07	0.00	0.08	0.34	0.13	0.00	0.05	0.73	Less than Criteria
02-2	21	22	pCi/g	1.17	0.21	0.11	0.23	1.44 J	0.28	0.27	0.56	2.62	Less than Criteria	1.36	0.40	0.01	0.08	1.25	0.36	0.08	0.06	2.61	Less than Criteria	0.91	0.24	0.02	0.07	0.07 U	0.07	0.01	0.07	0.77	0.21	0.01	0.06	1.75 *	Less than Criteria
02-2	22	23	pCi/g	1.31 J	0.37	0.31	0.65	1.54 J	0.44	0.36	0.78	2.85	Less than Criteria	0.69	0.23	0.01	0.06	0.68	0.22	0.07	0.05	1.37	Less than Criteria	0.39	0.13	0.01	0.05	0.06 U	0.05	0.01	0.06	0.41	0.13	0.00	0.04	0.86 *	Less than Criteria
02-2_FD	22	23	pCi/g	1.51	0.24	0.12	0.25	1.33 J	0.27	0.24	0.50	2.84	Less than Criteria	0.57	0.19	0.01	0.05	0.44	0.16	0.06	0.07	1.00	Less than Criteria	0.46	0.16	0.03	0.08	0.05 U	0.06	0.01	0.09	0.43	0.15	0.01	0.06	0.95 *	Less than Criteria
02-2GP	31	32	pCi/g	13.8 J	1.28	0.25	0.52	0.79 UJ	0.58	0.47	0.98	14.6 *	Exceeds Criteria	206	43.4	0.01	0.04	1.39	0.33	0.04	0.04	207	Exceeds Criteria	0.82	0.17	0.01	0.03	0.03	0.03	0.00	0.03	0.71	0.15	0.00	0.03	1.56	Less than Criteria
02-3GP	34	35	pCi/g	3.23	0.52	0.39	0.19	1.64 J	0.49	0.98	1.95	4.86	Less than Criteria	16.8	3.42	0.01	0.04	0.26	0.09	0.04	0.04	17.0	Exceeds Criteria	0.49	0.12	0.01	0.03	0.04	0.03	0.00	0.03	0.44	0.11	0.02	0.05	0.98	Less than Criteria
02-3GP	35	36	pCi/g	21.1 J	2.06	0.49	1.02	0.45 UJ	0.78	0.59	1.25	21.5 *	Exceeds Criteria	282	53.2	0.00	0.03	2.60	0.49	0.03	0.02	284	Exceeds Criteria	1.60	0.26	0.00	0.02	0.17	0.07	0.00	0.03	1.63	0.27	0.00	0.03	3.39	Less than Criteria
05-3	25	26	pCi/g	1.28	0.21	0.12	0.25	1.13	0.20	0.22	0.47	2.41	Less than Criteria	4.63	1.01	0.01	0.06	0.43	0.15	0.06	0.05	5.07	Less than Criteria	0.46	0.14	0.02	0.06	0.10	0.07	0.01	0.08	0.40	0.13	0.01	0.05	0.96	Less than Criteria
05-3_FD	25	26	pCi/g	5.32	0.56	0.21	0.42	1.09 J	0.35	0.29	0.62	6.41	Less than Criteria	88.9	18.0	0.00	0.07	0.82	0.25	0.07	0.06	89.7	Exceeds Criteria	0.65	0.17	0.01	0.05	0.06 U	0.06	0.01	0.07	0.71	0.18	0.01	0.06	1.42 *	Less than Criteria
05-3	28	29	pCi/g	1,487 J	121	5.09	10.2	19.8 QJ	6.41	5.36	10.8	1,507	Exceeds Criteria	25,825 QJ	7,538	1.45	17.7	203 QJ	78.6	15.4	15.5	26,028	Exceeds Criteria	429 J	73.2	1.30	5.59	22.9 QJ	12.5	0.35	6.90	431 J	73.5	0.15	8.00	883	Exceeds Criteria
05-3	29	30	pCi/g	5.60	0.55	0.12	0.25	1.19 J	0.28	0.30	0.63	6.79	Less than Criteria	444 QJ	97.7	0.25	1.12	6.76 QJ	2.48	1.51	0.92	450	Exceeds Criteria	2.86	0.50	0.02	0.06	0.19	0.10	0.01	0.07	2.51	0.46	0.04	0.10	5.56	Less than Criteria
05-3_FD	29	30	pCi/g	0.44	0.12	0.09	0.18	0.36 U	0.21	0.21	0.44	0.80 *	Less than Criteria	0.94	0.31	0.01	0.08	0.45	0.19	0.08	0.10	1.38	Less than Criteria	0.62	0.20	0.02	0.07	0.07 U	0.07	0.00	0.10	0.56	0.19	0.02	0.09	1.25 *	Less than Criteria
05-3	33	34	pCi/g	32.6 J	2.44	0.46	0.93	1.96 J	0.43	0.44	0.90	34.6	Exceeds Criteria	1,815 QJ	559	0.54	4.54	14.4 QJ	8.16	3.69	4.00	1,829	Exceeds Criteria	12.4	1.90	0.02	0.06	0.70 Q	0.25	0.00	0.08	11.9	1.84	0.01	0.07	25.0	Less than Criteria
08-1	28	29	pCi/g	1.27	0.21	0.23	0.47	0.88 J	0.19	0.30	0.64	2.15	Less than Criteria	1.81	0.46	0.02	0.08	0.88	0.26	0.07	0.05	2.69	Less than Criteria	0.86	0.24	0.01	0.06	0.11	0.08	0.00	0.07	0.91	0.24	0.00	0.05	1.88	Less than Criteria
08-1	40	41	pCi/g	1.49	0.22	0.13	0.20	1.59	0.27	0.21	0.44	3.08	Less than Criteria	1.57	0.46	0.01	0.09	1.31	0.38	0.09	0.08	2.88	Less than Criteria	0.84	0.23	0.02	0.07	0.08	0.07	0.00	0.07	1.00	0.26	0.00	0.05	1.92	Less than Criteria
08-1	44	45	pCi/g	1.29	0.28	0.20	0.42	1.43 J	0.44	0.36	0.76	2.72	Less than Criteria	77.8	16.9	0.01	0.06	0.48	0.19	0.08	0.06	78.2	Exceeds Criteria	0.57	0.17	0.01	0.05	0.09	0.07	0.00	0.06	0.47	0.15	0.00	0.05	1.13	Less than Criteria
08-1BGP	28	29	pCi/g	0.96 J	0.19	0.27	0.55	0.48 UJ	0.33	0.27	0.59	1.44 *	Less than Criteria	3.42	0.84	0.02	0.07	0.15	0.08	0.05	0.05	3.57	Less than Criteria	0.35	0.11	0.01	0.04	0.05	0.04	0.00	0.04	0.37	0.11	0.01	0.04	0.78	Less than Criteria
08-1BGP_FD	28	29	pCi/g	1.73	0.34	0.23	0.48	0.83 J	0.37	0.38	0.82	2.56	Less than Criteria	10.4 Q	2.65	0.01	0.07	0.19	0.11	0.07	0.07	10.6	Exceeds Criteria	0.41	0.11	0.01	0.03	0.05	0.04	0.00	0.04	0.43	0.11	0.00	0.02	0.89	Less than Criteria
08-1BGP	29	30	pCi/g	0.58	0.15	0.06	0.14	0.13 U	0.20	0.16	0.36	0.71 *	Less than Criteria	0.81	0.24	0.01	0.05	0.13	0.07	0.05	0.05	0.93	Less than Criteria	0.74	0.17	0.01	0.03	0.06	0.04	0.00	0.03	0.50	0.13	0.00	0.03	1.30	Less than Criteria
12-5	2	3	pCi/g	1.22	0.16	0.07	0.15	0.88	0.17	0.14	0.29	2.09	Less than Criteria	1.27	0.35	0.01	0.07	0.94	0.27	0.11	0.07	2.21	Less than Criteria	0.53	0.18	0.01	0.06	0.05 U	0.07	0.00	0.10	0.60	0.20	0.00	0.08	1.19 *	Less than Criteria
12-5	12	13	pCi/g	1.15	0.19	0.10	0.21	1.10	0.24	0.16	0.34	2.25	Less than Criteria	1.72	0.49	0.01	0.08	0.87	0.29	0.14	0.07	2.59	Less than Criteria	0.67	0.21	0.02	0.06	0.10	0.09	0.00	0.10	0.76	0.22	0.00	0.06	1.53	Less than Criteria
13-3	19	20	pCi/g	1.50	0.23	0.14	0.30	1.39 J	0.36	0.27	0.56	2.89	Less than Criteria	3.41	0.85	0.01	0.07	1.20	0.36	0.14	0.08	4.61	Less than Criteria	0.95	0.26	0.04	0.10	0.18	0.11	0.01	0.08	0.92	0.25	0.02	0.09	2.05	Less than Criteria
13-3	29	30	pCi/g	0.39 UJ	0.31	0.24	0.50	0.73 J	0.37	0.31	0.68	1.11 *	Less than Criteria	0.79	0.26	0.00	0.06	0.81	0.25	0.11	0.08	1.60	Less than Criteria	0.72	0.21	0.01	0.06	0.04 U	0.06	0.01	0.08	0.88	0.24	0.01	0.06	1.65 *	Less than Criteria
13-6	21	22	pCi/g	1.42	0.22	0.11	0.22	1.24 J	0.25	0.61	0.78	2.66	Less than Criteria	2.75	0.68	0.02	0.10	1.21	0.34	0.08	0.07	3.95	Less than Criteria	0.91	0.24	0.01	0.05	0.11	0.09	0.00	0.09	1.10	0.27	0.00	0.05	2.12	Less than Criteria
13-6_FD	21	22	pCi/g	1.26	0.19	0.11	0.22	1.10	0.21	0.14	0.30	2.35	Less than Criteria	1.40	0.39	0.00	0.08	1.11	0.32	0.07	0.08	2.51	Less than Criteria	1.00	0.27	0.01	0.09	0.10	0.09	0.00	0.07	1.01	0.27	0.00	0.08	2.11	Less than Criteria
13-6	39	40	pCi/g	1.16	0.18	0.10	0.21	1.34	0.24	0.15	0.32	2.50	Less than Criteria	1.38	0.43	0.02	0.11	0.97	0.32	0.13	0.14	2.35	Less than Criteria	0.81	0.32	0.03	0.11	0.09 U	0.11	0.01	0.15	1.04	0.37	0.00	0.16	1.94 *	Less than Criteria
14-2	19	20	pCi/g	1.31	0.18	0.09	0.20	1.33	0.22	0.19	0.40	2.64	Less than Criteria	2.76	0.70	0.01	0.07	1.05	0.32	0.14	0.08	3.81	Less than Criteria	0.75	0.20	0.02	0.06	0.10	0.07	0.00	0.06	0.80	0.21	0.00	0.05	1.64	Less than Criteria
14-2	29	31	pCi/g	1.19	0.19	0.11	0.23	1.14	0.21	0.14	0.31	2.33	Less than Criteria	1.52	0.43	0.01	0.07	1.36	0.38	0.13	0.06	2.88	Less than Criteria	1.03	0.28	0.04	0.11	0.03 U	0.06	0.02	0.11	1.02	0.27	0.01	0.08	2.08 *	Less than Criteria
14-4	5	6	pCi/g	0.90	0.14	0.08	0.17	0.68	0.13	0.21	0.44	1.59	Less than Criteria	1.29	0.39	0.01	0.08	1.10	0.34	0.15	0.09	2.39	Less than Criteria	1.08	0.25	0.03	0.08	0.12	0.08	0.01	0.08	0.73	0.19	0.01	0.06	1.92	Less than Criteria
14-4	28	29	pCi/g	0.82	0.20	0.14	0.29	0.84 J	0.24	0.23	0.51	1.66	Less than Criteria	2.08	0.55	0.00	0.09	1.46	0.39	0.13	0.06	3.54	Less than Criteria	0.94	0.23	0.03	0.08	0.08	0.07	0.00	0.06	1.23	0.28	0.01	0.07	2.25	Less than Criteria
14-5	12	13	pCi/g	1.24	0.22	0.14	0.29	1.22	0.28	0.23	0.48	2.46	Less than Criteria	1.66	0.48	0.01	0.08	1.19	0.36	0.10	0.10	2.86	Less than Criteria	0.80	0.23	0.01	0.05	0.12	0.09	0.01	0.08	0.87	0.24	0.00	0.05	1.79	Less than Criteria
14-5	60	61	pCi/g	1.31 J	0.29	0.24	0.50	1.43 J	0.45	0.34	0.73	2.74	Less than Criteria	1.03	0.32	0.01	0.06	1.12	0.33	0.08	0.09	2.15	Less than Criteria	0.98	0.25	0.01	0.08	0.09	0.08	0.00	0.09	0.86	0.23	0.00	0.08	1.94	Less than Criteria
14-7	13	14	pCi/g	0.90	0.15	0.19	0.39	0.48	0.16	0.15	0.32	1.38	Less than Criteria	1.54	0.49	0.04	0.14	0.89	0.32	0.18	0.11	2.43	Less than Criteria	1.07	0.26	0.01	0.05	0.10	0.08	0.01	0.07	1.01	0.26	0.01	0.06	2.18	Less than Criteria
14-7	39	40	pCi/g	1.32	0.23	0.16	0.33	0.99 J	0.30	0.29	0.61	2.31	Less than Criteria	1.80	0.54	0.03	0.14	1.26	0.40	0.17	0.10	3.05	Less than Criteria	0.86	0.22	0.01	0.05	0.07	0.07	0.00	0.09	0.83	0.22	0.00	0.07	1.76	Less than Criteria
15-2	24	25	pCi/g	4.78	0.51	0.15	0.31	1.48 J	0.29	0.29	0.60	6.26	Less than Criteria	116	23.8	0.02	0.09	1.84	0.46	0.14	0.10	117	Exceeds Criteria	0.98	0.26	0.04	0.10	0.06 U	0.07	0.02	0.11	0.93	0.25	0.01	0.06	1.97 *	Less than Criteria
15-2	43	44	pCi/g	1.40	0.20	0.12	0.24	1.42	0.25	0.16	0.35	2.82	Less than Criteria	1.36	0.44	0.02	0.11	1.33	0.42	0.17	0.08	2.69	Less than Criteria	0.73	0.20	0.02	0.07	0.02 U	0.04	0.01	0.07	0.82	0.21	0.01	0.06	1.56 *	Less than Criteria
16-3	6	7	pCi/g	1.36	0.24	0.14	0.28	1.61	0.32	0.22	0.46	2.98	Less than Criteria	1.86	0.53	0.02	0.11	1.30	0.39	0.15	0.08	3.16	Less than Criteria	0.69	0.22	0.02	0.08	0.05 U	0.07	0.00	0.11	0.75	0.23	0.01	0.07	1.50 *	Less than Criteria
16-3	11	12	pCi/g	1.17	0.19	0.10	0.21	1.67	0.23	0.16	0.34	2.84	Less than Criteria	1.77	0.52	0.01	0.09	1.37	0.41	0.15	0.08	3.14	Less than Criteria	0.90	0.23	0.03	0.08	0.14	0.09	0.01	0.08	1.05	0.26	0.01	0.07	2.09	Less than Criteria
16-3_FD	11	12	pCi/g	1.27	0.19	0.10	0.21	1.25	0.26	0.20	0.43	2.52	Less than Criteria	1.86	0.57	0.03	0.13	1.62	0.50	0.19	0.12	3.47	Less than Criteria	0.85	0.23	0.02	0.08	0.16	0.10	0.01	0.07	0.98	0.25	0.00	0.05	1.99	Less than Criteria
16-6	6	7	pCi/g	1.36	0.21	0.11	0.24	1.41	0.26	0.17	0.37	2.77	Less than Criteria	1.67	0.46	0.01	0.06	1.23	0.35	0.13	0.06	2.90	Less than Criteria	1.11	0.26	0.01	0.05	0.05 U	0.05	0.01	0.08	1.02	0.25	0.01	0.06	2.18 *	Less than Criteria
16-6	21	22	pCi/g	0.93	0.15	0.09	0.05	1.26	0.21	0.18	0.37	2.19	Less than Criteria	1.41	0.41	0.00	0.09	1.50	0.41	0.13	0.06	2.91	Less than Criteria	0.58	0.21	0.04	0.11	0.11	0.09	0.01	0.09	0.59	0.21	0.05	0.14	1.28	Less than Criteria
1C-4RGP	46	47	pCi/g	1.74	0.23	0.10	0.20	0.65	0.19	0.20	0.43	2.39	Less than Criteria	4.45	1.10	0.01	0.06	0.08 U	0.06	0.06	0.05	4.53 *	Less than Criteria	0.88	0.26	0.02	0.07	0.03 U	0.06	0.00	0.10	0.90	0.26	0.01	0.07	1.82 *	Less than Criteria
1C-4RBGP	46	47	pCi/g	1.20	0.19	0.11	0.24	0.66	0.24	0.23	0.49	1.86	Less than Criteria	2.03	0.61	0.01	0.06	0.18 U	0.11	0.07	0.08	2.21 *	Less than Criteria	0.55	0.20	0.02	0.07	0.03 U	0.06	0.00	0.10	0.58	0.20	0.01	0.07	1.17 *	Less than Criteria
1C-12BGP	53	54	pCi/g	1.14	0.29	0.20	0.41	0.63 UJ	0.38	0.32	0.70	1.77 *	Less than Criteria	0.66	0.23	0.02	0.08	0.34	0.14	0.06	0.06	0.99	Less than Criteria	0.62	0.15	0.02	0.05	0.03 U	0.04	0.01	0.05	0.72	0.17	0.01	0.04	1.38 *	Less than Criteria
1C-12BGP	54	55	pCi/g	1.86	0.26	0.12	0.25	1.02	0.26	0.20	0.43	2.88	Less than Criteria	9.41	2.17	0.00	0.04	0.39	0.14	0.05	0.04	9.80	Exceeds Criteria	0.52	0.12	0.01	0.04	0.04	0.04	0.00	0.04	0.61	0.14	0.01	0.03	1.17	Less than Criteria
1C-12BGP	55	56	pCi/g	31.0 J	2.47	0.51	1.04	1.25 UJ	0.67	0.60	1.23	32.3 *	Exceeds Criteria	399	92.0	0.00	0.04	2.19	0.55	0.06	0.04	401	Exceeds Criteria	1.83	0.34	0.02	0.05	0.22	0.10	0.00	0.06	1.92	0.35	0.03	0.07	3.97	Less than Criteria
1C-2RAGP	28	29	pCi/g	2.17	0.34	0.14	0.18	1.16 J	0.52	0.42	0.90	3.32	Less than Criteria	2.47	0.53	0.00	0.03	0.27	0.09	0.03	0.02	2.73	Less than Criteria	0.47	0.13	0.01	0.04	0.05	0.04	0.00	0.03	0.59	0.14	0.01	0.04	1.10	Less than Criteria
1C-12GP	48	49	pCi/g	1.46 J	0.39	0.29	0.60	1.48 J	0.65	0.61	1.29	2.94	Less than Criteria	1.74	0.52	0.02	0.08	0.14 U	0.10	0.12	0.12	1.88 *	Less than Criteria	0.54	0.14	0.01	0.04	0.01 U	0.02	0.00	0.04	0.56	0.14	0.00	0.03	1.10 *	Less than Criteria
1C-12GP	49	50	pCi/g	1.53	0.24	0.11	0.23	1.01 J	0.33	0.30	0.62	2.54	Less than Criteria	0.43	0.16	0.00	0.04	0.17	0.09	0.05	0.04	0.60	Less than Criteria	0.61	0.13	0.01	0.02	0.06	0.04	0.00	0.03	0.48	0.11	0.00	0.02	1.15	Less than Criteria
1C-6	19	20	pCi/g	1.40	0.19	0.11	0.23	1.13	0.23	0.18	0.37	2.54	Less than Criteria	1.29	0.38	0.01	0.06	1.71	0.45	0.08	0.06	3.00	Less than Criteria	1.26	0.30	0.02	0.07	0.10	0.08	0.01	0.08	1.03	0.26	0.01	0.08	2.39	Less than Criteria
1C-6	24	25	pCi/g	2.65	0.29	0.09	0.19	1.28	0.24	0.23	0.48	3.94	Less than Criteria	51.0	10.8	0.01	0.07	1.43	0.40	0.09	0.09	52.4	Exceeds Criteria	1.46	0.36	0.02	0.07	0.17	0.12	0.00	0.11	1.49	0.36	0.00	0.06	3.12	Less than Criteria
1C-6	25	26	pCi/g	7.04 J	0.94	0.34	0.71	0.13 UJ	0.63	0.46	1.01	7.17 *	Less than Criteria	240	52.0	0.01	0.09	1.09	0.33	0.09	0.07	241	Exceeds Criteria	1.08	0.27	0.02	0.07	0.10	0.08	0.01	0.07	1.04	0.26	0.05	0.12	2.21	Less than Criteria
1C-6	26	27	pCi/g	8.79 J	0.95	0.30	0.62	0.43 UJ	0.71	0.57	1.20	9.22 *	Exceeds Criteria	202	40.0	0.00	0.05	0.88	0.25	0.06	0.07	203	Exceeds Criteria	1.15	0.27	0.01	0.06	0.04 U	0.05	0.00	0.06	1.12	0.27	0.01	0.06	2.31 *	Less than Criteria
1C-6TIGP	22	23	pCi/g	1.45	0.20	0.12	0.16	0.84	0.21	0.17	0.36	2.29	Less than Criteria	0.39	0.14	0.00	0.03	0.21	0.09	0.04	0.05	0.60	Less than Criteria	0.60	0.13	0.01	0.03	0.05	0.04	0.00	0.03	0.53	0.12	0.00	0.02	1.19	Less than Criteria
WL-119-Sonic	34	35	pCi/g	1.28 J	0.32	0.24	0.51	1.36 J	0.43	0.43	0.91	2.64	Less than Criteria	0.38	0.13	0.01	0.05	0.31	0.11	0.04	0.04	0.69	Less than Criteria	0.60	0.16	0.01	0.04	0.03 U	0.04	0.00	0.05	0.58	0.16	0.00	0.05	1.20 *	Less than Criteria
WL-119BGP	38	39	pCi/g	1.57	0.33	0.23	0.48	1.44 J	0.37	0.38	0.81	3.01	Less than Criteria	0.65	0.19	0.01	0.05	0.56	0.16	0.05	0.05	1.20	Less than Criteria	0.36	0.10	0.01	0.02	0.03 U	0.03	0.00	0.03	0.35	0.10	0.00	0.03	0.73 *	Less than Criteria
WL-119CGP	43	44	pCi/g	1.31	0.20	0.13	0.27	0.98	0.21	0.16	0.35	2.30	Less than Criteria	3.03	0.68	0.00	0.04	0.40	0.13	0.04	0.04	3.44	Less than Criteria	0.48	0.12	0.01	0.02	0.02 U	0.02	0.00	0.03	0.53	0.13	0.00	0.03	1.03 *	Less than Criteria
WL-119CGP	45	46	pCi/g	0.87	0.18	0.16	0.34	0.32 U	0.25	0.21	0.46	1.19 *	Less than Criteria	4.20 Q	1.37	0.01	0.10	0.46	0.23	0.11	0.10	4.67	Less than Criteria	0.48	0.11	0.01	0.03	0.04	0.03	0.00	0.04	0.38	0.10	0.00	0.02	0.89	Less than Criteria
WL-119-Sonic	1	2	pCi/g	1.19	0.18	0.09	0.19	0.77	0.15	0.15	0.31	1.96	Less than Criteria	0.45	0.19	0.01	0.07	0.30	0.14	0.08	0.07	0.76	Less than Criteria	0.61	0.20	0.02	0.09	0.01 U	0.04	0.00	0.07	0.86	0.25	0.01	0.09	1.49 *	Less than Criteria
WL-119-Sonic	5	6	pCi/g	1.35	0.19	0.09	0.19	1.39	0.23	0.17	0.37	2.75	Less than Criteria	1.38	0.38	0.01	0.08	1.29	0.34	0.07	0.06	2.67	Less than Criteria	1.02	0.27	0.03	0.09	0.18	0.11	0.01	0.09	0.96	0.26	0.01	0.07	2.15	Less than Criteria
WL-119-Sonic	9	10	pCi/g	1.31	0.21	0.10	0.21	1.26 J	0.28	0.25	0.53	2.57	Less than Criteria	0.55	0.20	0.01	0.06	0.40	0.16	0.07	0.05	0.95	Less than Criteria	0.76	0.21	0.01	0.06	0.03 U	0.05	0.00	0.09	0.81	0.22	0.00	0.05	1.60 *	Less than Criteria
WL-119-Sonic	20	21	pCi/g	1.08	0.19	0.14	0.28	1.11	0.24	0.23	0.49	2.18	Less than Criteria	0.49	0.18	0.01	0.07	0.42	0.16	0.07	0.07	0.91	Less than Criteria	0.31	0.12	0.01	0.07	0.03 U	0.05	0.00	0.08	0.47	0.15	0.00	0.05	0.81 *	Less than Criteria
WL-119-Sonic	40	41	pCi/g	0.51	0.17	0.15	0.31	0.88	0.22	0.19	0.41	1.39	Less than Criteria	0.31	0.15	0.00	0.09	0.13 U	0.09	0.09	0.08	0.44 *	Less than Criteria	0.22	0.11	0.01	0.06	0.09	0.08	0.00	0.09	0.12	0.08	0.00	0.05	0.43	Less than Criteria
WL-119-Sonic	41	42	pCi/g	1.39	0.23	0.13	0.28	1.24 J	0.26	0.36	0.75	2.63	Less than Criteria	0.63	0.22	0.01	0.06	0.57	0.20	0.07	0.06	1.20	Less than Criteria	0.42	0.15	0.02	0.06	0.11	0.08	0.01	0.08	0.48	0.15	0.00	0.05	1.01	Less than Criteria
WL-119-Sonic	51	52	pCi/g	0.40	0.09	0.07	0.04	0.52	0.12	0.10	0.22	0.92	Less than Criteria	0.57	0.32	0.07	0.25	0.55	0.30	0.19	0.18	1.12	Less than Criteria	0.41	0.14	0.01	0.05	0.06 U	0.06	0.00	0.06	0.42	0.14	0.00	0.05	0.89 *	Less than Criteria
WL-119-Sonic_FD	9	10	pCi/g	1.41	0.21	0.12	0.24	1.32	0.24	0.20	0.42	2.72	Less than Criteria	0.58	0.19	0.01	0.05	0.52	0.17	0.05	0.06	1.10	Less than Criteria	0.58	0.17	0.01	0.05	0.01 U	0.03	0.00	0.05	0.48	0.16	0.00	0.06	1.07 *	Less than Criteria
Phase 1D data (and Cotter samples from Core of Phase 1D borings)																																					
1D-01	7	9	pCi/g	1.08 U	0.20	1.66	0.28	0.95	0.23	0.27	0.57	2.04 *	Less than Criteria	1.65 J+	0.45	0.08	0.08	0.39 J	0.16	0.01	0.07	2.05	Less than Criteria	0.44 J-	0.16	0.03	0.10	0.04 J	0.05	0.01	0.08	0.37 J	0.14	0.01	0.08	0.85	Less than Criteria
1D-01	24	27	pCi/g	1.11 U	0.28	1.56	0.44	0.47 J	0.32	0.28	0.62	1.58 *	Less than Criteria	1.21 J+	0.34	0.07	0.07	0.11 J	0.08	0.01	0.06	1.31	Less than Criteria	0.87 J-	0.22	0.01	0.01	0.08 J	0.07	0.00	0.08	0.77 J	0.20	0.00	0.06	1.72	Less than Criteria
1D-02	20	23	pCi/g	1.26	0.18	1.24	0.30	1.12	0.30	0.26	0.54	2.38	Less than Criteria	0.84 J+	0.25	0.05	0.05	0.45 J	0.16	0.00	0.05	1.29	Less than Criteria	0.31 J-	0.14	0.01	0.01	0.05 J	0.06	0.00	0.07	0.29 J	0.13	0.01	0.06	0.65	Less than Criteria
1D-02	27	30	pCi/g	1.14 U	0.23	1.51	0.34	1.05	0.35	0.27	0.58	2.19 *	Less than Criteria	0.68 J+	0.24	0.07	0.06	0.18 J	0.11	0.01	0.07	0.87	Less than Criteria	0.25 J-	0.14	0.01	0.01	0.08 J	0.08	0.01	0.10	0.37 J	0.17	0.01	0.08	0.70	Less than Criteria
1D-02	36	37	pCi/g	1.01 U	0.30	1.66	0.45	0.85 J	0.45	0.40	0.86	1.86 *	Less than Criteria	0.72 J+	0.26	0.08	0.08	0.70 J	0.25	0.01	0.08	1.42	Less than Criteria	0.25 J-	0.11	0.00	0.00	0.04 J	0.06	0.00	0.09	0.30 J	0.12	0.00	0.05	0.59	Less than Criteria

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D GCPT Soundings and Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Final Result Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Final Result Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228	Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230 Final Result Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Final Result Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234 Final Result Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Final Result Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Final Result Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238	Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
1D-03	25	29		184 J+	13.9	20.6	3.56	1.27 U	2.96	2.24	4.59	185 *	Exceeds Criteria	576 J+	121	0.07	0.09	4.07	0.92	0.00	0.06	580	Exceeds Criteria	9.36	1.52	0.01	0.08	0.59	0.23	0.01	0.11	9.27	1.51	0.00	0.10	19.2	Less than Criteria
1D-03	41	43	pCi/g	1.22 U	0.23	1.33	0.32	0.74	0.25	0.20	0.45	1.97 *	Less than Criteria	1.59 J+	0.43	0.07	0.07	0.21 J	0.11	0.00	0.07	1.80	Less than Criteria	0.22 J	0.11	0.01	0.00	0.00 UJ	0.04	0.00	0.09	0.28 J	0.12	0.00	0.08	0.50 *	Less than Criteria
1D-03_FD	41	43	pCi/g	0.41 U	0.22	1.50	0.57	0.29 J	0.32	0.26	0.58	0.70 *	Less than Criteria	0.73 J+	0.24	0.06	0.06	0.10 J	0.07	0.00	0.07	0.83	Less than Criteria	0.15 J	0.10	0.00	0.00	0.04 J	0.07	0.00	0.12	0.06 J	0.06	0.01	0.08	0.24	Less than Criteria
1D-04	61	62	pCi/g	1.25 U	0.20	1.31	0.21	1.15	0.27	0.23	0.50	2.40 *	Less than Criteria	1.84 J	0.62	0.18	0.18	1.47 J	0.51	0.01	0.15	3.31	Less than Criteria	2.83	1.26	0.06	0.63	0.32 J	0.55	0.01	0.97	2.78	1.25	0.10	0.73	5.93	Less than Criteria
1D-04	64	65	pCi/g	0.86	0.15	0.77	0.21	0.70	0.18	0.15	0.32	1.56	Less than Criteria	0.77 J	0.25	0.09	0.11	0.66 J	0.22	0.04	0.12	1.43	Less than Criteria	1.42	0.62	0.05	0.34	0.37	0.36	0.00	0.45	1.78	0.70	0.04	0.32	3.58	Less than Criteria
1D-05	51	52	pCi/g	53.9	4.27	7.67	0.75	1.35	0.65	0.70	1.45	55.3	Exceeds Criteria	216 J	42.3	0.06	0.05	1.94 J	0.45	0.01	0.06	218	Exceeds Criteria	0.23	0.13	0.04	0.15	0.14	0.11	0.01	0.12	0.18	0.13	0.06	0.17	0.54	Less than Criteria
1D-05	63	64	pCi/g	1.06 U	0.18	1.04	0.26	0.84	0.21	0.22	0.47	1.90 *	Less than Criteria	0.39	0.16	0.07	0.07	0.05 J	0.05	0.00	0.05	0.43	Less than Criteria	0.27 J	0.18	0.02	0.14	0.02 J	0.07	0.01	0.17	0.20 J	0.15	0.01	0.11	0.49	Less than Criteria
1D-06	80	81	pCi/g	0.59 U	0.22	1.05	0.36	1.11	0.25	0.23	0.50	1.70 *	Less than Criteria	0.42	0.19	0.13	0.14	0.31	0.16	0.05	0.14	0.73	Less than Criteria	2.24	0.45	0.00	0.08	0.11	0.09	0.00	0.10	2.19	0.44	0.02	0.10	4.54	Less than Criteria
1D-06	85	86	pCi/g	0.50 U	0.13	1.09	0.20	0.47	0.22	0.23	0.49	0.97 *	Less than Criteria	0.50 J	0.19	0.08	0.07	0.19 J	0.11	0.01	0.07	0.69	Less than Criteria	0.17 J	0.12	0.02	0.11	0.02 J	0.05	0.00	0.10	0.31 J	0.16	0.01	0.10	0.50	Less than Criteria
1D-07	84	85	pCi/g	3,630	242	105	11.7	31.8	9.45	8.29	16.7	3,662	Exceeds Criteria	16,703	3,437	20.9	23.0	178	53.1	8.73	22.6	16,881	Exceeds Criteria	373	167	9.89	87.0	40.9 J	69.7	1.09	123	223	126	9.38	86.6	637	Exceeds Criteria
1D-07	93	94	pCi/g	1.50	0.28	1.37	0.22	0.61	0.31	0.23	0.51	2.11	Less than Criteria	18.0	4.29	0.10	0.10	0.38	0.19	0.02	0.12	18.4	Exceeds Criteria	0.16	0.10	0.00	0.08	0.05 J	0.07	0.00	0.10	0.22	0.11	0.00	0.06	0.43	Less than Criteria
1D-08	75	76	pCi/g	4.37	0.45	1.77	0.32	0.89	0.27	0.24	0.51	5.26	Less than Criteria	3.54 J	0.93	0.13	0.15	0.24 J	0.16	0.02	0.13	3.77	Less than Criteria	0.66 J	0.48	0.02	0.35	0.26 J	0.36	0.05	0.54	0.59 J	0.48	0.09	0.53	1.50 *	Less than Criteria
1D-08	90	91	pCi/g	0.51 U	0.10	0.69	0.13	0.69	0.18	0.17	0.36	1.19 *	Less than Criteria	0.99 J	0.36	0.12	0.12	0.60 J	0.25	0.00	0.12	1.59	Less than Criteria	0.90 J	0.52	0.03	0.34	0.25 J	0.30	0.02	0.37	0.82 J	0.50	0.03	0.34	1.97	Less than Criteria
1D-09	78	79	pCi/g	0.21 U	0.25	2.37	0.43	0.16 U	0.44	0.33	0.74	Non-detect *	Non-detect	0.34 J+	0.15	0.07	0.07	0.19 J	0.11	0.01	0.07	0.53	Less than Criteria	0.06 J-	0.06	0.01	0.06	0.06 J	0.06	0.00	0.06	0.04 J	0.05	0.01	0.06	0.16	Less than Criteria
1D-09	88	89	pCi/g	17.0 J	1.43	4.59	0.50	1.10 U	0.50	0.49	1.03	18.1 *	Exceeds Criteria	316 J+	63.8	0.06	0.06	1.94 J	0.47	0.01	0.01	318	Exceeds Criteria	1.31 J-	0.56	0.07	0.35	0.07 UJ	0.15	0.11	0.51	1.43 J	0.59	0.10	0.35	2.68 *	Less than Criteria
1D-09	99	100	pCi/g	0.66 U	0.10	0.60	0.17	0.43	0.12	0.21	0.37	1.09 *	Less than Criteria	2.84 J+	0.69	0.07	0.07	0.16 J	0.10	0.01	0.07	3.00	Less than Criteria	0.26 J-	0.13	0.02	0.10	0.03 J	0.05	0.01	0.08	0.28 J	0.13	0.01	0.06	0.56	Less than Criteria
1D-10	46	49	pCi/g	1.34 U	0.24	1.43	0.34	1.58	0.29	0.25	0.54	2.92 *	Less than Criteria	0.46 J	0.17	0.06	0.06	0.33 J	0.13	0.00	0.05	0.79	Less than Criteria	0.21 J	0.13	0.01	0.08	0.06 J+	0.08	0.01	0.11	0.46 J	0.20	0.00	0.08	0.73	Less than Criteria
1D-10	74	76	pCi/g	0.81 U	0.20	1.14	0.26	0.66	0.23	0.19	0.43	1.47 *	Less than Criteria	0.31	0.13	0.06	0.06	0.32	0.13	0.01	0.06	0.62	Less than Criteria	0.38	0.16	0.02	0.10	0.15 J+	0.11	0.01	0.10	0.33	0.16	0.05	0.14	0.86	Less than Criteria
1D-11	85	86	pCi/g	24.4 J+	1.86	2.84	0.55	1.10	0.44	0.39	0.80	25.5	Exceeds Criteria	119 J+	24.1	0.06	0.07	1.35	0.34	0.00	0.05	120	Exceeds Criteria	1.48	0.33	0.00	0.07	0.07 J	0.07	0.00	0.09	1.41	0.32	0.01	0.06	2.97	Less than Criteria
1D-11	87	88	pCi/g	0.73 U	0.13	0.96	0.17	0.68	0.18	0.14	0.29	1.42 *	Less than Criteria	1.38 J+	0.36	0.05	0.06	0.26 J	0.11	0.00	0.04	1.64	Less than Criteria	0.86	0.24	0.02	0.09	0.07 J	0.07	0.01	0.10	0.74	0.22	0.03	0.11	1.66	Less than Criteria
1D-12	61	62	pCi/g	0.58 U	0.47	2.50	0.74	-0.37 U	0.67	0.36	0.86	Non-detect *	Non-detect	0.73 J+	0.24	0.07	0.06	0.16 J	0.10	0.00	0.06	0.89	Less than Criteria	0.11 J	0.08	0.00	0.06	0.01 J	0.03	0.00	0.07	0.08 J	0.07	0.01	0.06	0.20	Less than Criteria
1D-12	74	75	pCi/g	1.02 U	0.18	1.58	0.23	1.09	0.23	0.19	0.40	2.11 *	Less than Criteria	0.35 J+	0.14	0.05	0.04	0.17 J	0.09	0.01	0.06	0.51	Less than Criteria	0.23	0.11	0.01	0.07	0.03 J	0.04	0.00	0.06	0.21 J	0.11	0.04	0.11	0.47	Less than Criteria
1D-13	85	86	pCi/g	1.17 U	0.19	1.56	0.28	1.11	0.25	0.25	0.52	2.28 *	Less than Criteria	0.62 J+	0.21	0.06	0.06	0.52 J	0.18	0.00	0.06	1.13	Less than Criteria	0.30 J-	0.18	0.01	0.13	0.06 J	0.10	0.00	0.18	0.27 J	0.17	0.01	0.13	0.63	Less than Criteria
1D-13	93	94	pCi/g	4.22	0.37	1.48	0.28	0.43	0.15	0.20	0.41	4.65	Less than Criteria	4.27 J+	0.97	0.06	0.07	0.26 J	0.12	0.01	0.06	4.54	Less than Criteria	2.77 J-	0.58	0.02	0.11	0.31 J	0.18	0.01	0.12	3.63 J	0.71	0.06	0.18	6.71	Less than Criteria
1D-14	54	55	pCi/g	0.40 U	0.30	2.37	0.53	0.14 U	0.51	0.38	0.85	Non-detect *	Non-detect	0.21 J+	0.10	0.07	0.08	0.02 UJ	0.05	0.03	0.09	0.23 *	Less than Criteria	0.21 J-	0.10	0.00	0.05	0.01 J	0.03	0.00	0.06	0.09 J	0.07	0.00	0.05	0.32	Less than Criteria
1D-14	82	84	pCi/g	1.31 U	0.27	1.52	0.14	0.87	0.32	0.49	1.03	2.18 *	Less than Criteria	0.74 J+	0.24	0.06	0.05	0.34 J	0.14	0.01	0.06	1.08	Less than Criteria	0.40 J-	0.18	0.01	0.09	0.02 J	0.07	0.02	0.14	0.41 J	0.18	0.01	0.10	0.83	Less than Criteria
1D-15	77	80	pCi/g	0.70 U	0.19	1.03	0.30	0.49	0.21	0.26	0.55	1.20 *	Less than Criteria	0.20 J+	0.10	0.05	0.06	0.04 J	0.06	0.04	0.09	0.24	Less than Criteria	0.14 J	0.09	0.01	0.07	-0.01 U	0.03	0.01	0.08	0.08 J	0.07	0.01	0.08	0.22 *	Less than Criteria
1D-15	85	86	pCi/g	8.82 J+	0.85	2.85	0.48	0.24 U	0.42	0.32	0.68	9.06 *	Exceeds Criteria	30.9 J+	6.16	0.05	0.05	0.31 J	0.12	0.01	0.06	31.2	Exceeds Criteria	0.46	0.16	0.01	0.06	0.04 J	0.05	0.01	0.08	0.48	0.16	0.00	0.07	0.98	Less than Criteria
1D-16	50	51	pCi/g	33.5	2.76	5.55	0.84	0.98	0.65	0.74	1.52	34.4	Exceeds Criteria	971 J	198	0.06	0.05	6.45 J	1.31	0.01	0.07	978	Exceeds Criteria	5.03 J	1.00	0.05	0.16	0.30 J	0.19	0.04	0.19	4.77 J	0.96	0.06	0.18	10.1	Less than Criteria
1D-16	59	61	pCi/g	0.58 U	0.21	1.21	0.30	0.66	0.34	0.33	0.70	1.24 *	Less than Criteria	0.61	0.23	0.08	0.07	0.28	0.14	0.01	0.08	0.89	Less than Criteria	0.10 J	0.08	0.01	0.08	0.12 J	0.10	0.00	0.10	0.18 J	0.10	0.00	0.06	0.40	Less than Criteria
1D-16_FD	59	61	pCi/g	0.52 U	0.17	1.20	0.23	0.59	0.28	0.27	0.59	1.11 *	Less than Criteria	0.37	0.24	0.21	0.23	0.27	0.18	0.01	0.13	0.64	Less than Criteria	0.08	0.07	0.01	0.07	0.03 J	0.05	0.00	0.07	0.29 J	0.13	0.01	0.07	0.40	Less than Criteria
1D-17	30	31	pCi/g	0.38 U	0.21	1.46	0.40	0.39 J	0.41	0.35	0.75	0.77 *	Less than Criteria	0.35 J+	0.15	0.06	0.06	0.15 J	0.09	0.01	0.07	0.51	Less than Criteria	0.14 J-	0.09	0.00	0.08	0.03 J	0.04	0.00	0.07	0.13 J	0.08	0.00	0.08	0.30	Less than Criteria
1D-17	33	36	pCi/g	0.75 U	0.26	1.54	0.19	0.41 J	0.36	0.32	0.70	1.16 *	Less than Criteria	4.00 J+	0.97	0.08	0.07	0.18 J	0.12	0.04	0.13	4.18	Less than Criteria	0.85 J-	0.34	0.02	0.16	0.04 J	0.10	0.00	0.22	0.47 J	0.24	0.01	0.12	1.36	Less than Criteria
1D-18	13	14	pCi/g	0.76 U	0.16	1.24	0.20	0.31 J	0.16	0.12	0.27	1.07 *	Less than Criteria	0.56 J+	0.20	0.06	0.05	0.16 J	0.09	0.01	0.06	0.71	Less than Criteria	0.42 J-	0.16	0.01	0.07	0.05 J	0.06	0.00	0.07	0.21 J	0.11	0.00	0.08	0.67	Less than Criteria
1D-18	38	41	pCi/g	0.52 U	0.20	1.58	0.53	0.26 U	0.35	0.29	0.63	Non-detect *	Non-detect	5.97 J+	1.38	0.07	0.08	0.05 J	0.06	0.00	0.06	6.03	Less than Criteria	0.22 J-	0.12	0.01	0.07	0.05 J	0.06	0.00	0.07	0.11 J	0.08	0.01	0.07	0.38	Less than Criteria
1D-18	44	46	pCi/g	1.34	0.21	1.33	0.22	1.40	0.27	0.25	0.52	2.74	Less than Criteria	1.29 J+	0.38	0.07	0.06	0.78 J	0.26	0.00	0.09	2.07	Less than Criteria	0.31 J-	0.19	0.01	0.13	0.12 J	0.13	0.01	0.16	0.28 J	0.18	0.01	0.13	0.71	Less than Criteria
1D-19	61	63	pCi/g	1.17 U	0.32	1.74	0.43	1.23	0.50	0.46	0.97	2.40 *	Less than Criteria	0.59 J	0.22	0.08	0.07	0.46 J	0.18	0.01	0.08	1.05	Less than Criteria	0.40 J	0.16	0.00	0.09	0.16 J+	0.11	0.01	0.10	0.34 J	0.14	0.01	0.07	0.90	Less than Criteria
1D-19_FD	61	63	pCi/g	1.28 J+	0.18	1.20	0.20	1.08	0.24	0.27	0.55	2.36	Less than Criteria	0.70	0.24	0.09	0.10	0.24 J	0.13	0.02	0.10	0.94	Less than Criteria	0.66 J	0.21	0.00	0.06	0.19 J+	0.12	0.00	0.07	0.58 J	0.20	0.01	0.07	1.43	Less than Criteria
1D-20	80	81	pCi/g	0.71 U	0.10	0.75	0.04	0.08 J	0.10	0.08	0.17	0.80 *	Less than Criteria	1.36 J	0.59	0.23	0.27	0.38 J	0.28	0.04	0.28	1.73	Less than Criteria	1.92 J	0.83	0.13	0.56	0.14 UJ	0.40	0.20	0.81	0.93 J	0.59	0.16	0.61	3.00 *	Less than Criteria
1D-20_FD	80	81	pCi/g	0.83 U	0.13	0.91	0.12	0.05 U	0.15	0.12	0.26	Non-detect *	Non-detect	1.43	0.51	0.14	0.14	0.14 J	0.12	0.01	0.10	1.57	Less than Criteria	2.10	0.79	0.02	0.28	0.47	0.40	0.02	0.34	1.04	0.54	0.02	0.27	3.62	Less than Criteria
1D-20	89	90	pCi/g	1.33 U	0.19	1.44	0.22	1.15	0.23	0.20	0.42	2.47 *	Less than Criteria	1.43	0.49	0.14	0.11	1.20	0.42	0.02	0.15	2.63	Less than Criteria	3.36	1.55	0.10	0.86	0.34 J	0.57	0.07	0.97	3.98	1.70	0.12	0.92	7.68	Less than Criteria
Area 1 Additional Borings																																					
AC-01	10	11	pCi/g	4,926	343	139	28.7	14.8 U	20.7	15.5	31.3	4,941 *	Exceeds Criteria	7,908 J+	1,823	8.73	11.1	257	69.6	5.04	15.7	8,165	Exceeds Criteria	183	41.4	3.48	8.11	30.5 J+	16.0	0.23	11.4	206 J+	44.9	0.53	9.23	420	Exceeds Criteria
AC-01	30	31	pCi/g	49.5	3.87	5.65	0.99	0.98 J	0.77	0.57	1.17	50.4	Exceeds Criteria	1,946	436	0.10	0.11	10.2	2.21	0.01	0.06	1,956	Exceeds Criteria	5.58	0.87	0.01	0.05	0.28	0.12	0.00	0.05	5.51	0.86	0.00	0.04	11.4	Less than Criteria
AC-02B	10	12	pCi/g	8.95	0.83	2.16	0.38	0.56 J	0.32	0.39	0.80	9.51	Exceeds Criteria	472	111	0.08	0.09	2.91	0.74	0.01	0.08	475	Exceeds Criteria	1.83	0.37	0.01	0.04	0.09 J	0.07	0.00	0.06	1.91	0.38	0.00	0.06	3.82	Less than Criteria
AC-02B	23	26	pCi/g	0.98 U	0.26	1.65	0.41	1.27	0.36	0.37	0.79	2.25 *	Less than Criteria	1.79	0.47	0.07	0.08	0.77	0.23	0.01	0.07	2.56	Less than Criteria	0.62	0.17	0.01	0.05	0.03 J	0.04	0.00	0.05	0.60	0.17	0.01	0.05	1.26	Less than Criteria
AC-03	5	6	pCi/g	2,599 J+	183	113	20.3	6.28 U	16.0	12.0	24.2	2,606 *	Exceeds Criteria	17,784 J+	3,962	8.73	11.3	515	121	2.57	12.0	18,299	Exceeds Criteria	129 J	30.6	3.00	6.94	17.7 J+	10.9	0.43	6.81	140 J+	32.2	1.13	6.91	287	Exceeds Criteria
AC-03	44	45	pCi/g	0.40 U	0.20	1.07	0.31	0.26 J	0.31	0.25	0.55	0.66 *	Less than Criteria	0.59	0.20	0.06	0.07	0.39	0.15	0.01	0.06	0.98	Less than Criteria	0.33 J+	0.13	0.03	0.07	0.05 J	0.06	0.01	0.08	0.34	0.14	0.01	0.06	0.72	Less than Criteria
AC-04B	13	14	pCi/g	0.62 U	0.36	1.96	0.63	0.91	0.41	0.47	1.03	1.53 *	Less than Criteria	1.96	0.51	0.06	0.05	0.24	0.11	0.00	0.05	2.20	Less than Criteria	0.33 J	0.11	0.01	0.06	0.06 J	0.05	0.00	0.05	0.22 J	0.09	0.00	0.04	0.61	Less than Criteria
AC-04B	32	33	pCi/g	1.01 U	0.16	1.12	0.23	1.16	0.19	0.12	0.26	2.17 *	Less than Criteria	4.62 J	1.03	0.06	0.06	0.92 J	0.25	0.01	0.05	5.54	Less than Criteria	0.47 J	0.14	0.01	0.05	0.00 UJ	0.02	0.00	0.05	0.45 J	0.13	0.01	0.04	0.92 *	Less than Criteria
AC-04B_FD	32	33	pCi/g	0.96 U	0.14	0.99	0.16	1.20	0.23	0.21	0.44	2.16 *	Less than Criteria	1.38 J	0.40	0.06	0.06	0.90	0.28	0.00	0.07	2.27	Less than Criteria	0.57 J	0.15	0.01	0.04	0.11 J	0.07	0.00	0.06	0.52 J	0.14	0.01	0.04	1.20	Less than Criteria
AC-05	11	12	pCi/g	1.11 U	0.16	1.17	0.19	1.27	0.23	0.16	0.34	2.38 *	Less than Criteria	3.28	0.81	0.06	0.06	1.04 J	0.30	0.01	0.06	4.32	Less than Criteria	0.80 J	0.20	0.01	0.05	0.05 J	0.05	0.00	0.06	0.85 J	0.21	0.00	0.04	1.70	Less than Criteria
AC-05	25	26	pCi/g	0.80 U	0.13	0.94	0.17	0.84	0.18	0.14	0.30	1.65 *	Less than Criteria	1.20	0.31	0.05	0.05	1.03	0.26	0.00	0.03	2.24	Less than Criteria	0.48 J	0.14	0.04	0.09	0.08 J	0.06	0.01	0.06	0.66 J	0.17	0.01	0.05	1.22	Less than Criteria
AC-06	13	16	pCi/g	1.05 U	0.14	1.28	0.24	1.21	0.21	0.17	0.35	2.26 *	Less than Criteria	0.97	0.31	0.08	0.08	1.25	0.36	0.01	0.08	2.22	Less than Criteria	0.67 J	0.17	0.01	0.04	0.03 J	0.04	0.00	0.07	0.66 J	0.17	0.00	0.04	1.37	Less than Criteria
AC-06	23	26	pCi/g	0.60 U	0.11	0.88	0.12	0.70	0.16	0.14	0.29	1.30 *	Less than Criteria	1.36 J	0.37	0.07	0.07	0.50 J	0.17	0.01	0.06	1.86	Less than Criteria	0.41 J	0.13	0.01	0.06	0.08 J	0.06	0.00	0.05	0.50 J	0.15	0.00	0.04	0.98	Less than Criteria
AC-07	22	23	pCi/g	1.20 U	0.22	1.26	0.30	1.40	0.24	0.30	0.63	2.60 *	Less than Criteria	1.45	0.38	0.05	0.05	1.23	0.32	0.00	0.05	2.68	Less than Criteria	0.83 J	0.20	0.01	0.05	0.07 J	0.05	0.00	0.05	0.80 J	0.19	0.00	0.04	1.70	Less than Criteria
AC-07	32	33	pCi/g	0.73 U	0.21	1.36	0.32	0.90	0.33	0.31	0.66	1.63 *	Less than Criteria	0.86	0.29	0.07	0.07	0.50	0.20	0.03	0.11	1.37	Less than Criteria	0.39 J	0.12	0.01	0.04	0.04 J	0.04	0.00	0.05	0.48 J	0.14	0.01	0.04	0.91	Less than Criteria
Cotter Borings																																					
WL-102A-CT	2	3	pCi/g	1.03	0.15	0.03	0.07	0.14 U	0.25	0.20	0.42	1.17 *	Less than Criteria	5.81 J+	0.42	0.01	0.02	0.83 J	0.16	0.01	0.04	6.64	Less than Criteria	0.64	0.17	0.01	0.03	0.05 J	0.06	0.02	0.07	0.58	0.16	0.01	0.03	1.27	Less than Criteria
WL-102A-CT	4	5	pCi/g	0.58 J+	0.27	0.14	0.34	0.12 UJ	0.43	0.35	0.76	0.70 *	Less than Criteria	4.43 J+	0.38	0.01	0.05	0.58	0.14	0.01	0.04	5.01	Less than Criteria	0.51	0.15	0.01	0.03	0.02 U	0.04	0.01	0.07	0.49	0.14	0.01	0.06	1.02 *	Less than Criteria
WL-102A-CT_FD	4	5	pCi/g	6.75 J+	0.58	0.11	0.26	0.05 UJ	0.24	0.19	0.42	6.80 *	Less than Criteria	1.82 J+	0.24	0.02	0.05	0.68	0.14	0.01	0.05	2.50	Less than Criteria	0.54	0.15	0.01	0.03	0.01 U	0.03	0.01	0.06	0.53	0.15	0.01	0.03	1.08 *	Less than Criteria
WL-102A-CT	22	23	pCi/g	1.41	0.19	0.03	0.08	1.11	0.32	0.19	0.42	2.52	Less than Criteria	1.75 J+	0.24	0.01	0.02	1.23	0.20	0.01	0.04	2.98	Less than Criteria	1.01	0.20	0.01	0.05	0.05 J	0.05	0.01	0.04	1.05	0.21	0.01	0.05	2.11	Less than Criteria
WL-106A-CT	4	6	pCi/g	18.0	0.61	0.03	0.07	0.77	0.29	0.19	0.40	18.8	Exceeds Criteria	401 J+	3.58	0.01	0.05	1.14	0.19	0.01	0.02	402	Exceeds Criteria	11.3 J	0.82	0.01	0.04	0.69 J	0.23	0.01	0.06	12.2 J	0.85	0.01	0.04	24.2	Less than Criteria
WL-106A-CT	10	12	pCi/g	9.64 J+	0.69	0.12	0.28	0.27 UJ	0.31	0.23	0.51	9.91 *	Exceeds Criteria	165 J+	2.60	0.02	0.07	0.83 J	0.18	0.01	0.05	166	Exceeds Criteria	3.94	0.41	0.01	0.06	0.24	0.12	0.02	0.07	4.67	0.44	0.01	0.03	8.85	Less than Criteria
WL-114-CT	7	8	pCi/g	0.98 J+	0.23	0.07	0.18	0.74	0.34	0.24	0.51	1.72	Less than Criteria	4.78 J+	0.40	0.01	0.04	0.89	0.18	0.02	0.06	5.67	Less than Criteria	0.72	0.18	0.02	0.07	0.02 U	0.04	0.01	0.06	0.78	0.18	0.01	0.06	1.52 *	Less than Criteria
WL-114-CT	32	33	pCi/g	0.46	0.10	0.03	0.08	0.51	0.25	0.17	0.37	0.97	Less than Criteria	0.64 J+	0.14	0.02	0.05	0.47	0.12	0.01	0.04	1.11	Less than Criteria	0.43	0.14	0.01	0.05	0.01 J	0.03	0.01	0.04	0.32	0.12	0.01	0.06	0.76	Less than Criteria
Cotter Samples from Core of Non-Cotter Borings																																					
01-2-CT	39	40	pCi/g	0.72 J+	0.22	0.11	0.24	0.51 UJ	0.34	0.25	0.53	1.23 *	Less than Criteria	0.86 J+	0.16	0.01	0.04	0.35	0.10	0.00	0.03	1.20	Less than Criteria	0.39	0.13	0.02	0.07	0.01 U	0.03	0.01	0.04	0.41	0.13	0.01	0.06	0.82 *	Less than Criteria
05-3-CT-A	28	30	pCi/g	33.7 J+	1.23	0.08	0.19	0.57 J	0.35	0.26	0.55	34.3	Exceeds Criteria	3,660 J+	143	1.76	7.71	7.17 U	6.99	2.48	9.12	3,667 *	Exceeds Criteria	6.10	0.54	0.03	0.09	0.34	0.14	0.01	0.07	5.51	0.51	0.02	0.08	11.9	Less than Criteria
05-3-CT-B	33	34	pCi/g	73.9 J+	1.80	0.08	0.20	0.40 U	0.30	0.22	0.47	74.3 *	Exceeds Criteria	2,310 J+	158	3.42	8.12	0.45 U	6.25	4.81	17.7	2,310 *	Exceeds Criteria	12.3	0.80	0.03	0.10	0.67	0.21	0.01	0.07	12.1	0.79	0.03	0.10	25.1	Less than Criteria

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D GCPT Soundings and Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result	Radium-226 Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result	Radium-228 Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228	Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria
1C-6-CT	25	27	pCi/g	26.7	J+	1.16	0.09	0.21	0.29	U	0.33	0.25	0.54	27.0 *	Exceeds Criteria
1D-16-CT	46	47	pCi/g	2.74	J+	0.37	0.11	0.26	0.32	U	0.28	0.21	0.46	3.06 *	Less than Criteria
1D-7-CT	83	84	pCi/g	1,200	J+	9.25	0.12	0.29	4.94	J	0.49	0.17	0.36	1,205	Exceeds Criteria
Cotter Third Phase Samples															
AC-01-CT	19	20	pCi/g	38.3		0.82	0.03	0.07	0.37	J+	0.24	0.17	0.36	38.7	Exceeds Criteria
AC-03-CT	9	10	pCi/g	141	J	1.70	0.05	0.12	0.29	J+	0.22	0.16	0.34	141	Exceeds Criteria
AC-03-CT	14	19	pCi/g	1.01		0.14	0.02	0.06	0.31	J+	0.24	0.17	0.38	1.32	Less than Criteria
AC-03-CT	36	39	pCi/g	0.44	J	0.11	0.04	0.09	0.23	J+	0.31	0.23	0.51	0.67	Less than Criteria
EPA Verification Samples															
01-2-CT_(es)	39	40	pCi/g	0.63	U	0.30		1.63	0.36	U	0.10		0.53	Non-detect	Less than Criteria
01-2-CT_(es)_SD	39	40	pCi/g	1.48	U	0.30		1.70	0.55	U	0.10		0.57	Non-detect	Less than Criteria
05-3-CT-A_(es)	28	30	pCi/g	37.2		1.84		5.75	1.18	U	0.28		1.40	38.4 *	Exceeds Criteria
05-3-CT-A_(es)_SD	28	30	pCi/g	29.1		1.65		5.80	0.76	U	0.24		1.20	29.9 *	Exceeds Criteria
05-3-CT-B_(es)	33	34	pCi/g	126		5.83		15.5	-0.29	U	0.91		4.28	126 *	Exceeds Criteria
05-3-CT-B_(es)_SD	33	34	pCi/g	79.9		3.89		12.5	1.18	U	0.49		2.38	81.1 *	Exceeds Criteria
1C-6-CT_(es)	25	27	pCi/g	40.9		2.83		9.49	1.48	U	0.50		2.60	42.4 *	Exceeds Criteria
1C-6-CT_(es)_SD	25	27	pCi/g	26.0		2.14		7.19	0.26	U	0.44		2.19	26.3 *	Exceeds Criteria
1D-07-CT_(es)	83	84	pCi/g	3,810		221		216	5.86	U	6.36		29.4	3,816 *	Exceeds Criteria
1D-07-CT_(es)_SD	83	84	pCi/g	3,560		207		208	-0.44	U	6.09		28.1	3,560 *	Exceeds Criteria
1D-16-CT_(es)	46	47	pCi/g	2.63		0.48		2.00	1.07		0.11		0.37	3.70	Less than Criteria
1D-16-CT_(es)_SD	46	47	pCi/g	2.77		0.44		2.46	1.08		0.10		0.37	3.85	Less than Criteria
WL-102A-CT_(es)	4	5	pCi/g	1.90	U	0.43		2.39	0.92		0.13		0.34	2.82 *	Less than Criteria
WL-102A-CT_(es)_FD	4	5	pCi/g	1.24	U	0.36		1.96	0.56		0.07		0.33	1.80 *	Less than Criteria
WL-102A-CT_(es)_FD_SD	4	5	pCi/g	1.73		0.31		1.72	0.61		0.07		0.28	2.34	Less than Criteria
WL-102A-CT_(es)_SD	4	5	pCi/g	1.13	U	0.28		1.19	0.48		0.06		0.22	1.61 *	Less than Criteria
WL-106A-CT_(es)	10	12	pCi/g	8.12		0.63		2.22	0.22	U	0.12		0.59	8.34 *	Exceeds Criteria
WL-106A-CT_(es)_SD	10	12	pCi/g	10.6		0.83		3.13	0.50	U	0.12		0.62	11.1 *	Exceeds Criteria
WL-114-CT_(es)	7	8	pCi/g	2.37	U	0.45		2.51	0.90		0.09		0.42	3.27 *	Less than Criteria
WL-114-CT_(es)_SD	7	8	pCi/g	2.94		0.40		2.27	0.87		0.09		0.32	3.81	Less than Criteria
EPA Split Samples															
AC-05_(es)	11	12	pCi/g	1.32		0.29	0.07	0.18	1.31		0.33	0.11	0.29	2.63	Less than Criteria
AC-05_(es)_SD	11	12	pCi/g												
AC-05_(es)	25	26	pCi/g	0.74		0.20	0.08	0.17	0.85		0.21	0.05	0.13	1.59	Less than Criteria
AC-05_(es)_SD	25	26	pCi/g												
EPA Pyrolosis Samples															
1D-07_pyr	84	85	pCi/g	3,430		178		16.0						3,430	Exceeds Criteria
AC-01_pyr	10	11	pCi/g	4,574		239		24.0						4,574	Exceeds Criteria
AC-03_pyr	5	6	pCi/g	1,801		95.0		15.0						1,801	Exceeds Criteria

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Thorium-230 Result	Thorium-230 Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result	Thorium-232 Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria
1C-6-CT	25	27	2,450	J+	95.6	1.18	2.79	2.78	U	3.21	1.17	2.78	2,453 *	Exceeds Criteria
1D-16-CT	46	47	1.84	J+	0.24	0.01	0.02	0.85		0.16	0.01	0.04	2.69	Less than Criteria
1D-7-CT	83	84	678,000	J+	15,300	109	475	847	J	538	108	256	678,847	Exceeds Criteria
Cotter Third Phase Samples														
AC-01-CT	19	20	1,350	J+	6.55	0.01	0.04	1.92		0.25	0.01	0.04	1,352	Exceeds Criteria
AC-03-CT	9	10	4,130	J+	11.5	0.01	0.02	4.02		0.36	0.01	0.04	4,134	Exceeds Criteria
AC-03-CT	14	19	2.02	J+	0.25	0.01	0.04	0.84		0.16	0.01	0.02	2.86	Less than Criteria
AC-03-CT	36	39	0.97	J+	0.18	0.02	0.06	0.37		0.11	0.01	0.04	1.33	Less than Criteria
EPA Verification Samples														
01-2-CT_(es)	39	40	1.34	J	0.19		0.21	0.87		0.15		0.17	2.21 *	Less than Criteria
01-2-CT_(es)_SD	39	40	0.00	U			0.00	3.72	J			1.96	3.72	Less than Criteria
05-3-CT-A_(es)	28	30	813		52.3		2.17	1.58	U	0.76		2.78	815 *	Less than Criteria
05-3-CT-A_(es)_SD	28	30	0.04				0.01	7.15				1.56	7.19	Less than Criteria
05-3-CT-B_(es)	33	34	2,350		148		1.79	9.11		1.60		2.24	2359.11	Exceeds Criteria
05-3-CT-B_(es)_SD	33	34	0.09				0.00	5.03				2.01	5.12	Exceeds Criteria
1C-6-CT_(es)	25	27	799		51.7		1.84	7.91		1.48		1.83	806.91	Exceeds Criteria
1C-6-CT_(es)_SD	25	27	0.03				0.00	1.96	U			1.96	1.99 *	Exceeds Criteria
1D-07-CT_(es)	83	84	45,100		2,900		88.7	208		52.0		88.4	45,308	Exceeds Criteria
1D-07-CT_(es)_SD	83	84	3.73				0.01	78.6				1.92	82	Exceeds Criteria
1D-16-CT_(es)	46	47	3.57	J	0.35		0.16	1.06		0.17		0.20	4.63 *	Less than Criteria
1D-16-CT_(es)_SD	46	47	0.00	U			0.00	8.19				1.72	8.19	Exceeds Criteria
WL-102A-CT_(es)	4	5	4.85		0.44		0.17	0.65		0.13		0.21	5.50 *	Less than Criteria
WL-102A-CT_(es)_FD	4	5	2.02	J	0.24		0.16	0.55		0.11		0.16	2.57 *	Less than Criteria
WL-102A-CT_(es)_FD_SD	4	5	0.00	U			0.00	5.72				1.63	5.72	Less than Criteria
WL-102A-CT_(es)_SD	4	5	0.00	U			0.00	5.20				1.94	10.1	Exceeds Criteria
WL-106A-CT_(es)	10	12	111		7.29		0.36	0.56		0.17		0.36	111.56	Exceeds Criteria
WL-106A-CT_(es)_SD	10	12	0.01				0.00	1.68	J			1.66	1.69	Exceeds Criteria
WL-114-CT_(es)	7	8	5.70	J	0.52		0.24	1.23		0.19		0.24	6.93 *	Less than Criteria
WL-114-CT_(es)_SD	7	8	0.00	U			0.00	6.48				2.00	6.48	Exceeds Criteria
EPA Split Samples														
AC-05_(es)	11	12	2.55		0.36	0.01	0.02	1.31		0.33	0.11	0.29	3.86	Less than Criteria
AC-05_(es)_SD	11	12						0.76		0.17	0.01	0.02	0.76	Less than Criteria
AC-05_(es)	25	26	0.93		0.19	0.01	0.04	0.85		0.21	0.05	0.13	1.79	Less than Criteria
AC-05_(es)_SD	25	26						0.92		0.19	0.01	0.02	0.92	Less than Criteria
EPA Pyrolosis Samples														
1D-07_pyr	84	85	57,400		3,490		34.5	261		37.9		34.4	57,661	Exceeds Criteria
AC-01_pyr	10	11	58,800		3,580		42.2	119		24.3		33.6	58,919	Exceeds Criteria
AC-03_pyr	5	6	38,200		2,330		33.3	60.8		17.2		33.2	38,261	Exceeds Criteria

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Uranium-234 Result	Uranium-234 Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result	Uranium-235 Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result	Uranium-238 Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238	Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
1C-6-CT	25	27	2.09		0.29	0.01	0.05	0.06	U	0.06	0.01	0.06	1.81		0.27	0.02	0.06	3.96 *	Less than Criteria
1D-16-CT	46	47	0.69		0.17	0.01	0.05	0.03	U	0.04	0.02	0.07	0.55		0.15	0.02	0.06	1.27 *	Less than Criteria
1D-7-CT	83	84	21.3		1.02	0.01	0.06	0.76		0.21	0.01	0.05	14.6		0.84	0.01	0.04	36.7	Less than Criteria
Cotter Third Phase Samples																			
AC-01-CT	19	20	3.69		0.42	0.02	0.07	0.12	J	0.08	0.01	0.04	4.12		0.44	0.01	0.04	7.93	Less than Criteria
AC-03-CT	9	10	8.10		0.59	0.01	0.06	0.31		0.13	0.01	0.06	7.45		0.57	0.01	0.03	15.9	Less than Criteria
AC-03-CT	14	19	0.64		0.18	0.02	0.07	0.03	J	0.04	0.01	0.05	0.69		0.19	0.01	0.06	1.35	Less than Criteria
AC-03-CT	36	39	0.32		0.13	0.02	0.07	0.01	J	0.03	0.01	0.07	0.30		0.13	0.02	0.08	0.63	Less than Criteria
EPA Verification Samples																			
01-2-CT_(es)	39	40	1.223	UJ				0.02093					0.4529					1.7	Less than Criteria
01-2-CT_(es)_SD	39	40																	
05-3-CT-A_(es)	28	30	6.302					0.2675					5.6277					12.2	Less than Criteria
05-3-CT-A_(es)_SD	28	30																	
05-3-CT-B_(es)	33	34	11.48					0.57138					12.52					24.6	Exceeds Criteria
05-3-CT-B_(es)_SD	33	34																	
1C-6-CT_(es)	25	27	2.377					0.10058					2.131					4.6	Less than Criteria
1C-6-CT_(es)_SD	25	27																	
1D-07-CT_(es)	83	84	209.04					9.459					202.8					421.3	Exceeds Criteria
1D-07-CT_(es)_SD	83	84																	
1D-16-CT_(es)	46	47	1.0733	U				0.03745					0.8292					1.9	Less than Criteria
1D-16-CT_(es)_SD	46	47																	
WL-102A-CT_(es)	4	5	1.2106	U				0.02675					0.5528					1.8	Less than Criteria
WL-102A-CT_(es)_FD	4	5	1.0171					0.0332					0.6660					1.7	Less than Criteria
WL-102A-CT_(es)_FD_SD	4	5																	
WL-102A-CT_(es)_SD	4	5																	
WL-106A-CT_(es)	10	12	4.5677					0.21828					4.595					9.4	Less than Criteria
WL-106A-CT_(es)_SD	10	12																	
WL-114-CT_(es)	7	8	1.248	U				0.03659					0.8059					2.1	Less than Criteria
WL-114-CT_(es)_SD	7	8																	
EPA Split Samples																			
AC-05_(es)	11	12											0.82	U	0.84	1.12	2.38	0.82	Less than Criteria
AC-05_(es)_SD	11	12											0.64		0.16	0.01	0.04	0.64	Less than Criteria
AC-05_(es)	25	26											0.93		0.57	0.79	1.67	0.93	Less than Criteria
AC-05_(es)_SD	25	26											0.57		0.15	0.01	0.04	0.57	Less than Criteria
EPA Pyrolosis Samples																			
1D-07_pyr	84	85	200.93					9.0736					193.14					403.1	Exceeds Criteria
AC-01_pyr	10	11	194.06					8.774					193.14					396.0	Exceeds Criteria
AC-03_pyr	5	6	91.104					4.3656					95.904					191.4	Exceeds Criteria

Notes:

Final Q = final qualifier CSU[1] = combined standard uncertainty (+/- sigma for McLaren/Hart samples) CV = critical value MDA = minimum detectable activity pCi/g - picocuries per gram

* Indicates that result for one of the two isotopes was non-detect

The results highlighted in yellow represent combined values greater than the unrestricted use criteria established by EPA

J = The analyte was analyzed for, and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample.

J+ = Same as J qualification but with an indication of positive bias in the sample concentration.

U = The analyte was analyzed for and is not present above the level of the associated value. The associated numerical value indicates the approximate concentration necessary to detect the analyte in the sample.

For calculating combined Ra and combined Th values, if one of the the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If both values were <MDA, combined results reported as "Non-detect".

For calculating combined U values, if one or two of the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If all three values were <MDA, combined results reported as "Non-detect".

The results highlighted in pink were "rejected based on data quality and representativeness"

The data summarized on this table are presented in Appendix D.

Table 2-4: Area 2 Combined Radium, Thorium, and Uranium Results (RI Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result	Radium-226 Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result	Radium-228 Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228		Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230 Result	Thorium-230 Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result	Thorium-232 Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232		Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234 Result	Uranium-234 Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result	Uranium-235 Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result	Uranium-238 Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238		Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
McLaren/Hart RI Data																																															
WL-207-MH	5	5	pCi/g	0.93	U			0.93	1.59	U			1.59	Non-detect	*	Non-detect	1.21		0.70		0.54	1.42		0.75		0.39	2.63		Less than Criteria	0.80		0.37		0.22	1.27	U			1.27	0.66		0.33		0.20	2.10	*	Less than Criteria
WL-207-MH	10	10	pCi/g	0.76		0.22		0.33	1.10	U			1.10	1.31	*	Less than Criteria	1.78		1.43		1.45	1.37		1.22		1.17	3.15		Less than Criteria	0.71		0.34		0.21	0.61	U			0.61	0.81		0.36		0.21	1.83	*	Less than Criteria
WL-208-MH	5	5	pCi/g	3.26		0.32		0.37	0.68		0.46		0.66	3.94		Less than Criteria	123		23.0		0.10	1.43		0.42		0.08	124		Exceeds Criteria	2.05		0.59		0.12	1.18	U			1.18	1.60		0.50		0.10	4.24	*	Less than Criteria
WL-208-MH	9	9	pCi/g	1.35		0.23		0.25	0.74	U			0.74	1.72	*	Less than Criteria	10.1		2.00		0.07	0.36		0.16		0.07	10.4		Exceeds Criteria	1.65		0.47		0.19	0.77	U			0.77	1.75		0.48		0.15	3.79	*	Less than Criteria
WL-209-MH	0	0	pCi/g	3,720		142		10.0	21.3	U			21.3	3,731	*	Exceeds Criteria	29,200		5,290		0.10	127		23.0		0.09	29,327		Exceeds Criteria	575		180		0.70	263		33.0		33.0	294		92.0		0.70	1,132		Exceeds Criteria
WL-209-MH	5	5	pCi/g	2,970		123		7.00	16.3	U			16.3	2,978	*	Exceeds Criteria	39,300		7,750		40.2	138		60.0		32.2	39,438		Exceeds Criteria	335		57.0		0.19	74.8		22.9		23.8	249		43.0		0.14	659		Exceeds Criteria
WL-209-MH_FD	5	5	pCi/g	3,140		116		5.00	16.7		9.30		11.3	3,157		Exceeds Criteria	32,680		6,420		29.0	180		65.0		20.2	32,860		Exceeds Criteria	527		87.0		0.20	62.6		25.4		13.4	287		47.0		0.15	877		Exceeds Criteria
WL-209-MH	25	25	pCi/g	0.85		0.18		0.29	0.92	U			0.92	1.31	*	Less than Criteria	26.9		5.40		0.12	0.71		0.27		0.05	27.6		Exceeds Criteria	0.46		0.22		0.23	0.84	U			0.84	0.58		0.23		0.12	1.46	*	Less than Criteria
WL-209-MH_FD	25	25	pCi/g	0.62		0.20		0.27	0.85	U			0.85	1.05	*	Less than Criteria	12.9		3.70		0.72	0.39	U	0.53		0.84	13.0	*	Exceeds Criteria	0.59		0.24		0.09	0.70	U			0.70	0.61		0.24		0.08	1.55	*	Less than Criteria
WL-210-MH	0	0	pCi/g	2,280		89.0		4.00	9.55	U			9.55	2,285	*	Exceeds Criteria	18,200		3,510		15.1	59.2		23.2		17.5	18,259		Exceeds Criteria	216		67.0		0.70	182		22.0		14.0	134		42.0		0.60	532		Exceeds Criteria
WL-210-MH	5	5	pCi/g	520		26.0		3.00	6.72	U			6.72	523	*	Exceeds Criteria	12,400		2,140		0.14	106		19.0		0.06	12,506		Exceeds Criteria	145		25.0		0.18	10.1	U			10.1	65.5		11.2		0.12	216	*	Exceeds Criteria
WL-210-MH_FD	5	5	pCi/g	458		20.0		2.00	4.66	U			4.66	460	*	Exceeds Criteria	15,610		2,700		0.11	120		21.0		0.06	15,730		Exceeds Criteria	267		46.0		0.17	27.2		11.9		5.40	128		22.0		0.14	422		Exceeds Criteria
WL-210-MH	40	40	pCi/g	0.68		0.18		0.31	0.83	U			0.83	1.10	*	Less than Criteria	4.27		1.08		0.14	0.77		0.31		0.10	5.0		Less than Criteria	0.69		0.26		0.12	0.78	U			0.78	0.91		0.31		0.11	1.99	*	Less than Criteria
WL-210-MH_FD	40	40	pCi/g	1.66		0.40		0.59	1.45	U			1.45	2.39	*	Less than Criteria	10.8		2.20		0.10	0.82		0.28		0.07	11.6		Exceeds Criteria	0.93		0.32		0.11	1.50	U			1.50	0.54		0.23		0.09	2.22	*	Less than Criteria
WL-211-MH	5	5	pCi/g	8.52		0.58		0.33	1.15	U			1.15	9.10	*	Exceeds Criteria	66.1		11.8		0.15	1.38		0.35		0.08	67.5		Exceeds Criteria	2.30		0.58		0.10	0.75	U			0.75	2.61		0.64		0.11	5.29	*	Less than Criteria
WL-211-MH	25	25	pCi/g	0.42		0.19		0.31	0.85	U			0.85	0.85	*	Less than Criteria	4.97		1.04		0.16	0.32		0.16		0.08	5.29		Less than Criteria	0.68		0.28		0.26	0.79	U			0.79	0.66		0.27		0.26	1.74	*	Less than Criteria
WL-212-MH	5	5	pCi/g	1.26		0.40		0.46	1.16	U			1.16	1.84	*	Less than Criteria	5.72		1.20		0.10	0.29		0.14		0.08	6.01		Less than Criteria	1.57		0.46		0.17	1.15	U			1.15	1.66		0.47		0.12	3.81	*	Less than Criteria
WL-212-MH	10	10	pCi/g	1.77		0.24		0.28	0.90	U			0.90	2.22	*	Less than Criteria	28.3		6.2		0.20	1.85		0.58		0.10	30		Exceeds Criteria	1.86		0.53		0.14	0.56	U			0.56	1.77		0.51		0.12	3.91	*	Less than Criteria
WL-213-MH	0	0	pCi/g	1.00		0.26		0.37	0.90	U			0.90	1.45	*	Less than Criteria	20.7		4.20		0.13	0.97		0.34		0.12	21.7		Exceeds Criteria	1.64		0.58		0.45	0.88	U			0.88	1.53		0.55		0.42	3.61	*	Less than Criteria
WL-213-MH	5	5	pCi/g	1.26		0.23		0.27	0.92	U			0.92	1.72	*	Less than Criteria	17.3		3.40		0.16	0.89		0.30		0.15	18.2		Exceeds Criteria	1.00		0.38		0.19	0.83	U			0.83	1.53		0.49		0.13	2.95	*	Less than Criteria
WL-213-MH	25	25	pCi/g	0.93		0.33		0.52	1.49	U			1.49	1.68	*	Less than Criteria	3.13		0.75		0.05	0.52		0.21		0.07	3.65		Less than Criteria	1.06		0.36		0.14	1.35	U			1.35	0.45		0.22		0.13	2.19	*	Less than Criteria
WL-214-MH	5	5	pCi/g	0.95		0.18		0.22	0.81	U			0.81	1.36	*	Less than Criteria	21.6		5.40		0.41	6.32		1.78		0.25	27.9		Exceeds Criteria	1.09		0.36		0.12	0.52	U			0.52	0.81		0.30		0.09	2.16	*	Less than Criteria
WL-214-MH	25	25	pCi/g	0.52	U			0.52	0.89	U			0.89	Non-detect	*	Non-detect	12.8		2.50		0.18	0.36		0.19		0.12	13.2		Exceeds Criteria	0.97		0.35		0.11	0.89	U			0.89	0.67		0.28		0.12	2.09	*	Less than Criteria
WL-215-MH	0	0	pCi/g	0.70		0.20		0.29	0.73	U			0.73	1.07	*	Less than Criteria	5.35		1.14		0.07	0.31		0.15		0.07	5.66		Less than Criteria	1.86		0.76		0.48	0.78	U			0.78	1.53		0.68		0.45	3.78	*	Less than Criteria
WL-216-MH	5	5	pCi/g	88.4		5.20		0.90	2.21	U			2.21	89.5	*	Exceeds Criteria	1,130		161		0.93	3.05		1.45		0.81	1,133		Exceeds Criteria	12.5		4.00		1.90	3.07	U			3.07	11.4		3.80		2.20	25.4	*	Less than Criteria
WL-216-MH	25	25	pCi/g	1.03		0.21		0.39	1.62		0.44		0.54	2.65		Less than Criteria	1.46		0.46		0.17	1.17		0.39		0.10	2.63		Less than Criteria	0.81		0.29		0.09	0.61	U			0.61	0.97		0.32		0.09	2.09	*	Less than Criteria
WL-217-MH	5	5	pCi/g	0.60		0.21		0.31	0.81	U			0.81	1.01	*	Less than Criteria	0.96		0.30		0.13	0.00		0.01		0.09	0.96	*	Less than Criteria	0.45		0.20		0.08	0.53	U			0.53	0.51		0.21		0.08	1.23	*	Less than Criteria
WL-217-MH	10	10	pCi/g	1.27		0.24		0.29	1.04	U			1.04	1.79	*	Less than Criteria	8.95		1.90		0.12	0.72		0.31		0.11	9.67		Exceeds Criteria	1.03		0.33		0.17	0.60	U			0.60	0.96		0.31		0.12	2.29	*	Less than Criteria
WL-218-MH	0	0	pCi/g	1.06		0.19		0.24	0.82		0.38		0.66	1.88		Less than Criteria	1.77		0.57		0.14	0.77		0.32		0.07	2.54		Less than Criteria	1.53		0.59		0.24	0.58	U			0.58	1.12		0.48		0.16	2.94	*	Less than Criteria
WL-218-MH	5	5	pCi/g	0.85		0.20		0.41	1.01		0.48		0.70	1.86		Less than Criteria	1.19		0.43		0.14	0.67		0.30		0.12	1.86		Less than Criteria	0.73		0.28		0.12	0.84	U			0.84	0.81		0.30		0.12	1.96	*	Less than Criteria
WL-218-MH	40	40	pCi/g	0.68		0.23		0.43	1.16	U			1.16	1.26	*	Less than Criteria	2.09		0.73		0.15	0.39		0.26		0.15	2.48		Less than Criteria	0.84		0.32		0.12	0.73	U			0.73	0.53		0.24		0.11	1.74	*	Less than Criteria
WL-219-MH	5	5	pCi/g	1.12		0.26		0.33	1.17		0.59		0.77	2.29		Less than Criteria	1.07		0.40		0.15	1.12		0.42		0.14	2.19		Less than Criteria	0.91		0.31		0.09	0.80	U			0.80	1.09		0.35		0.09	2.40	*	Less than Criteria
WL-219-MH	10	10	pCi/g	0.62		0.22		0.41	1.04	U			1.04	1.14	*	Less than Criteria	0.64		0.25		0.08	0.44		0.20		0.07	1.08		Less than Criteria	1.16		0.56		0.39	0.62	U			0.62	0.60		0.38		0.33	2.07	*	Less than Criteria
WL-220-MH	5	5	pCi/g	0.81		0.23		0.36	1.22	U			1.22	1.42	*	Less than Criteria	1.53		0.46		0.11	0.69		0.27		0.10	2.22		Less than Criteria	1.16		0.36		0.09	0.79	U			0.79	1.00		0.33		0.09	2.56	*	Less than Criteria
WL-220-MH	25	25	pCi/g	0.78		0.24		0.38	1.25		0.38		0.56	2.03		Less than Criteria	0.56		0.27		0.11	0.22		0.16		0.10	0.78		Less than Criteria	0.89		0.33		0.12	0.67	U			0.67	0.95		0.34		0.13	2.18	*	Less than Criteria
WL-221-MH	5	5	pCi/g	0.75		0.20		0.34	1.12	U			1.12	1.31	*	Less than Criteria	4.28		0.94		0.24	0.70		0.28		0.24	4.98		Less than Criteria	1.12		0.38		0.13	0.64	U			0.64	0.82		0.31		0.13	2.26	*	Less than Criteria
WL-221-MH	35	35	pCi/g	0.33	U			0.33	1.09	U			1.09	Non-detect	*	Non-detect	1.24		0.41		0.16	0.63		0.27		0.14	1.87		Less than Criteria	0.52		0.21		0.10	0.79	U			0.79	0.50		0.21		0.11	1.42	*	Less than Criteria
WL-222-MH	0	0	pCi/g	2.94		0.59		0.53	1.75	U			1.75	3.82	*	Less than Criteria	131		25.0		0.19	1.31		0.40		0.20	132		Exceeds Criteria	2.26		0.79		0.25	1.99	U			1.99	3.36		1.04		0.42	6.62	*	Less than Criteria
WL-222-MH	5	5	pCi/g	1.80		0.26		0.29	0.83		0.44		0.70	2.63		Less than Criteria	81.4		15.4		0.76	1.30		0.38		0.17	82.7		Exceeds Criteria	1.46		0.43		0.13	0.64	U			0.64	1.21		0.38		0.09	2.99	*	Less than Criteria
WL-222-MH	30	30	pCi/g	0.82		0.39		0.60	1.27	U			1.27	1.46	*	Less than Criteria	0.88		0.32		0.21	1.00		0.34		0.15	1.88		Less than Criteria	0.51		0.26		0.12	1.22	U			1.22	0.40		0.23		0.12	1.52	*	Less than Criteria
WL-223-MH	5	5	pCi/g	1.73		0.27		0.30	1.14	U			1.14	2.30	*	Less than Criteria	9.16		1.97		0.12	0.64		0.30		0.12	9.80		Exceeds Criteria	1.44		0.41		0.11	0.75	U			0.75	1.22		0.36		0.10	3.04	*	Less than Criteria
WL-223-MH	22	22	pCi/g	0.52		0.19		0.33	0.88	U			0.88	0.96	*	Less than Criteria	0.68		0.28		0.12	0.18		0.13		0.10	0.86		Less than Criteria	2.37		0.62		0.14	0.60	U			0.60	1.93		0.54		0.15	4.60	*	Less than Criteria
WL-224-MH	5	5	pCi/g	0.84		0.21		0.28	1.23		0.47		0.67	2.07		Less than Criteria	2.85		1.31		1.15	0.35	U	0.49		0.91	3.03	*	Less than Criteria	0.75		0.50		0.68	0.71	U			0.71	0.63		0.41		0.40	1.74	*	Less than Criteria
WL-224-MH	35	35	pCi/g	1.00		0.22		0.37	1.19		0.41		0.90	2.19		Less than Criteria	4.08		1.71		0.84	0.28	U	0.42		0.62	4.22	*	Less than Criteria	1.13		0.96		0.80	0.69	U			0.69	0.77		0.78		0.52	2.25	*	Less than Criteria
WL-225-MH	5	5	pCi/g	1.07		0.27		0.40	1.18	U			1.18	1.66	*	Less than Criteria	1.43		0.46		0.27	0.97		0.35		0.17	2.40		Less than Criteria	3.17		1.69		1.22	0.75	U			0.75	1.29		1.04		1.01	4.84	*	Less than Criteria
WL-225-MH	35	35	pCi/g	0.51	U			0.51	1.50	U			1.50	Non-detect	*	Non-detect	0.91		0.91		0.23	0.33		0.17		0.16	1.24		Less than Criteria	0.72		0.42		0.40	0.93	U			0.93	0.16	U	0.36		0.77	1.27	*	Less than Criteria
WL-226-MH	10	10	pCi/g	1.40		0.27		0.34	0.95		0.46		0.82	2.35		Less than Criteria	14.1		4.00		1.10	0.32	U	0.51		0.85	14.3	*	Exceeds Criteria	1.38		0.62		0.52	0.80	U			0.80	1.63		0.65		0.29	3.41	*	Less than Criteria
WL-226-MH	20	20	pCi/g	3.26		0.44		0.40	1.12	U			1.12	3.82	*	Less than Criteria	149		29.0		0.15	1.25	U	0.39		0.11	150	*	Exceeds Criteria	6.02		2.20		1.31	0.87	U			0.87	6.32		2.24		0.91	12.8	*	Less than Criteria
WL-227-MH	5	5	pCi/g	1.32		0.22		0.29	1.35		0.43		0.73	2.67		Less than Criteria	27.4		5.40		0.08	2.40	U	0.61		0.07	28.6	*	Exceeds Criteria	1.68		0.67		0.57	0.66	U			0.66	2.01		0.71		0.32	4.02	*	Less than Criteria
WL-227-MH	40	40	pCi/g	0.43		0.18		0.24	0.79	U			0.79	0.83	*	Less than Criteria	2.78		1.32		0.94	0.51	U	0.53		0.55	3.04	*	Less than Criteria	0.66		0.43		0.55	0.54	U			0.54	0.27	U	0.30		0.53	1.07	*	Less than Criteria
WL-228-MH	5	5	pCi/g	0.79		0.20		0.30	1.29		0.41		0.62	2.08		Less than Criteria	2.72		1.45		1.05	0.13	U	0.34		0.79	2.79	*	Less than Criteria	1.50		1.09		1.37	0.51	U			0.51	1.84		1.19		1.30	3.60	*	Less than Criteria
WL-228-MH	15	15	pCi/g	0.64		0.25		0.37	1.12	U			1.12	1.20	*	Less than Criteria	2.13		0.76		0.46	0.62		0.39		0.37	2.75		Less than Criteria	0.60	U	0.46		0.74	0.75	U			0.75	0.26	U	0.39		0.78	Non-detect	*	Non-detect
WL-229-MH	5	5	pCi/g	1.15		0.28		0.70	1.24	U			1.24	1.77	*	Less than Criteria	4.97		1.89		0.97	1.47		0.97		0.89	6.44		Less than Criteria	0.82		0.47		0.52	0.64	U			0.64	1.45		0.60		0.39	2.59	*	Less than Criteria
WL-229-MH	20	20	pCi/g	0.38		0.19		0.34	0.96	U			0.96	0.86	*	Less than Criteria	1.17		0.89		1.02	0.55	U	0.58		0.69	1.45	*	Less than Criteria	0.79		0.46		0.56	0.64	U			0.64	0.54		0.36		0.39	1.65	*	Less than Criteria
WL-230-MH	5	5	pCi/g	1.67		0.26		0.34	1.16	U			1.16	2.25	*	Less than Criteria	56.9		11.30		0.22	1.21	U	0.40		0.22	57.5	*	Exceeds Criteria	2.23		0.81		0.49	0.63	U			0.63	0.92		0.48		0.16	3.47	*	Less than Criteria
WL-230-MH	35	35	pCi/g	0.53		0.22		0.36	0.89	U			0.89	0.98	*	Less than Criteria	1.33		0.98		1.25	0.10	U	0.29		0.75	1.38	*	Less than Criteria	1.75		1.18		1.18	0.69	U			0.69	2.05		1.23		0.46	4.15	*	Less than Criteria
WL-231-MH	0	0	pCi/g	0.91		0.22		0.29	0.92	U			0.92	1.37	*	Less than Criteria	1.21		0.39		0.20	0.08	U	0.10		0.19	1.25	*	Less than Criteria	3.18		1.06		0.32	0.85	U			0.85	2.04		0.79		0.26	5.65	*	Less than Criteria
WL-231-MH	5	5	pCi/g	4.06		0.37		0.28	1.02	U			1.02	4.57	*	Less than Criteria	41.8		8.3		0.27	0.61		0.26		0.26	42.4		Exceeds Criteria	6.97		2.76		2.14	0.73	U			0.73	3.86		2.03		2.18	11.2	*	Less than Criteria
WL-231-MH	10	10	pCi/g	1.37		0.24		0.40	0.75	U			0.75	1.75	*	Less than Criteria	10.2		3.00		1.40	0.06	U	0.28		0.87	10.2	*	Exceeds Criteria	2.29		0.82		0.53	0.79	U			0.79	2.01		0.74		0.15	4.70	*	Less than Criteria
WL-233-MH	27	27	pCi/g	4.44		0.46		0.38	1.11	U			1.11	5.00	*	Less than criteria	427		80.0		0.70	1.19		0.83		0.56	428		Exceeds Criteria	4.58		2.18		1.64	1.02	U			1.02	4.48		2.17		1.80	9.57	*	Less than Criteria
WL-233-MH	30	30	pCi/g	0.79		0.20		0.41	1.05	U			1.05	1.32	*	Less than Criteria	9.93		2.72		0.90	0.82		0.64		0.49	10.8		Exceeds Criteria	2.60		1.76		2.34	0.64	U			0.64	1.99		1.49		1.93	4.91	*	Less than Criteria
WL-234-MH	10	10	pCi/g	3,060		116		4.00	14.5		7.90		10.3	3,075		Exceeds Criteria	13,000		2,370		8.59	29.9		13.2		5.77	13,015	*	Exceeds Criteria	128		39.0		5.00	774		150		12.0	138		42.0		5.00	1,040		Exceeds Criteria
WL-234-MH_FD	10	10	pCi/g	1,260		49.0		3.00	6.62	U			6.62	1,263	*	Exceeds Criteria	1,200		3,670		116	58.1	U	84.6		98.7	1,229	*	Exceeds Criteria	45.4		9.70		0.50	97.6		11.2		7.90	60.7		12.4		1.10	204		Exceeds Criteria
WL-234-MH	20	20	pCi/g	0.66	U			0.66	1.25	U			1.25	Non-detect	*	Non-detect	16.2		3.20		0.04	0.67		0.23		0.07	16.9		Exceeds Criteria	0.94		0.45		0.37	0.86	U			0.86	0.98		0.44		0.28	2.35	*	Less than Criteria
WL-234-MH_FD	20	20	pCi/g	1.18		0.26		0.39	1.23	U			1.23	1.80	*	Less than Criteria	11.3		2.20		0.50	0.85		0.43		0.38	12.2		Exceeds Criteria	1.64		1.29		0.99	0.85	U			0.85	2.11		1.47		0.99	4.18	*	Less than Criteria
WL-235-MH	0	0	pCi/g	0.90		0.21		0.32	1.19		0.45		0.56	2.09		Less than Criteria	12.4		2.48		0.13	1.03		0.31		0.10	13.4		Exceeds Criteria	0.97		0.45		0.31	0.56	U			0.56	0.77		0.40		0.37	2.02	*	Less than Criteria
WL-235-MH	5	5	pCi/g	0.74		0.46		0.56	1.58	U			1.58	1.53	*	Less than Criteria	3.21		1.45		1.16	0.18	U	0.38		0.83	3.30	*	Less than Criteria	1.47		0.66		0.61	1.63	U			1.63	0.91		0.50		0.50	3.20	*	Less than Criteria
WL-235-MH	30	30	pCi/g	1.09		0.25		0.43	0.93	U			0.93	1.56	*	Less than Criteria	3.15		1.43		1.00	0.01	U	0.28		0.94	3.16	*	Less than Criteria	1.25		0.53		0.41	0.84	U			0.84	1.31		0.53		0.24	2.98	*	Less than Criteria
WL-236-MH	5	5	pCi/g	1.03		0.23		0.34	1.00	U			1.00	1.53	*	Less than Criteria	5.92		1.49		0.97	0.62	U	0.46		0.69	6.23	*	Less than Criteria	1.43		1.22		1.41	0.72	U			0.72	1.56		1.21		0.60	3.35	*	Less than Criteria
WL-236-MH	35	35	pCi/g	1.01		0.24		0.35	1.23	U			1.23	1.63	*	Less than Criteria	4.90		1.33		1.01	0.90	U	0.63		1.02	5.35	*	Less than Criteria	2.37		1.43		0.54	0.69	U			0.69	1.95		1.29		0.82	4.67	*	Less than Criteria
WL-239-MH	5	5	pCi/g	0.96		0.11		0.10	1.13		0.19		0.17	2.09		Less than Criteria	0.50		0.20		0.12	0.26		0.13		0.07	0.76		Less than Criteria	1.24		0.46		0.19	0.35	U			0.35	1.22		0.45		0.14	2.64	*	Less than Criteria
WL-239-MH	25	25	pCi/g	0.90		0.08		0.06	0.72		0.13		0.12	1.62		Less than Criteria	0.58		0.26		0.25	0.31		0.17		0.14	0.89		Less than Criteria	0.83		0.46		0.46	0.25	U			0.25	0.48		0.36		0.47	1.44	*	Less than Criteria
WL-241-MH	5	5	pCi/g	12.9		0.54		0.10	0.24	U			0.24	13.0	*	Exceeds Criteria	343		66.0		0.11	3.84		0.90		0.05	347		Exceeds Criteria	4.51		1.20		0.15	0.38	U			0.38	3.90		1.07		0.18	8.60	*	Less than Criteria
WL-241-MH	15	15	pCi/g	1.04		0.09		0.07	0.96		0.16		0.16	2.00		Less than Criteria	0.57		0.21		0.13	0.18		0.11		0.08	0.75		Less than Criteria	0.59		0.29		0.20	0.23	U			0.23	0.64		0.30		0.13	1.35	*	Less than Criteria
WL-242-MH	0	0	pCi/g	1.57		0.26		0.51	0.77	U			0.77	1.96	*	Less than Criteria	8.63		2.62		0.76	0.00	U	0.00		0.34	8.63	*	Exceeds Criteria	1.83		0.50		0.17						1.63		0.46		0.13	3.46		Less than Criteria
WL-242-MH	2	2	pCi/g	2.42		0.45		0.59	1.57	U			1.57	3.21	*	Less than Criteria	21.3		5.30		1.11	0.52	U	0.58		0.75	21.6	*	Exceeds Criteria	1.35		0.43		0.10						0.75		0.30		0.10	2.10		Less than Criteria
WL-243-MH	0	0	pCi/g	4.78		0.44		0.33	1.13		0.54		0.84	5.91		Less than criteria	265		50.0		0.22	6.73		1.36		0.15	272		Exceeds Criteria	3.99		0.98		0.24						3.63		0.91		0.18	7.62		Less than Criteria
WL-244-MH	0	0	pCi/g	1.54		0.22		0.33	1.05	U			1.05	2.07	*	Less than Criteria	20.8		4.10		0.71	0.78		0.68		0.65	21.6		Exceeds Criteria	0.88		0.30		0.12						1.35		0.40		0.09	2.23		Less than Criteria
WL-245-MH	0	0	pCi/g	0.95		0.26		0.34	1.20	U			1.20	1.55	*	Less than Criteria	3.92		0.93		0.16	0.38		0.20		0.11	4.30		Less than Criteria	0.93		0.32		0.23						0.71		0.27		0.18	1.64		Less than Criteria
WL-246-MH	0	0	pCi/g	1.04		0.26		0.37	1.07	U			1.07	1.58	*	Less than Criteria	2.91		0.82		0.30	0.63		0.31		0.15	3.54		Less than Criteria	0.94		0.32		0.14						0.73		0.28		0.18	1.67		Less than Criteria
A2 Additional Borings (and Cotter samples from A2 Additional Borings)																																															
AC-08	24	26	pCi/g	1.21	U	0.30	2.79	0.34	1.32		0.34	0.22	0.49	2.52	*	Less than Criteria	2.17	J+	0.54	0.06	0.07	0.75	J+	0.23	0.01	0.06	2.93		Less than Criteria	0.69		0.19	0.02	0.05	0.19	J	0.10	0.00	0.06	0.70		0.19	0.01	0.05	1.58		Less than Criteria
AC-08	35	36	pCi/g	0.70	U	0.13	0.92	0.16	0.43		0.13	0.10	0.22	1.14	*	Less than Criteria	0.71	J+	0.26	0.07	0.08	0.35	J+	0.16	0.02	0.09	1.07		Less than Criteria	0.51		0.16	0.03	0.07	0.12	J	0.08	0.01	0.08	0.53		0.17	0.03	0.08	1.15		Less than Criteria
AC-09	25	28	pCi/g	0.90	U	0.18	1.12	0.26	0.97		0.22	0.17	0.36	1.86	*	Less than Criteria	0.37	J	0.15	0.06	0.07	0.13	J	0.09	0.03	0.09	0.50		Less than Criteria	0.21	J	0.10	0.02	0.06	0.02	J	0.03	0.00	0.05	0.24	J	0.10	0.01	0.05	0.47		Less than Criteria

Table 2-4: Area 2 Combined Radium, Thorium, and Uranium Results (RI Borings, Additional Characterization Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result	Radium-226 Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result	Radium-228 Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228		Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230 Result	Thorium-230 Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result	Thorium-232 Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232		Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234 Result	Uranium-234 Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result	Uranium-235 Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result	Uranium-238 Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238		Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
AC-09_FD	25	28	pCi/g	0.73	U	0.19	1.42	0.34	0.80		0.23	0.19	0.42	1.53	*	Less than Criteria	0.41	J	0.14	0.04	0.04	0.23		0.10	0.00	0.04	0.64		Less than Criteria	0.20	J	0.09	0.03	0.06	0.03	J	0.04	0.01	0.06	0.16	J	0.08	0.01	0.06	0.39		Less than Criteria
AC-09	32	33	pCi/g	1.02	U	0.31	2.01	0.17	0.70	J	0.49	0.42	0.90	1.72	*	Less than Criteria	0.85		0.25	0.04	0.05	0.85		0.24	0.01	0.06	1.70		Less than Criteria	0.67	J	0.16	0.02	0.05	0.07	J	0.05	0.00	0.04	0.64	J	0.16	0.01	0.05	1.38		Less than Criteria
AC-10	12	13	pCi/g	1.66		0.22	1.17	0.23	0.48		0.21	0.17	0.37	2.15		Less than Criteria	12.2	J+	3.02	0.10	0.12	0.37	J+	0.17	0.05	0.13	12.6		Exceeds Criteria	1.28		0.30	0.05	0.10	0.18	J	0.11	0.01	0.09	1.55	J+	0.34	0.01	0.05	3.01		Less than Criteria
AC-10	26	28	pCi/g	0.77	U	0.14	1.09	0.18	0.66		0.16	0.10	0.22	1.44	*	Less than Criteria	0.62	J+	0.19	0.05	0.05	0.41	J+	0.14	0.01	0.05	1.03		Less than Criteria	0.52	J	0.24	0.05	0.12	0.05	J	0.08	0.01	0.14	0.77	J+	0.30	0.01	0.14	1.34		Less than Criteria
AC-11	8	9	pCi/g	0.57	U	0.23	1.89	0.44	0.13	U	0.35	0.27	0.61	Non-detect	*	Non-detect	0.29	J	0.12	0.05	0.05	0.14	J	0.08	0.01	0.05	0.42		Less than Criteria	0.33	J+	0.11	0.01	0.05	0.03	J	0.03	0.00	0.04	0.16	J	0.07	0.00	0.05	0.52		Less than Criteria
AC-11	17	19	pCi/g	0.95	U	0.18	1.22	0.24	0.72		0.23	0.22	0.47	1.67	*	Less than Criteria	0.49	J	0.16	0.06	0.07	0.30	J	0.12	0.03	0.08	0.79		Less than Criteria	0.48	J+	0.14	0.02	0.05	0.05	J	0.05	0.01	0.06	0.41	J	0.13	0.00	0.04	0.94		Less than Criteria
AC-12	2	4	pCi/g	2.85		0.28	1.19	0.19	0.36		0.16	0.17	0.35	3.21		Less than Criteria	44.0	J	10.9	0.09	0.10	0.41	J	0.19	0.01	0.09	44.4		Exceeds Criteria	1.04	J+	0.24	0.05	0.09	0.04	J	0.04	0.01	0.06	0.87	J	0.21	0.01	0.04	1.95		Less than Criteria
AC-12	10	11	pCi/g	0.88	U	0.15	0.93	0.17	0.58		0.17	0.17	0.35	1.46	*	Less than Criteria	4.44	J	0.96	0.06	0.07	0.23	J	0.10	0.01	0.06	4.68		Less than Criteria	0.51	J+	0.16	0.02	0.06	0.01	J	0.02	0.00	0.05	0.48		0.15	0.01	0.05	1.00		Less than Criteria
AC-13	20	22	pCi/g	8.46		0.90	3.78	0.78	0.33	U	0.54	0.42	0.91	8.78	*	Exceeds Criteria	104	J+	20.7	0.04	0.05	0.66	J+	0.18	0.00	0.04	105		Exceeds Criteria	1.97		0.33	0.02	0.04	0.33		0.11	0.00	0.04	1.80		0.31	0.00	0.03	4.10		Less than Criteria
AC-13	31	33	pCi/g	0.68	U	0.37	2.02	0.56	-0.03	U	0.17	0.44	0.98	Non-detect	*	Non-detect	2.01	J+	0.46	0.05	0.05	0.21	J+	0.09	0.02	0.06	2.21		Less than Criteria	0.29		0.11	0.03	0.06	0.10	J	0.07	0.00	0.06	0.31		0.11	0.00	0.04	0.69		Less than Criteria
AC-14	13	14	pCi/g	0.71	U	0.32	3.18	0.81	0.05	U	0.58	0.43	0.96	Non-detect	*	Non-detect	2.99	J	1.26	0.48	0.60	2.57	J	1.12	0.03	0.42	5.56		Less than Criteria	0.33	J+	0.12	0.02	0.05	0.07	J	0.06	0.00	0.05	0.21		0.10	0.02	0.07	0.61		Less than Criteria
AC-14	25	26	pCi/g	0.28	U	0.08	0.77	0.17	0.55		0.13	0.09	0.20	0.84	*	Less than Criteria	0.48	J	0.17	0.05	0.05	0.40	J	0.15	0.01	0.05	0.89		Less than Criteria	0.43	J+	0.13	0.02	0.05	0.05	J	0.05	0.01	0.06	0.37	J	0.12	0.00	0.05	0.85		Less than Criteria
AC-15	26	27	pCi/g	0.66	U	0.18	1.53	0.32	0.62		0.27	0.21	0.45	1.28	*	Less than Criteria	0.18		0.08	0.04	0.04	0.09	J	0.06	0.00	0.04	0.27		Less than Criteria	0.38	J+	0.12	0.03	0.06	0.05	J	0.04	0.00	0.05	0.25		0.09	0.01	0.04	0.67		Less than Criteria
AC-15	32	34	pCi/g	0.56	U	0.18	1.05	0.27	0.35	J	0.29	0.25	0.55	0.91	*	Less than Criteria	1.45	J	0.39	0.06	0.06	0.34	J	0.14	0.01	0.06	1.79		Less than Criteria	0.30	J+	0.11	0.03	0.06	0.11	J	0.07	0.00	0.04	0.28	J	0.10	0.02	0.07	0.69		Less than Criteria
AC-15_FD	32	34	pCi/g	0.31	U	0.12	0.59	0.20	0.33	J	0.16	0.15	0.32	0.64	*	Less than Criteria	0.44	J	0.16	0.06	0.06	0.50	J	0.17	0.01	0.07	0.94		Less than Criteria	0.47	J+	0.14	0.03	0.06	0.05	J	0.05	0.00	0.05	0.41	J	0.13	0.01	0.04	0.93		Less than Criteria
AC-16	19	20	pCi/g	554		39.5	21.0	4.76	13.8		2.52	2.57	5.18	568		Exceeds Criteria	8,710		1,811	6.24	7.84	43.7		17.3	2.12	9.28	8,753		Exceeds Criteria	310	J+	53.7	5.24	9.90	29.7	J	13.4	0.93	7.87	266	J	47.9	4.22	10.4	606		Exceeds Criteria
AC-16	22	23	pCi/g	358		23.8	13.0	1.71	8.01		1.40	1.35	2.71	366		Exceeds Criteria	5,166	J	1,048	6.76	6.74	30.5	J	14.0	2.94	10.2	5,197		Exceeds Criteria	294	J+	55.6	2.73	5.90	14.8	J	10.5	0.93	9.16	248	J	49.0	0.73	5.88	557		Exceeds Criteria
AC-16_FD	22	23	pCi/g	317		24.7	25.0	4.34	10.6		3.50	4.32	8.28	327		Exceeds Criteria	12,250	J	2,514	7.27	7.52	68.7	J	22.9	1.93	9.12	12,319		Exceeds Criteria	442	J+	72.6	3.06	7.06	24.7	J	12.9	0.18	9.26	432	J	71.2	1.07	6.54	899		Exceeds Criteria
AC-16	29	30	pCi/g	1.17		0.19	1.16	0.26	0.97		0.21	0.17	0.35	2.14		Less than Criteria	15.9	J	3.84	0.08	0.08	1.07	J	0.34	0.02	0.09	17.0		Exceeds Criteria	0.92	J+	0.21	0.02	0.05	0.10	J	0.07	0.00	0.05	0.76	J	0.19	0.00	0.04	1.77		Less than Criteria
AC-17	8	10	pCi/g	0.83		0.14	0.82	0.08	0.32	J	0.20	0.17	0.38	1.16		Less than Criteria	1.61	J	0.56	0.11	0.11	0.30	J	0.17	0.01	0.10	1.91		Less than Criteria	0.88	J+	0.25	0.03	0.06	0.05	J	0.07	0.00	0.10	0.74		0.23	0.01	0.06	1.68		Less than Criteria
AC-17	32	33	pCi/g	0.39	U	0.18	1.30	0.34	0.39	J	0.27	0.25	0.55	0.78	*	Less than Criteria	0.45	J+	0.16	0.07	0.08	0.14	J+	0.08	0.04	0.09	0.59		Less than Criteria	0.27		0.12	0.03	0.07	0.10	J	0.08	0.02	0.09	0.29		0.12	0.02	0.08	0.67		Less than Criteria
AC-17	2	5	pCi/g	206	J	14.0	12.5	2.17	8.16		1.44	1.50	3.03	215		Exceeds Criteria	1,752	J+	368	7.27	7.73	23.0	J+	11.5	0.34	5.38	1,775		Exceeds Criteria	116	J	30.1	3.38	7.82	25.4	J	13.9	0.48	7.68	112	J	29.5	1.02	7.10	253		Exceeds Criteria
AC-18_FD	2	5	pCi/g	333	J	22.2	17.3	1.66	9.19		1.62	1.30	2.62	343		Exceeds Criteria	2,167	J+	449	6.70	6.65	31.2	J+	13.7	0.55	6.05	2,199		Exceeds Criteria	180	J	42.1	2.93	9.99	32.5	J	16.7	0.53	8.58	208	J	46.3	1.99	9.94	420		Exceeds Criteria
AC-18	10	11	pCi/g	184		14.8	19.1	2.97	6.53		2.39	2.06	4.17	190		Exceeds Criteria	3,414	J+	743	7.25	7.18	22.5	J+	12.6	3.62	11.5	3,436		Exceeds Criteria	133		30.9	3.29	7.55	16.6	J	10.4	0.62	7.43	154		34.0	0.65	5.24	303		Exceeds Criteria
AC-19	5	6	pCi/g	1,005		66.3	19.3	2.47	8.07		1.99	1.70	3.41	1,013		Exceeds Criteria	976	J+	201	5.63	5.29	9.76	J+	6.73	0.29	4.61	986		Exceeds Criteria	74.8		23.1	3.80	8.76	4.49	J	6.25	0.96	9.47	75.0	J+	23.0	1.25	7.65	154		Exceeds Criteria
AC-19	36	37	pCi/g	1.20		0.18	1.13	0.24	1.17		0.21	0.19	0.41	2.37		Less than Criteria	1.39	J+	0.38	0.06	0.06	1.07	J+	0.30	0.01	0.05	2.46		Less than Criteria	0.77		0.21	0.02	0.06	0.12	J	0.08	0.00	0.05	0.76		0.20	0.01	0.05	1.64		Less than Criteria
AC-20	23	24	pCi/g	580		38.5	18.2	3.74	8.43		1.74	2.00	4.02	588		Exceeds Criteria	6,737	J+	1,397	7.63	8.09	40.4	J+	16.6	1.51	8.50	6,777		Exceeds Criteria	423		83.6	5.59	12.4	39.1	J	19.6	0.61	9.69	391	J+	78.5	1.62	9.83	853		Exceeds Criteria
AC-20	47	49	pCi/g	1.33		0.20	1.05	0.25	1.55		0.25	0.19	0.40	2.88		Less than Criteria	1.54	J+	0.38	0.04	0.04	1.06	J+	0.27	0.01	0.04	2.60		Less than Criteria	0.85	J	0.21	0.02	0.05	0.10	J	0.07	0.01	0.06	0.78	J+	0.20	0.02	0.07	1.73		Less than Criteria
AC-20_FD	47	49	pCi/g	1.40	U	0.37	2.67	0.46	1.56		0.44	0.40	0.86	2.95	*	Less than Criteria	1.32	J+	0.34	0.05	0.05	1.20	J+	0.30	0.02	0.07	2.52		Less than Criteria	0.89		0.22	0.02	0.04	0.11	J	0.08	0.00	0.05	0.72	J+	0.20	0.00	0.06	1.72		Less than Criteria
AC-21	12	13	pCi/g	272		18.8	27.1	3.26	8.48		2.28	2.37	4.82	280		Exceeds Criteria	3,491	J+	788	6.81	10.6	137		41.3	0.87	8.75	3,628		Exceeds Criteria	956		144	3.38	7.87	66.8	J+	22.8	0.45	7.18	869	J+	132	0.95	6.64	1,892		Exceeds Criteria
AC-21	30	32	pCi/g	1.11	U	0.32	2.34	0.44	0.75		0.35	0.50	1.04	1.86	*	Less than Criteria	22.6	J+	4.71	0.12	0.10	1.17	J+	0.39	0.01	0.10	23.8		Exceeds Criteria	4.56		0.91	0.07	0.15	0.55	J	0.28	0.01	0.16	4.03		0.83	0.03	0.16	9.14		Less than Criteria
AC-21	40	42	pCi/g	0.80	U	0.12	1.07	0.18	0.49		0.18	0.16	0.35	1.29	*	Less than Criteria	5.61	J+	1.21	0.04	0.04	0.53	J+	0.16	0.00	0.05	6.14		Less than Criteria	1.09	J	0.24	0.03	0.06	0.10	J	0.07	0.01	0.06	1.07	J	0.23	0.01	0.05	2.26		Less than Criteria
AC-21A	13	14	pCi/g	376		30.4	51.9	7.58	6.84	J	6.11	4.74	9.69	383		Exceeds Criteria	4,112	J+	908	7.61	9.60	102	J	32.6	2.37	11.1	4,214		Exceeds Criteria	1,711	J	263	6.59	13.6	203	J+	50.0	1.45	12.1	1,823	J+	279	3.86	13.1	3,736		Exceeds Criteria
AC-21A	47	48	pCi/g	1.55		0.20	1.07	0.20	1.01		0.21	0.17	0.36	2.55		Less than Criteria	1.96	J+	0.48	0.05	0.05	0.87	J	0.24	0.01	0.05	2.82		Less than Criteria	0.51	J	0.14	0.02	0.05	0.05	J+	0.05	0.01	0.06	0.43	J+	0.13	0.01	0.05	0.99		Less than Criteria
AC-22	18	19	pCi/g	14.8		1.17	2.89	0.40	0.58	J	0.36	0.30	0.63	15.4		Exceeds Criteria	129		26.3	0.05	0.06	0.69		0.20	0.02	0.07	129		Exceeds Criteria	3.70	J+	0.57	0.02	0.04	0.25	J	0.10	0.00	0.05	3.44	J	0.53	0.00	0.03	7.40		Less than Criteria
AC-22	41	42	pCi/g	1.26	U	0.36	1.87	0.63	1.65		0.55	0.51	1.09	2.90	*	Less than Criteria	1.58		0.40	0.05	0.04	1.13		0.29	0.00	0.04	2.72		Less than Criteria	0.87	J+	0.23	0.05	0.10	0.10	J	0.08	0.01	0.08	0.65		0.20	0.04	0.10	1.63		Less than Criteria
AC-23	23	24	pCi/g	344		24.3	22.6	3.52	1.51	U	3.11	2.34	4.74	346	*	Exceeds Criteria	1,458	J+	314	8.57	9.68	12.7	J+	9.39	3.27	10.8	1,471		Exceeds Criteria	47.1		18.1	3.96	9.06	10.6	J	9.12	0.74	8.92	42.9	J+	17.0	1.30	7.90	101		Exceeds Criteria
AC-23	67	68	pCi/g	0.47	U	0.10	0.61	0.15	0.38		0.12	0.14	0.29	0.84	*	Less than Criteria	4.77	J+	1.10	0.05	0.06	0.33	J+	0.13	0.01	0.06	5.11		Less than Criteria	0.38	J	0.14	0.02	0.06	0.11	J	0.08	0.00	0.06	0.34	J+	0.13	0.01	0.05	0.83		Less than Criteria
AC-24	4	5	pCi/g	1,188		78.3	21.1	3.17	9.53		2.22	1.87	3.75	1,198		Exceeds Criteria	6,029	J+	902	7.36	6.86	54.1	J+	18.4	0.38	5.97	6,083		Exceeds Criteria	48.4		17.7	4.10	9.17	10.6	J	9.11	1.39	10.3	56.8	J+	19.2	1.90	8.73	116		Exceeds Criteria
AC-24	14	15	pCi/g	56.2		4.19	7.60	1.50	29.1		2.34	1.83	3.70	85.3		Exceeds Criteria	20.5	J+	4.72	0.26	0.22	10.0	J+	2.27	0.11	0.37	30.5		Exceeds Criteria	5.92		1.43	0.12	0.25	0.70	J	0.47	0.04	0.39	7.56	J+	1.68	0.03	0.25	14.2		Less than Criteria
AC-24	39	41	pCi/g	1.08	U	0.26	2.46	0.39	1.11		0.44	0.37	0.79	2.19	*	Less than Criteria	0.99	J+	0.28	0.05	0.04	0.80	J+	0.22	0.00	0.04	1.79		Less than Criteria	0.75		0.21	0.03	0.07	0.08	J	0.07	0.01	0.06	0.85	J+	0.22	0.01	0.05	1.67		Less than Criteria
AC-24	47	48	pCi/g	0.51	U	0.26	1.74	0.39	0.60		0.29	0.23	0.52	1.11	*	Less than Criteria	0.56	J+	0.19	0.05	0.05	0.35	J+	0.14	0.00	0.06	0.90		Less than Criteria	0.80		0.22	0.03	0.06	0.19	J	0.10	0.00	0.06	0.76	J+	0.21	0.01	0.06	1.75		Less than Criteria
AC2-25	37	38	pCi/g	1.25	U	0.20	1.53	0.28	1.50		0.27	0.19	0.41	2.75	*	Less than Criteria	0.79	J+	0.22	0.05	0.05	0.27	J+	0.11	0.02	0.07	1.07		Less than Criteria	0.61		0.17	0.02	0.04	0.10	J	0.07	0.00	0.07	0.47		0.14	0.01	0.04	1.18		Less than Criteria
AC2-25	43	45	pCi/g	1.27	U	0.21	1.74	0.24	1.19		0.29	0.23	0.50	2.46	*	Less than Criteria	4.52	J+	1.00	0.05	0.05	1.03	J+	0.27	0.01	0.05	5.55		Less than Criteria	0.62		0.18	0.03	0.06	0.19	J	0.11	0.00	0.08	0.67		0.19	0.01	0.05	1.48		Less than Criteria
AC-26A	4	5	pCi/g	12.5		1.48	4.14	0.74	0.94	J	0.62	0.52	1.09	13.4		Exceeds Criteria	246	J+	58.2	0.06	0.06	2.09		0.57	0.01	0.08	248		Exceeds Criteria	4.93		0.77	0.03	0.07	0.36	J+	0.14	0.01	0.07	4.83	J+	0.75	0.01	0.05	10.1		Less than Criteria
AC-26A	37	38	pCi/g	2.41		0.28	1.38	0.26	1.40		0.30	0.26	0.54	3.81		Less than Criteria	10.1	J+	2.30	0.05	0.05	1.49		0.39	0.00	0.05	11.6		Exceeds Criteria	0.75	J	0.18	0.02	0.05	0.06	J+	0.05	0.00	0.05	0.89	J+	0.20	0.01	0.05	1.70		Less than Criteria
Cotter Borings																																															
WL-209-CT	1	3	pCi/g	882	J+	4.87	0.07	0.15	5.48	J	0.49	0.16	0.35	887		Exceeds Criteria	1,470,000	J+	19,600	82.9	363	1,150		556	82.5	361	1,471,150		Exceeds Criteria	107	J	3.62	0.06	0.21	5.22	J	0.90	0.05	0.22	102	J	3.53	0.05	0.20	214		Exceeds Criteria
WL-209-CT_FD	1	3	pCi/g	855	J+	4.86	0.06	0.14	4.57	J	0.45	0.16	0.35	860		Exceeds Criteria	256,000	J+	7,560	70.5	308	420	J	305	70.1	166	256,420		Exceeds Criteria	101	J	3.58	0.06	0.23	5.15	J	0.90	0.03	0.12	107	J	3.68	0.02	0.09	213		Exceeds Criteria
WL-209-CT	9	10	pCi/g	460	J	3.84	0.08	0.19	45.0	J	1.37	0.19	0.42	505		Exceeds Criteria	9,330	J+	121	0.51	2.18	5.51	J	2.96	0.36	1.88	9,336		Exceeds Criteria	0.29		0.11	0.01	0.05	0.03	J	0.04	0.01	0.04	0.51		0.15	0.01	0.03	0.82		Less than Criteria
WL-209-CT	21	23	pCi/g	0.76	J	0.14	0.05	0.11	0.23	J	0.24	0.18	0.39	0.99		Less than Criteria	0.80	J+	0.16	0.01	0.05	0.63		0.14	0.01	0.02	1.43		Less than Criteria	0.48	J	0.14	0.01	0.06	0.00	U	0.01	0.01	0.07	0.55		0.15	0.01	0.05	1.03	*	Less than Criteria
WL-209-CT_FD	21	23	pCi/g	0.59		0.12	0.04	0.09	0.42	J	0.23	0.15	0.34	1.01		Less than Criteria	0.79	J+	0.16	0.02	0.06	0.66		0.14	0.01	0.04	1.45		Less than Criteria	0.22	J	0.09	0.01	0.05	0.03	J	0.04	0.01	0.04	0.51		0.14	0.01	0.05	0.75		Less than Criteria
WL-209-CT	26	27	pCi/g	0.49	J	0.12	0.05	0.11	0.55	J	0.24	0.16	0.34	1.04		Less than Criteria	0.55	J+	0.13	0.01	0.04	0.46		0.12	0.01	0.04	1.01		Less than Criteria	0.44		0.13	0.01	0.05	0.01	J	0.03	0.01	0.04	0.35		0.12	0.01	0.05	0.81		Less than Criteria
WL-234-CT	8	10	pCi/g	1,040	J+	8.62	0.10	0.26	3.82	J	0.46	0.18	0.40	1,044		Exceeds Criteria	644,000	J+	9,870	47.8	113	662		321	47.6	208	644,662		Exceeds Criteria	53.8	J	2.22	0.03	0.12	2.81	J	0.57	0.02	0.09	50.1	J	2.14	0.04	0.14	107		Exceeds Criteria
WL-234-CT_FD	8	10	pCi/g	757	J+	7.00	0.10	0.24	1.92	J	0.35	0.17	0.38	759		Exceeds Criteria	65,500	J+	2,850	87.4	267	202	J	165	38.9	170	65,702		Exceeds Criteria	44.2	J	1.92	0.03	0.13	2.05	J	0.46	0.02	0.12	43.3	J	1.90	0.03	0.12	89.6		Exceeds Criteria
WL-234-CT	18	19	pCi/g	110	J	1.60	0.05	0.12	0.63	J	0.25	0.16	0.35	111		Exceeds Criteria	4,290	J+	81.5	0.50	2.17	3.81	J	2.44	0.24	1.64	4,294		Exceeds Criteria	0.20		0.09	0.01	0.03	0.03	J	0.05	0.02	0.08	0.19		0.09	0.01	0.05	0.42		Less than Criteria
WL-234-CT	44	45	pCi/g	0.99		0.15	0.03	0.08	0.39	J	0.22	0.15	0.33	1.38		Less than Criteria	1.18	J+	0.19	0.01	0.04	0.98		0.18	0.01	0.02	2.16		Less than Criteria	0.55		0.15	0.01	0.05	0.01	J	0.03	0.01	0.04	0.72		0.17	0.01	0.05	1.28		Less than Criteria
Cotter Samples from Core of Non-Cotter Borings																																															
WL-210-CT (AC-24)	4	5	pCi/g	633	J+	4.06	0.05	0.12	1.50	J	0.31	0.17	0.37	635		Exceeds Criteria	57,000	J+	2,070	23.8	104	318	J	157	23.6	103	57,318		Exceeds Criteria	58.9	J	2.32	0.02	0.10	2.84	J	0.57	0.03	0.15	58.7	J	2.32	0.04	0.14	120		Exceeds Criteria
WL-210-CT (AC-24)	45	46	pCi/g	0.49		0.11	0.03	0.08	0.25	J	0.22	0.16	0.36	0.74		Less than Criteria	0.52	J+	0.13	0.01	0.04	0.20		0.08	0.01	0.02	0.72		Less than Criteria	0.80		0.18	0.01	0.06	0.05	J	0.05	0.01	0.04	1.08		0.21	0.01	0.03	1.93		Less than Criteria
WL-210-CT (AC-24)	21	22	pCi/g	0.99		0.16	0.04	0.10	0.67		0.27	0.17	0.37	1.67		Less than Criteria	4.24	J+	0.36	0.01	0.04	1.02		0.18	0.01	0.04	5.26		Less than Criteria	0.77		0.19	0.01	0.06	0.05	J	0.06	0.01	0.06	0.89		0.20	0.01	0.03	1.72		Less than Criteria
Cotter Third Phase Samples																																															
AC-08-CT	4	10	pCi/g	0.75		0.12	0.03	0.07	0.46	J+	0.28	0.20	0.43	1.21		Less than Criteria	1.23	J+	0.21	0.01	0.04	0.75		0.16	0.01	0.05	1.98		Less than Criteria	0.61		0.17	0.02	0.07	0.04	J	0.05	0.01	0.07	0.86		0.20	0.01	0.06	1.51		Less than Criteria
AC-10-CT	12	13	pCi/g	1.64		0.17	0.02	0.06	0.24	J+	0.23	0.17	0.36	1.88		Less than Criteria	9.63	J+	0.54	0.01	0.04	0.62		0.14	0.01	0.03	10.2		Exceeds Criteria	1.22		0.24	0.01	0.06	0.11	J	0.08	0.01	0.05	1.62		0.28	0.02	0.07	2.95		Less than Criteria
AC-13-CT	4	6	pCi/g	2.85		0.23	0.02	0.06	0.21	J+	0.22	0.16	0.36	3.06		Less than Criteria	55.6	J+	1.45	0.01	0.05	0.22		0.09	0.02	0.06	55.8		Exceeds Criteria	1.49		0.27	0.02	0.08	0.12	J	0.09	0.03	0.10	1.40		0.26	0.02	0.07	3.01		Less than Criteria
AC-15-CT	29	30	pCi/g	0.26		0.08	0.03	0.07	0.21	J+	0.24	0.18	0.39	0.47		Less than Criteria	0.56	J+	0.13	0.01	0.02	0.48		0.12	0.01	0.04	1.04		Less than Criteria	0.42		0.14	0.01	0.06	0.01	J	0.03	0.01	0.07	0.34		0.13	0.01	0.06	0.77		Less than Criteria
AC-16-CT	11	14	pCi/g	1.27		0.15	0.03	0.06	0.42	J+	0.23	0.15	0.34	1.69		Less than Criteria	5.38	J+	0.41	0.01	0.04	0.88		0.17	0.01	0.04	6.26		Less than Criteria	1.19		0.23	0.02	0.07	0.03	J	0.04	0.01	0.07	1.22		0.24	0.02	0.07	2.44		Less than Criteria
AC-16-CT	19	20	pCi/g	273		2.31	0.03	0.07	2.51	J+	0.38	0.18	0.38	276		Exceeds Criteria	7,420	J+	15.7	0.01	0.04	11.2		0.61	0.01	0.02	7,431		Exceeds Criteria	115	J	3.77	0.04	0.18	5.87	J	0.95	0.04	0.20	116	J	3.79	0.02	0.09	237		Exceeds Criteria
AC-16-CT_FD	11	14	pCi/g	1.81		0.19	0.03	0.08	3.81	J+	0.46	0.18	0.38	5.62		Less than criteria	31.1	J+	0.99	0.01	0.04	1.01		0.18	0.01	0.05	32.1		Exceeds Criteria	0.94		0.21	0.04	0.11	0.04	J	0.06	0.03	0.09	1.10		0.23	0.02	0.07	2.09		Less than Criteria
AC-21-CT	20	24	pCi/g	45.0		0.93	0.03	0.07	0.68	J+	0.27	0.18	0.39	45.7		Exceeds Criteria	1,240	J+	6.34	0.01	0.05	1.96		0.25	0.01	0.02	1,242		Exceeds Criteria	102	J	3.42	0.04	0.17	5.80	J	0.91	0.03	0.11	107	J	3.50	0.02	0.13	215		Exceeds Criteria
EPA Verification Samples																																															
WL-210-CT_(es)	4	5	pCi/g	704		21.1		26.0	2.98	U	1.13		5.25	707	*	Exceeds Criteria	8,410		540		21.0	41.6		10.1		16.8	8451.6		Exceeds Criteria	62.40					2.782					61.61					126.79		Exceeds Criteria
WL-210-CT_(es)_SD	4	5	pCi/g	596		18.0		24.1	0.90	U	0.99		4.60	597	*	Exceeds Criteria	0.78				0.01	22.5				1.73	23		Exceeds Criteria																		
WL-209-CT_(es)	1	3	pCi/g	2,390		69.3		55.6	9.86	U	2.24		10.3	2,400	*	Exceeds Criteria	25,200		1,600		54.8	75.5		20.9		54.6	25,276		Exceeds Criteria	121.68					5.864					125.54					253.08		Exceeds Criteria
WL-209-CT_(es)_FD	1	3	pCi/g	1,880		54.4		39.4	8.26	U	1.88		8.62	1,888	*	Exceeds Criteria	36,600		2,330		38.9	107		25.2		48.6	36,707		Exceeds Criteria	116.69					5.029					111.56					233.27		Exceeds Criteria
WL-209-CT_(es)_FD_SD	1	3	pCi/g	1,650		48.3		44.5	4.92	U	1.73		8.01	1,655	*	Exceeds Criteria	2.02				0.01	44.0				1.82	46		Exceeds Criteria																		
WL-209-CT_(es)_SD	1	3	pCi/g	1,570		45.6		36.8	5.51	U	1.64		7.56	1,576	*	Exceeds Criteria	2.55				0.01	54.9				1.85	25,255		Exceeds Criteria																		
WL-234-CT_(es)	8	10	pCi/g	1,310		38.7		41.5	1.48	U	1.65		7.64	1,311	*	Exceeds Criteria	11,100		726		33.6	114		23.8		33.5	11,214		Exceeds Criteria	55.66					2.525					54.95					113.13		Exceeds Criteria
WL-234-CT_(es)_FD	8	10	pCi/g	979		28.9		28.5	4.14	U	1.46		6.81	983	*	Exceeds Criteria	5,150		337		20.6	25.7	U	8.71		26.3	5175.7	*	Exceeds Criteria	37.44					1.75					37.96					77.15		Exceeds Criteria
WL-234-CT_(es)_FD_SD	8	10	pCi/g	771		23.1		28.5	2.25	U	1.16		5.37	773	*	Exceeds Criteria	1.01				0.01	20.4				1.79	21		Exceeds Criteria																		
WL-234-CT_(es)_SD	8	10	pCi/g	1,200		35.3		34.4	1.05	U	1.48		6.86	1,201	*	Exceeds Criteria	1.48				0.01	29.2				1.60	31		Exceeds Criteria																		

Table 2-4: Area 2 Combined Radium, Thorium, and Uranium Results (RI Borings, Additional Characterization Borings, and Cotter Borings)

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Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226 Result	Radium-226 Final Q	Radium-226 CSU[1]	Radium-226 CV	Radium-226 MDA	Radium-228 Result	Radium-228 Final Q	Radium-228 CSU[1]	Radium-228 CV	Radium-228 MDA	Combined Radium 226 + 228	Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria
EPA Split Samples															
AC-10_(es)	26	28	pCi/g	0.99		0.23	0.07	0.17	0.37		0.22	0.14	0.32	1.36	Less than Criteria
AC-10_(es)_SD	26	28	pCi/g												
AC-13_(es)	20	22	pCi/g	4.51		0.71	0.12	0.28	0.21	U	0.31	0.31	0.69	4.72 *	Less than Criteria
AC-13_(es)_SD	20	22	pCi/g												
AC-14_(es)	25	26	pCi/g	0.49		0.13	0.03	0.08	0.48		0.18	0.04	0.12	0.97	Less than Criteria
AC-14_(es)_SD	25	26	pCi/g												
AC-18_(es)	2	5	pCi/g	276		29.0	0.86	1.75	4.61		2.31	1.27	2.62	281	Exceeds Criteria
AC-18_(es)_SD	2	5	pCi/g												
AC-19_(es)	5	6	pCi/g	483		50.3	0.76	1.54	6.97		1.45	1.56	3.16	490	Exceeds Criteria
AC-19_(es)_SD	5	6	pCi/g												
AC-23_(es)	23	24	pCi/g	217		22.7	0.49	1.00	2.72		1.77	0.88	1.79	220	Exceeds Criteria
AC-23_(es)_SD	23	24	pCi/g												
AC-24_(es)	4	5	pCi/g	618		64.4	0.98	1.99	9.52		1.82	2.20	4.45	628	Exceeds Criteria
AC-24_(es)_SD	4	5	pCi/g												
AC-25_(es)	37	38	pCi/g	1.08		0.26	0.09	0.20	1.48		0.36	0.13	0.31	2.56	Less than Criteria
AC-25_(es)_SD	37	38	pCi/g												
EPA Pyrolosis Split Samples															
A2-S1_pyr	0	0	pCi/g	2,514		134		18.0						2,514	Exceeds Criteria
AC-21_pyr	12	13	pCi/g	196		11.4		5.00						196	Exceeds Criteria
WL-234-CT_pyr	8	10	pCi/g	1,210		64.0		10.0						1,210	Exceeds Criteria
Missouri Department of Natural Resources Sample															
S10	0	0	pCi/g	3.28		0.88		0.36	0.55	U	0.53		1.08	3.83	Less than Criteria

Sample Designation	Thorium-230 Result	Thorium-230 Final Q	Thorium-230 CSU[1]	Thorium-230 CV	Thorium-230 MDA	Thorium-232 Result	Thorium-232 Final Q	Thorium-232 CSU[1]	Thorium-232 CV	Thorium-232 MDA	Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria
EPA Split Samples												
AC-10_(es)	0.78		0.16	0.01	0.03	0.37		0.22	0.14	0.32	1.15	Less than Criteria
AC-10_(es)_SD						0.34		0.10	0.01	0.02	0.34	Less than Criteria
AC-13_(es)	128		16.1	0.25	1.34	0.21	U	0.31	0.31	0.69	128 *	Exceeds Criteria
AC-13_(es)_SD						0.17	U	0.58	0.31	1.45	0.17 *	Less than Criteria
AC-14_(es)	0.50		0.13	0.01	0.02	0.48		0.18	0.04	0.12	0.98	Less than Criteria
AC-14_(es)_SD						0.40		0.12	0.01	0.04	0.40	Less than Criteria
AC-18_(es)	9,650		1,140	30.7	112	4.61		2.31	1.27	2.62	9,655	Exceeds Criteria
AC-18_(es)_SD						-8.31	U	11.8	21.6	93.1	Non-detect	Less than Criteria
AC-19_(es)	19,600		2,360	33.6	110	6.97		1.45	1.56	3.16	19,607	Exceeds Criteria
AC-19_(es)_SD						72.7		103	33.4	109	72.7	Exceeds Criteria
AC-23_(es)	7,970		985	15.1	49.1	2.72		1.77	0.88	1.79	7,973	Exceeds Criteria
AC-23_(es)_SD						0.00	U	8.14	15.0	48.9	Non-detect	Less than Criteria
AC-24_(es)	26,700		3,100	67.4	262	9.52		1.82	2.20	4.45	26,710	Exceeds Criteria
AC-24_(es)_SD						84.2		119	38.7	126	84.2	Exceeds Criteria
AC-25_(es)	1.22		0.22	0.01	0.05	1.48		0.36	0.13	0.31	2.70	Less than Criteria
AC-25_(es)_SD						0.86		0.18	0.01	0.02	0.86	Less than Criteria
EPA Pyrolosis Split Samples												
A2-S1_pyr	51,800		3,150		33.7	118		24.3		33.6	51,918	Exceeds Criteria
AC-21_pyr	6,680		410		14.5	9.85		3.16		6.85	6,690	Exceeds Criteria
WL-234-CT_pyr	26,200		1,610		34.0	48.7		15.6		33.9	26,249	Exceeds Criteria
Missouri Department of Natural Resources Sample												
S10	22.6		4.01		0.10	1.95		0.47		0.08	24.6	Exceeds Criteria

Sample Designation	Uranium-234 Result	Uranium-234 Final Q	Uranium-234 CSU[1]	Uranium-234 CV	Uranium-234 MDA	Uranium-235 Result	Uranium-235 Final Q	Uranium-235 CSU[1]	Uranium-235 CV	Uranium-235 MDA	Uranium-238 Result	Uranium-238 Final Q	Uranium-238 CSU[1]	Uranium-238 CV	Uranium-238 MDA	Combined Uranium 234 + 235 + 238	Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
EPA Split Samples																	
AC-10_(es)											0.74	U	0.58	0.89	1.89	0.74 *	Less than Criteria
AC-10_(es)_SD											0.36		0.11	0.01	0.02	0.36	Less than Criteria
AC-13_(es)											0.90	U	1.50	2.39	5.00	0.90 *	Less than Criteria
AC-13_(es)_SD											1.73		0.28	0.01	0.02	1.73	Less than Criteria
AC-14_(es)											1.68		1.37	0.84	1.78	1.68	Less than Criteria
AC-14_(es)_SD											0.34		0.11	0.01	0.05	0.34	Less than Criteria
AC-18_(es)											176		27.1	13.0	26.3	176	Exceeds Criteria
AC-18_(es)_SD											161		17.3	0.20	0.94	161	Exceeds Criteria
AC-19_(es)											27.4		7.69	13.0	26.1	27.4	Less than Criteria
AC-19_(es)_SD											55.8		5.07	0.03	0.10	55.8	Exceeds Criteria
AC-23_(es)											22.1		5.42	7.99	16.1	22.1	Less than Criteria
AC-23_(es)_SD											33.0		3.05	0.02	0.07	33.0	Less than Criteria
AC-24_(es)											21.1		7.58	11.8	23.7	21.1	Less than Criteria
AC-24_(es)_SD											49.6		4.54	0.01	0.05	49.6	Less than Criteria
AC-25_(es)											1.31		0.76	1.14	2.41	1.31	Less than Criteria
AC-25_(es)_SD											0.99		0.19	0.01	0.02	0.99	Less than Criteria
EPA Pyrolosis Split Samples																	
A2-S1_pyr	153.504					7.1048					151.848					312.5	Exceeds Criteria
AC-21_pyr	792.48					37.022					799.2					1628.7	Exceeds Criteria
WL-234-CT_pyr	68.016					3.2528					71.595					142.9	Exceeds Criteria
Missouri Department of Natural Resources Sample																	
S10	0.90		0.27		0.10	0.10	U	0.09		0.10	1.01		0.28		0.08	2.01	Less than Criteria

Notes:

Final Q = final qualifier   CSU[1] = combined standard uncertainty (+/- sigma for McLaren/Hart samples)   CV = critical value   MDA = minimum detectable activity   pCi/g - picocuries per gram

* Indicates that result for one of the two isotopes was non-detect

The results highlighted in yellow represent combined values greater than the unrestricted use criteria established by EPA

J = The analyte was analyzed for, and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample.

J+ = Same as J qualification but with an indication of positive bias in the sample concentration.

U = The analyte was analyzed for and is not present above the level of the associated value. The associated numerical value indicates the approximate concentration necessary to detect the analyte in the sample.

- In calculated combined Ra and combined Th values, if one of the the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If both values were <MDA, combined results reported as "Non-detect".
- In calculated combined U values, if one or two of the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If all three values were <MDA, combined results reported as "Non-detect".

The results highlighted in pink were "rejected based on data quality and representativeness"

The data summarized on this table are presented in Appendix D.

Table 2-5: Summary Statistics for Radium, Thorium and Uranium Results - Areas 1 and 2

	Radium-226	Radium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-235	Uranium-238
Area 1							
Number of Analyses	214	214	213	213	207	205	206
Frequency of Detection	79%	74%	100%	94%	100%	100%	100%
Median of Detects	1.282	0.920	1.729	0.780	0.840	0.042	0.825
Mean of Detects	87.84	1.338	1232	8.208	7.160	0.340	7.364
Standard Deviation of Detects	729.5	3.031	7130	48.46	42.08	1.970	39.55
Maximum Value	4,926	31.85	58,800	514.9	428.7	21.49	431.1
95% Upper Confidence Limit	891.4	14.63	2132	14.63	15.12	0.719	13.62
Area 2							
Number of Analyses	224	224	225	225	227	220	221
Frequency of Detection	89%	72%	100%	100%	98%	100%	99%
Median of Detects	1.310	0.910	8.602	0.780	1.087	0.052	1.050
Mean of Detects	101.5	1.861	1,569	7.148	28.75	1.343	25.14
Standard Deviation of Detects	486.3	4.763	6,267	23.98	148.8	7.329	145.6
Maximum Value	3,720	45.00	51,800	138.0	1,711	88.34	1,823
95% Upper Confidence Limit	966.9	10.49	2,428	10.49	53.76	2.646	52.09

All results except for Number of Analyses are in units of picocuries per gram (pCi/g).

Table 2-6: Summary of Thorium-230 Decay and Radium-226 In-Growth Over Time - Area 1

Time (years)	Thorium-230 pCi/g	Radium -226: From Initial Ra_{226} (pCi/g)	Radium -226: Ingrowth from Th_{230} (pCi/g)	Radium -226: Total (pCi/g)
0	2,132	891	0	891
30	2,131	880	27	907
100	2,130	854	90	944
200	2,128	818	177	994
500	2,122	718	414	1132
1,000	2,112	578	745	1323
2,000	2,093	375	1,222	1,597
3,000	2,074	243	1,524	1,768
5,000	2,036	102	1,830	1,933
7,000	1,999	43	1,937	1,980
8,000	1,981	28	1,955	1,983
9,000	1,963	18	1,961	1,979
10,000	1,945	12	1,958	1,970
15,000	1,857	1	1,894	1,896
20,000	1,774	0	1,812	1,812
30,000	1,618	0	1,653	1,653
40,000	1,476	0	1,508	1,508
50,000	1,346	0	1,376	1,376
80,000	1,022	0	1,044	1,044

Constants	half life (y)	lambda (1/y)	Specific Mass to Activity (µg/pCi)
Th_{230} Half-Life	75,400	9.193E-06	4.95E-05
Ra_{226} Half-Life	1,602	4.327E-04	1.01E-06

Initial Values (from ProUCL runs for updated BRA)

Thorium 230	2,132	pCi/g	95% UCL for Area 1
Radium-226	891.4	pCi/g	95% UCL for Area 1

Th-230(pCi/g) = Initial_Th230(pCi/g)*EXP[-Lambda_Th(1/y)*Time(y)]

Ra-226(pCi/g) = {Initial_Ra226(pCi/g) x EXP[-Lambda_Ra(1/y) x Time(y)]} + {[Lambda_Ra(1/y) x Initial_Th230(pCi/g)] / [Lambda_Ra(1/y) - Lambda_Th(1/y)]} x {EXP[-Lambda_Th(1/y) x Time(y)] - EXP[-Lambda_Ra(1/y) x Time(y)])}

Notes: pCi/g = picoCuries per gram BRA = Baseline Risks Assessment UCL = upper confidence limit

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Table 2-7: Summary of Thorium-230 Decay and Radium-226 In-Growth Over Time - Area 2

Time (years)	Thorium-230 pCi/g	Radium -226: From Initial Ra_{226} (pCi/g)	Radium -226: Ingrowth from Th_{230} (pCi/g)	Radium -226: Total (pCi/g)
0	2,428	967	0	967
30	2,427	954	31	986
100	2,426	926	103	1029
200	2,424	887	201	1088
500	2,417	779	471	1250
1,000	2,406	627	849	1476
2,000	2,384	407	1,391	1,798
3,000	2,362	264	1,736	2,000
5,000	2,319	111	2,084	2,195
7,000	2,277	47	2,206	2,253
8,000	2,256	30	2,227	2,257
9,000	2,235	20	2,233	2,253
10,000	2,215	13	2,230	2,243
15,000	2,115	1	2,157	2,159
20,000	2,020	0	2,064	2,064
30,000	1,843	0	1,883	1,883
40,000	1,681	0	1,717	1,717
50,000	1,533	0	1,567	1,567
80,000	1,164	0	1,189	1,189

Constants	half life (y)	lambda (1/y)	Specific Mass to Activity (µg/pCi)
Th_{230} Half-Life	75,400	9.193E-06	4.95E-05
Ra_{226} Half-Life	1,602	4.327E-04	1.01E-06

Initial Values (from ProUCL runs for updated BRA)

Thorium 230	2,428	pCi/g	95% UCL for Area 2
Radium-226	967	pCi/g	95% UCL for Area 2

Th-230(pCi/g) = Initial_Th230(pCi/g)*EXP[-Lambda_Th(1/y)*Time(y)]

Ra-226(pCi/g) = {Initial_Ra226(pCi/g) x EXP[-Lambda_Ra(1/y) x Time(y)]} + {[Lambda_Ra(1/y) x Initial_Th230(pCi/g)] / [Lambda_Ra(1/y) - Lambda_Th(1/y)]} x {EXP[-Lambda_Th(1/y) x Time(y)] - EXP[-Lambda_Ra(1/y) x Time(y)])}

Notes: pCi/g = picoCuries per gram BRA = Baseline Risks Assessment UCL = upper confidence limit

Table 2-8: Buffer Zone Crossroad Property Combined Radium, Thorium, and Uranium Results

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Sample Site	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Units	Radium-226					Radium-228					Combined Radium 226 + 228		Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria	Thorium-230					Thorium-232					Combined Thorium 230 + 232	Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria	Uranium-234					Uranium-235					Uranium-238					Combined Uranium 234 + 235 + 238		Combined Uranium relative to 54.4 pCi/g Unrestricted Use Criteria
				Result	Final Q	+/- Sigma	CV	MDA	Result	Final Q	+/- Sigma	CV	MDA				Result	Final Q	+/- Sigma	CV	MDA	Result	Final Q	+/- Sigma	CV	MDA			Result	Final Q	+/- Sigma	CV	MDA	Result	Final Q	+/- Sigma	CV	MDA	Result	Final Q	+/- Sigma	CV	MDA			
McLaren/Hart RI Data																																														
FP-1	0.25	0.25	pCi/g	7.23	U			7.23	2.13	U			2.13	Non-detect	*	Non-detect	12.8		2.80		0.20	1.10		0.38		0.22	13.9	Exceeds Criteria	0.73		0.19		0.08	0.15		0.08		0.07	0.81		0.21		0.09	1.69		Less than Criteria
FP-1	0.25	0.25	pCi/g	7.19		3.98		4.63	2.06	U			2.06	8.22	*	Exceeds Criteria	1.39		0.33		0.06	1.06		0.27		0.05	2.45	Less than Criteria	0.84		0.20		0.07	0.15		0.07		0.05	0.80		0.19		0.06	1.79		Less than Criteria
FP-1	2	2	pCi/g	4.94	U			4.94	2.29	U			2.29	Non-detect	*	Non-detect	1.16		0.29		0.06	0.84		0.23		0.05	2.00	Less than Criteria	0.69		0.18		0.04	0.13		0.07		0.05	0.75		0.19		0.06	1.57		Less than Criteria
FP-2	0.25	0.25	pCi/g	6.28	U			6.28	2.85	U			2.85	Non-detect	*	Non-detect	2.92		0.63		0.10	1.08		0.29		0.14	4.00	Less than Criteria	1.08		0.24		0.07	0.14		0.08		0.10	1.17		0.26		0.09	2.39		Less than Criteria
FP-2	2	2	pCi/g	7.99		4.85		4.93	2.61	U			2.61	9.30	*	Exceeds Criteria	1.24		0.31		0.12	1.13		0.29		0.10	2.37	Less than Criteria	0.78		0.21		0.10	0.26		0.11		0.08	0.94		0.24		0.10	1.98		Less than Criteria
FP-3	0.25	0.25	pCi/g	6.23	U			6.23	2.05	U			2.05	Non-detect	*	Non-detect	1.26		0.31		0.11	0.85		0.23		0.10	2.11	Less than Criteria	0.69		0.18		0.07	0.06		0.05		0.06	0.79		0.20		0.05	1.54		Less than Criteria
FP-3	2	2	pCi/g	4.24	U			4.24	1.66	U			1.66	Non-detect	*	Non-detect	1.26		0.31		0.07	0.91		0.24		0.05	2.17	Less than Criteria	1.94		0.40		0.07	0.38		0.13		0.05	2.62		0.51		0.07	4.94		Less than Criteria
FP-4	0.25	0.25	pCi/g	9.06		3.81		3.62	2.60	U			2.60	10.4	*	Exceeds Criteria	2.61		0.57		0.07	1.16		0.30		0.06	3.77	Less than Criteria	1.01		0.23		0.04	0.11		0.07		0.06	0.96		0.23		0.05	2.08		Less than Criteria
FP-4	2	2	pCi/g	5.58	U			5.58	1.73	U			1.73	Non-detect	*	Non-detect	2.20		0.49		0.07	1.28		0.32		0.05	3.5	Less than Criteria	0.71		0.19		0.06	0.10		0.06		0.06	0.84		0.21		0.06	1.65		Less than Criteria
FP-5	0.25	0.25	pCi/g	4.08		3.10		2.99	0.94	U			0.94	4.55	*	Less than Criteria	28.6		5.20		0.08	1.38		0.34		0.08	30.0	Exceeds Criteria	0.84		0.20		0.05	0.06		0.05		0.05	1.05		0.23		0.04	1.95		Less than Criteria
FP-5	2	2	pCi/g	6.04	U			6.04	1.96	U			1.96	Non-detect	*	Non-detect	5.31		1.03		0.09	1.20		0.30		0.02	6.5	Less than Criteria	1.11		0.32		0.08	0.22		0.13		0.09	1.20		0.33		0.09	2.53		Less than Criteria
FP-6	0.25	0.25	pCi/g	5.59	U			5.59	1.56	U			1.56	Non-detect	*	Non-detect	1.20		0.29		0.06	0.95		0.24		0.06	2.2	Less than Criteria	0.73		0.18		0.07	0.07		0.06		0.10	0.91		0.21		0.06	1.71		Less than Criteria
FP-6	2	2	pCi/g	3.25	U			3.25	1.95	U			1.95	Non-detect	*	Non-detect	1.80		0.39		0.05	1.20		0.28		0.05	3.0	Less than Criteria	0.86		0.21		0.04	0.09		0.06		0.03	1.07		0.25		0.05	2.02		Less than Criteria
FP-7	0.25	0.25	pCi/g	4.72		2.89		3.49	1.78	U			1.78	5.61	*	Less than Criteria	2.08		0.43		0.07	1.14		0.27		0.05	3.22	Less than Criteria	0.88		0.26		0.06	0.15		0.10		0.04	0.82		0.25		0.07	1.85		Less than Criteria
FP-7	2	2	pCi/g	6.63	U			6.63	2.13	U			2.13	Non-detect	*	Non-detect	1.51		0.32		0.03	0.10		0.23		0.03	1.61	Less than Criteria	0.65		0.25		0.15	0.05		0.08		0.14	0.71		0.26		0.13	1.41		Less than Criteria
FP-8	0.25	0.25	pCi/g	5.22	U			5.22	1.68	U			1.68	Non-detect	*	Non-detect	21.8		3.80		0.09	1.57		0.35		0.09	23.37	Exceeds Criteria	0.95		0.28		0.06	0.11		0.09		0.08	0.81		0.25		0.08	1.87		Less than Criteria
FP-8	2	2	pCi/g	5.78	U			5.78	2.92	U			2.92	Non-detect	*	Non-detect	2.04		0.42		0.08	1.29		0.29		0.07	3.33	Less than Criteria	0.93		0.34		0.21	0.07		0.18		0.32	1.30		0.42		0.24	2.30		Less than Criteria
WL-201-MH	5	5	pCi/g	1.06		0.22		0.34	4.10	U			4.10	3.11	*	Less than Criteria	1.06		0.31		0.15	0.32		0.15		0.13	1.38	Less than Criteria	1.30	U			1.30	0.22	U	0.17		0.22	1.19		0.40		0.17	1.95	*	Less than Criteria
WL-201-MH	15	15	pCi/g	0.47		0.16		0.24	0.73	U			0.73	0.84	*	Less than Criteria	0.63		0.23		0.11	0.28		0.15		0.08	0.91	Less than Criteria	2.35	U			2.35	0.13	U	0.08		0.13	0.31		0.18		0.12	1.55	*	Less than Criteria
WL-202-MH	5	5	pCi/g	0.75		0.41		0.54	1.59	U			1.59	1.55	*	Less than Criteria	0.83		0.29		0.11	0.44		0.20		0.09	1.27	Less than Criteria	1.27		0.77		1.02	0.17	U	0.08		0.17	0.88		0.37		0.12	2.24	*	Less than Criteria
WL-202-MH	15	15	pCi/g	0.81	U			0.81	1.18	U			1.18	Non-detect	*	Non-detect	0.26		0.14		0.08	0.16		0.11		0.08	0.42	Less than Criteria	3.75	U			3.75	0.12	U	0.00		0.12	0.24		0.16		0.10	2.18	*	Less than Criteria
WL-203-MH	0	0	pCi/g	1.07		0.24		0.38	1.28	U			1.28	1.71	*	Less than Criteria	3.03		0.88		0.15	0.43		0.24		0.12	3.46	Less than Criteria	1.46		1.06		1.43	0.31		0.25		0.27	1.95		0.63		0.20	3.72		Less than Criteria
WL-203-MH	5	5	pCi/g	0.94		0.22		0.33	0.99	U			0.99	1.44	*	Less than Criteria	0.80		0.27		0.10	0.14		0.10		0.06	0.9	Less than Criteria	1.48	U			1.48	0.18		0.17		0.15	0.95		0.38		0.11	1.87	*	Less than Criteria
WL-203-MH	15	15	pCi/g	0.53		0.21		0.33	0.98	U			0.98	1.02	*	Less than Criteria	0.41		0.18		0.11	0.23		0.13		0.08	0.64	Less than Criteria	1.86	U			1.86	0.16	U	0.11		0.16	0.60		0.27		0.12	1.61	*	Less than Criteria
WL-204-MH	5	5	pCi/g	1.06		0.22		0.31	0.99		0.45		0.56	2.05		Less than Criteria	0.77		0.26		0.09	0.47		0.20		0.06	1.24	Less than Criteria	1.03	U			1.03	0.22		0.18		0.15	0.77		0.33		0.08	1.51	*	Less than Criteria
WL-204-MH	25	25	pCi/g	0.77		0.20		0.36	0.85		0.36		0.72	1.62		Less than Criteria	0.43		0.19		0.08	0.32		0.16		0.07	0.75	Less than Criteria	1.04	U			1.04	0.11	U	0.06		0.11	0.36		0.20		0.09	0.94	*	Less than Criteria
WL-205-MH	5	5	pCi/g	0.95		0.22		0.26	1.19	U			1.19	1.55	*	Less than Criteria	0.80		0.28		0.11	0.66		0.25		0.08	1.46	Less than Criteria	1.48		0.81		0.92	0.15		0.14		0.15	1.76		0.50		0.09	3.39		Less than Criteria
WL-205-MH	15	15	pCi/g	0.90		0.26		0.34	0.95	U			0.95	1.38	*	Less than Criteria	1.01		0.40		0.25	0.95		0.38		0.15	1.96	Less than Criteria	1.76		1.18		1.52	0.18		0.15		0.14	0.95		0.34		0.10	2.89		Less than Criteria
WL-206-MH	0	0	pCi/g	17.2		1.20		0.40	1.21	U			1.21	17.8	*	Exceeds Criteria	537		102		0.05	3.92		0.91		0.07	541	Exceeds Criteria	2.53	U			2.53	0.33	U	0.22		0.33	4.17		1.04		0.26	5.60	*	Less than Criteria
WL-206-MH	5	5	pCi/g	1.20		0.37		0.57	1.58	U			1.58	1.99	*	Less than Criteria	6.60		1.40		0.36	1.21		0.43		0.21	7.81	Exceeds Criteria	4.01	U			4.01	0.19		0.10		0.06	1.17		0.27		0.06	3.37	*	Less than Criteria
WL-206-MH	10	10	pCi/g	0.72		0.18		0.28	0.96	U			0.96	1.20	*	Less than Criteria	1.66		0.51		0.21	0.82		0.33		0.16	2.48	Less than Criteria	1.83		0.79		1.04	0.06	U	0.05		0.06	0.60		0.17		0.04	2.46	*	Less than Criteria
RC-01	0	0.25	pCi/g	-1.26	U	0.18		0.15	1.83		0.52		0.71	1.20	*	Less than Criteria	2.75		0.66		0.09	1.40		0.39		0.07	4.2	Less than Criteria	1.00		0.35		0.15	0.08	U	0.09		0.13	0.09	J	0.33		0.10	1.13	*	Less than Criteria
RC-02	0	0.25	pCi/g	-0.05	U	0.01		0.13	1.47		0.48		0.68	1.45	*	Less than Criteria	30.6		6.10		0.10	1.28		0.36		0.14	31.9	Exceeds Criteria	1.06		0.35		0.05	0.14	J	0.11		0.10	1.08		0.36		0.05	2.28		Less than Criteria
RC-03	0	0.25	pCi/g	-1.35	U	0.20		0.14	1.67		0.49		0.68	1.00	*	Less than Criteria	6.30		1.60		0.20	0.97	J	0.38		0.23	7.3	Less than Criteria	0.80	J	0.30		0.11	0.03	U	0.06		0.12	0.89	J	0.32		0.08	1.71	*	Less than Criteria
RC-04	0	0.25	pCi/g	-2.26	U	0.35		0.13	1.92		0.51		0.69	0.79	*	Less than Criteria	2.60		0.65		0.18	1.25		0.37		0.07	3.9	Less than Criteria	0.93	J	0.33		0.14	0.06	J	0.08		0.06	0.94	J	0.33		0.05	1.93		Less than Criteria
RC-05	0	0.25	pCi/g	-0.72	U	0.10		0.10	1.59		0.47		0.66	1.23	*	Less than Criteria	2.48		0.61		0.08	1.21		0.35		0.09	3.69	Less than Criteria	0.91	J	0.33		0.16	0.14	J	0.12		0.14	0.69	J	0.27		0.09	1.74		Less than Criteria
RC-06	0	0.25	pCi/g	-0.03	U	0.00		0.12	1.26		0.48		0.72	1.25	*	Less than Criteria	4.60		1.00		0.10	1.18		0.34		0.04	5.8	Less than Criteria	0.97	J	0.36		0.13	0.15	U	0.14		0.18	0.96	J	0.35		0.05	2.01	*	Less than Criteria
RC-07	0	0.25	pCi/g	0.38	U	0.05		0.12	0.96	J	0.44		0.68	1.15	*	Less than Criteria	2.84		0.72		0.16	1.56		0.45		0.08	4.40	Less than Criteria	0.63	J	0.26		0.13	0.02	U	0.11		0.05	0.90	J	0.05		0.32	1.54	*	Less than Criteria
Missouri Department of Natural Resources Sample																																														
S09	0	0	pCi/g	2.31		0.69		0.39	1.32		0.41		0.73	2.48		Less than Criteria	8.04		1.49		0.08	1.17		0.32		0.06	9.21	Exceeds Criteria	0.95		0.25		0.09	0.07	U	0.08		0.11	0.86		0.24		0.08	1.85		Less than Criteria

Notes:

Final Q = final qualifier   CSU = combined standard uncertainty (+/- sigma for McLaren/Hart samples)   CV = critical value   MDA = minimum detectable activity   pCi/g - picocuries per gram

* Indicates that result for one of the two isotopes was non-detect

The results highlighted in yellow represent combined values greater than the unrestricted use criteria e

J = The analyte was analyzed for, and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample.

J+ = Same as J qualification but with an indication of positive bias in the sample concentration.

U = The analyte was analyzed for and is not present above the level of the associated value. The associated numerical value indicates the approximate concentration necessary to detect the analyte in the sample.

- For calculating combined Ra and combined Th values, if of the the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If both values were <MDA, combined results reported as "Non-detect".
- For calculating combined U values, if one or two of the the results was <MDA, one-half of the MDA was used in the calculation and the combined value was noted with an *. If all three values were <MDA, combined results reported as "Non-detect".

The data summarized on this table are presented in Appendix D.

Table 2-9: Summary Comparison of Area 1 and 2 Soil Sample Results to RCRA Toxicity Characteristic Regulatory Levels

EPA HW No.	Contaminant	TC Level (mg/L)	x DAF of 20	Maximum Concentration in Soil (mg/kg) [1]	No. of Samples	No. of Detects	Detect Freq. (%)	Location and Depth (ft)
D004	Arsenic	5.0	100	**610**	190	166	87.4%	AC-16 @ 19-20
D005	Barium	100.0	2,000	**322,000**	156	156	100%	AC-1 PYR @ 10-11
D006	Cadmium	1.0	20	**62**	189	155	82.0%	AC-20 @ 47-49
D007	Chromium	5.0	100	**890**	376	364	96.8%	WL-208 @ 20 *
D008	Lead	5.0	100	**30,000**	188	185	98.4%	1C-6-CT @ 25-27
D009	Mercury	0.2	4	**12**	182	135	74.2%	1D-15 @77-80
D010	Selenium	1.0	20	**250**	188	126	67.0%	WL-114 @ 0 & AC-16 @ 19-20
D011	Silver	5.0	100	18	186	83	44.6%	AC-24 @ 14-15
D012	Endrin	0.02	0	0.18	36	4	11.1%	WL-218 @ 25
D013	Lindane (gamma BHC)	0.4	8	ND	35	0	0%	
D014	Methoxychlor	10.0	200	0.0057	33	1	3.0%	WL-227 @ 40
D015	Toxaphene	0.5	10	ND	33	0	0%	
D016	2,4-D	10.0	200	NA	NA	NA	NA	
D017	2,4,5-TP (Silvex)	1.0	20	NA	NA	NA	NA	
D018	Benzene	0.5	10	**120 J**	36	2	5.6%	Wl-208 @ 20 *
D019	Carbon tetrachloride	0.5	10	ND	36	0	0%	ND
D020	Chlordane	0.03	0.6	0.015	33	1	3.0%	WL-104 @ 25
D021	Chlorobenzene	100.0	2,000	180	36	8	22.2%	WL-230 @ 16
D022	Chloroform	6.0	120	**890**	36	0	0%	Wl-208 @ 20 *
D023	o-Cresol (2-Methylphenol)	200.0	4,000	0.17 J	32	2	6.3%	WL-213 @ 25
D024	m-Cresol (3-Methylphenol)	200.0	4,000	NA	NA	NA	NA	NA
D025	p-Cresol (4-Methylphenol)	200.0	4,000	0.98	34	4	11.8%	WL-213 @ 25
D026	Cresol	200.0	4,000	NA	NA	NA	NA	NA
D027	1,4-Dichlorobenzene	7.5	150	**530 Y ****	38	13	34.2%	WL-230 @ 16
D028	1,2-Dichloroethane	0.5	10	ND	36	0	0%	ND
D029	1,1-Dichloroethylene	0.7	14	ND	36	0	0%	ND
D030	2,4-Dinitrotoluene	0.13	3	ND	34	0	0%	
D031	Heptachlor (and its epoxide)	0.008	0	ND	70	0	0%	
D032	Hexachlorobenzene	0.13	3	ND	34	0	0%	
D033	Hexachlorobutadiene	0.5	10	ND	34	0	0%	
D034	Hexachloroethane	3.0	60	ND	34	0	0%	
D035	Methyl ethyl ketone (2-butanone)	200.0	4,000	52	64	10	15.6%	WL-208 @ 15
D036	Nitrobenzene	2.0	40	ND	34	0	0%	
D037	Pentachlorophenol	100.0	2,000	0.085 J	34	1	2.9%	WL-208 @ 28
D038	Pyridine	5.0	100	NA	NA	NA	NA	
D039	Tetrachloroethylene	0.7	14	ND	36	0	0%	
D040	Trichloroethylene	0.5	10	ND	36	0	0%	
D041	2,4,5-Trichlorophenol	400.0	8,000	ND	32	0	0%	
D042	2,4,6-Trichlorophenol	2.0	40	ND	34	0	0%	
D043	Vinyl chloride	0.2	4	ND	36	0	0%	

Notes:

HW = Hazardous Waste   TC = Toxicity Characteristic   DAF = Dilution-Attenuation Factor   ft = feet

mg/L = milligrams per liter   mg/kg = milligrams per kilogram

[1]Bolded maximum concentrations = measured contaminant concentration is greater than the RegulatoryLevel times a DAF of 20.

ND = not detected NA = constituent not analyzed for

J - Estimated value, as result was below laboratory reporting limit.

Y - Estimated value, as all surrogate compounds were diluted beyond detection limits.

* Result is from a sample obtained from a crushed 5-gallon bucket.

** Result is from EPA Method 8270. A result of 2,100 Y was obtained from the EPA Method 8260 analysis of this sample.

Table 2-10: Baseline Perimeter Air Monitoring Results for Radon

DRAFT

On-Site Perimeter Monitoring Stations

Monitoring Station No.	Test Duration 5/1/15 7/23/15	Test Duration 7/23/15 10/14/15	Test Duration 10/14/15 1/7/16	Test Duration 1/7/16 4/13/16	Test Duration 4/13/16 7/20/16	Test Duration 7/20/16 10/26/16	Test Duration 10/26/16 1/26/17	Test Duration 1/26/17 5/2/17	Average (1/2 RL for ND)	Average (RLs for ND)
A1	<0.4	<0.4	0.5	<0.4	<0.4	0.5	<0.4	<0.4	0.28	1.33
A2	<0.4	0.7	0.6	0.6	<0.4	<0.4	<0.4	<0.4	1.04	1.61
A3	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.4	0.23	1.30
A4	<0.4	0.4	<0.4	0.5	<0.4	<0.4	<0.4	<0.4	0.83	1.43
A5	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.20	1.30
A6	<0.4	0.5	0.4	0.4	<0.4	<0.4	0.4	<0.4	0.76	1.31
A7	<0.4	0.7	0.5	<0.4	<0.4	<0.4	<0.4	<0.4	0.30	1.35
A8	<0.4	0.5	<0.4	0.5	<0.4	<0.4	<0.4	<0.4	0.28	0.88
A8 DUP								<0.4		
A9	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.20	1.30
A10	<0.4	0.5	0.4	<0.4	<0.4	0.4	<0.4	0.4	0.30	1.31
A10 DUP			<0.4							
A11	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.5	0.25	1.31
A11 DUP		0.4								
A12	<0.4	<0.4	0.5	<0.4	<0.4	<0.4	<0.4	0.5	0.28	1.33
A12 DUP	<0.4									
A13	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.4	<0.4	0.23	1.30
A13 DUP				0.6			<0.4			

EPA Off-Site Monitoirng Stations (TetraTech, 2015)

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Number of Measurements	43	43	43	41	42
Minimum Concentration	0.19	0.15	0.12	0.09	0.11
Median Concentration	0.28	0.24	0.27	0.21	0.3
Maximum Concentration	1.01	1.81	1.88	0.95	1.45

Note: All concentrations are in units of picoCuries per liter (pCi/L).

Table 2-11: Summary of Gross Alpha Results in Particulate Air Samples

On-Site Perimeter Monitoring Stations

Summary Statistic	Station A-1 (pCi/m^3)	Station A-2 (pCi/m^3)	Station A-3 (pCi/m^3)	Station A-4 (pCi/m^3)	Station A-5 (pCi/m^3)	Station A- 6 (pCi/m^3)	Station A-7 (pCi/m^3)
Detections	19/19	15/15	19/19	19/19	19/19	19/19	19/19
Minimum Concentration	26/26	22/22 [1]	26/26	26/26	26/26	26/26	22/22
Median Concentration	1.39E-03 J	1.41E-03	1.23E-03	1.28E-03	1.40E-03	5.27E-04 J+	1.18E-03
Maximum Concentration	3.51E-03	3.28E-03	3.41E-03	3.34E-03	3.50E-03	3.50E-03	2.78E-03

Summary Statistic	Station A-8 (pCi/m^3)	Station A- 9 (pCi/m^3)	Station A-10 (pCi/m^3)	Station A- 11 (pCi/m^3)	Station A-12 (pCi/m^3)	Station A-13 (pCi/m^3)
Detections	26/26	25/25 [2]	26/26	26/26	26/26	26/26
Minimum Concentration	1.50E-03	1.46E-03	5.70E-04	6.56E-04	1.58E-03	1.40E-03
Median Concentration	3.59E-03	3.38E-03	3.12E-03	3.57E-03	3.49E-03	3.64E-03
Maximum Concentration	5.82E-03 J+	4.57E-03 J+	5.82E-03 J+	6.16E-03 J+	5.72E-03 J+	5.61E-03 J+

Represents results for monitoring performed from May 2015 through April 2017

EPA Off-Site Monitroing Stations (TetraTech, 2015)

Summary Statistic	Station 1 (pCi/m^3)	Station 2 (pCi/m^3)	Station 3 (pCi/m^3)	Station 4 (pCi/m^3)	Station 5 (background) (pCi/m^3)
Detections	36/44	34/44	30/44	40/64	32/44
Minimum Concentration	1.99E-04 U	1.93E-04 U	1.02E-04 U	1.17E-04 U	1.10E-04 U
Median Concentration	6.42E-04	6.25E-04	6.32E-04	6.06E-04	6.97E-04
Maximum Concentration	1.63E-03 J	1.68E-03 J	1.58E-03 J	1.38E-03 J	1.65E-03 J

Notes: pCi/m^3 = picoCuries per cubic meter; U - Not detected; J - Estimated value; J+ - Estimated value, biased high

Table 2-12: Summary of Gross Beta Results in Particulate Air Samples

On-Site Perimeter Monitoring Stations

Summary Statistic	Station A-1 (pCi/m^3)	Station A-2 (pCi/m^3)	Station A-3 (pCi/m^3)	Station A-4 (pCi/m^3)	Station A-5 (pCi/m^3)	Station A-6 (pCi/m^3)	Station A-7 (pCi/m^3)
Detections	26/26	22/22 [1]	26/26	26/26	26/26	26/26	26/26
Minimum Concentration	9.25E-03 J+	1.03E-02 J+	1.14E-02 J+	1.11E-02 J+	1.17E-02 J+	4.06E-03 J+	9.88E-03 J+
Median Concentration	2.70E-02	2.48E-02	2.72E-02	2.65E-02	2.91E-02	2.68E-02	2.23E-02
Maximum Concentration	4.81E-02 J+	4.39E-02 J+	4.60E-02 J+	4.77E-02 J+	4.31E-02 J+	4.43E-02 J+	4.35E-02 J+

Summary Statistic	Station A-8 (pCi/m^3)	Station A-9 (pCi/m^3)	Station A-10 (pCi/m^3)	Station A-11 (pCi/m^3)	Station A-12 (pCi/m^3)	Station A-13 (pCi/m^3)
Detections	26/26	25/25 [2]	26/26	26/26	26/26	26/26
Minimum Concentration	1.30E-02 J+	9.97E-03 J+	9.79E-03 J+	1.19E-02 J+	1.05E-02 J+	1.35E-02 J+
Median Concentration	2.65E-02	2.56E-02	2.22E-02	2.68E-02	2.73E-02	2.65E-02
Maximum Concentration	4.87E-02 J+	4.23E-02 J+	3.84E-02 J+	4.76E-02 J+	4.46E-02 J+	4.45E-02 J+

Represents results for monitoring performed from May 2015 through April 2017

EPA Off-Site Monitoring Stations (TetraTech, 2015)

Summary Statistic	Station 1 (pCi/m^3)	Station 2 (pCi/m^3)	Station 3 (pCi/m^3)	Station 4 (pCi/m^3)	Station 5 (pCi/m^3)
Detections	44/44	44/44	44/44	64/64	44/44
Minimum Concentration	1.15E-02	4.13E-03 J	1.32E-02 J	1.16E-02 J	1.21E-02 J
Median Concentration	1.98E-02	2.05E-02	2.04E-02	1.87E-02	1.93E-02
Maximum Concentration	3.95E-02	4.36E-02	3.96E-02	4.15E-02	4.31E-02

Notes: pCi/m^3 = picoCuries per cubic meter; U - Not detected; J - Estimated value; J+ - Estimated value, biased high

Table 2-13: Thorium-230 Statistics for Particulate Air Samples

On-Site Perimeter Monitoring Stations

Summary Statistic	Station 1 (pCi/m3)	Station 2 (pCi/m3)	Station 3 (pCi/m3)	Station 4 (pCi/m3)	Station 5 (pCi/m3)	Station 6 (pCi/m3)	Station 7 (pCi/m3)	Station 8 (pCi/m3)	Station 9 (pCi/m3)	Station 10 (pCi/m3)	Station 11 (pCi/m3)	Station 12 (pCi/m3)	Station 13 (pCi/m3)
Detections	9/10	8/10[1]	10/10	10/10	10/10	10/10	10/10	10/10	9/9[2]	10/10	10/10	10/10	10/10
Minimum Concentration	8.21E-06 J+	7.20E-06 U	1.90E-05	1.41E-05 J+	1.67E-05 J+	1.05E-05 J	1.60E-05 J+	1.15E-05 J+	1.32E-05	1.00E-05 J+	1.10E-05 J+	8.97E-06 J+	1.45E-05 J
Median Concentration	2.07E-05	2.17E-05	2.87E-05	3.84E-05	3.16E-05	2.32E-05	3.62E-05	2.61E-05	3.05E-05	3.40E-05	3.28E-05	2.90E-05	2.62E-05
Maximum Concentration	6.58E-05 J+	8.02-05 J+	7.03E-05 J+	4.94E-05 J+	7.02E-05 J+	8.06E-05 J+	7.22E-05 J+	6.66E-05 J+	5.62E-05 J+	8.02E-05 J+	2.09E-04 J+	8.64E-05 J+	4.39E-05 J

Sampling results from May, June, September and December, 2015, March, May, August, and November, 2016, and February, and April 2017 .

pCi/m^3 = picoCuries/cubic meter

[1] Station A-2 was out of service for a 4 month period due to flooding.

[2] Station A-9 was out of service for 1 month due to power failure.

EPA Off-Site Monitoring Stations (TetraTech, 2015)

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections	42/44	39/44	42/44	55/64	42/44
Minimum Concentration	1.77E-04 U	2.63E-04 J	1.37E-04 J	1.81E-04 J	2.71E-04 U
Median Concentration	4.71E-04	5.66E-04	5.10E-04	5.38E-04	5.17E-04
Maximum Concentration	4.37E-03	1.36E-03 J	8.86E-04 J	1.80E-03 J	1.99E-03 J

Notes: All concentrations in picoCuries per cubic meter (pCi/m^3)

J = Indicates an estimated result

U = Indicates a non-detected result

Table 2-14 Uranium-238 Statistics for Particulate Air Samples

On-Site Perimeter Monitoring Stations

Summary Statistic	Station 1 (pCi/m3)	Station 2 (pCi/m3)	Station 3 (pCi/m3)	Station 4 (pCi/m3)	Station 5 (pCi/m3)	Station 6 (pCi/m3)	Station 7 (pCi/m3)	Station 8 (pCi/m3)	Station 9 (pCi/m3)	Station 10 (pCi/m3)	Station 11 (pCi/m3)	Station 12 (pCi/m3)	Station 13 (pCi/m3)
Detections	10/10	9/9 [1]	10/10	10/10	10/10	10/10	10/10	10/10	9/9 [2]	10/10	10/10	10/10	10/10
Minimum Concentration	1.34E-05 J+	1.84E-05 J+	2.09E-05 J+	1.60E-05 J+	1.38E-05 J	8.94E-06 J+	1.77E-05 J+	1.30E-05 J+	1.71E-05 J+	1.79E-05 J+	1.93E-05 J+	1.87E-05 J+	1.69E-05 J+
Median Concentration	3.08E-05	2.85E-05	2.81E-05	2.73E-05	2.64E-05	2.55E-05	2.93E-05	3.05E-05	2.97E-05	3.13E-05	2.45E-05	2.47E-05	2.69E-05
Maximum Concentration	3.64E-05 J+	8.95E-05 J+	5.08E-05 J	4.06E-05 J	5.72E-05 J+	3.71E-05 J+	5.37E-05 J+	5.05E-05 J	4.52E-05 J+	4.34E-05 J+	5.05E-05 J+	4.13E-05	4.26E-05 J+

Sampling results from May, June, September and December, 2015, March, May, August, and November, 2016, and February, and April 2017 .

pCi/m^3 = picoCuries/cubic meter

[1] Station A-2 was out of service for a 4 month period due to flooding.

[2] Station A-9 was out of service for 1 month due to power failure.

EPA Off-Site Monitoring Stations (TetraTech, 2015)

Summary Statistic	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5 (reference)**
Detections	19/44	24/44	22/44	21/64	14/44
Minimum Concentration	-1.61E-04 U	-8.55E-05 U	-4.42E-05 U	-1.34E-05 U	-2.39E-05 U
Median Concentration	9.38E-05	1.24E-04	1.12E-04	1.03E-04	1.02E-04
Maximum Concentration	6.22E-04 J	1.08E-03 J	3.86E-04 J	3.07E-04 J	2.25E-04 J

Notes: All concentrations in picoCuries per cubic meter (pCi/m^3)

J = Indicates an estimated result

U = Indicates a non-detected result

Table 2-15: Total Radium Statistics for Particulate Air Samples

On-Site Perimeter Monitoring Stations

Summary Statistic	Station 1 (pCi/m3)	Station 2 (pCi/m3)	Station 3 (pCi/m3)	Station 4 (pCi/m3)	Station 5 (pCi/m3)	Station 6 (pCi/m3)	Station 7 (pCi/m3)	Station 8 (pCi/m3)	Station 9 (pCi/m3)	Station 10 (pCi/m3)	Station 11 (pCi/m3)	Station 12 (pCi/m3)	Station 13 (pCi/m3)
Detections	4/10	5/9[1]	4/10	6/10	4/10	5/10	5/10	6/10	2/9[2]	5/10	6/10	3/10	5/10
Minimum Concentration	2.07E-05 U	1.21E-04 U	7.11E-05 U	5.15E-05 U	3.71E-05 U	4.51E-05 U	4.15E-05	2.85E-05 U	2.75E-05 U	1.11E-05 U	1.48E-04 U	3.63E-05 U	2.53E-05 U
Median Concentration	9.12E-05	1.77E-04	1.81E-04	1.75E-04	1.11E-04	2.16E-04	2.70E-04	1.66E-04	8.41E-05	1.59E-04	2.88E-04	1.38E-04	1.37E-04
Maximum Concentration	3.22E-04	3.57E-04	8.75E-04	3.33E-04 J	5.51E-04 U	3.50E-04 J	3.94E-04	5.21E-04	2.26E-04	2.90E-04	4.44E-04	6.14E-04 J	3.50E-04

Sampling results from May, June, September and December, 2015, March, May, August, and November, 2016, and February, and April 2017 .

pCi/m3 = picoCuries/cubic meter

[1] Station A-2 was out of service for a 4 month period due to flooding.

[2] Station A-9 was out of service for 1 month due to power failure.

EPA Off-Site Monitoring Stations (TetraTech, 2015)

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections	3/43	4/43	3/43	3/63	2/43
Minimum Concentration	-2.50E-04 U	-6.83E-04 U	-1.56E-04 U	-4.86E-04 U	-4.34E-04 U
Median Concentration	4.49E-04	4.55E-04	3.50E-04	4.58E-04	4.68E-04
Maximum Concentration	1.10E-03 J	1.80E-03 J	2.01E-03	1.38E-03 J	4.40E-03

Notes: All concentrations in picoCuries per cubic meter (pCi/m^3)

J = Indicates an estimated result

U = Indicates a non-detected result

Table 2-16: Summary of EPA Off-site Air Monitoring Results

SUMMARY STATISTICS OF GROSS ALPHA RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (background)
Detections[1]	36/44	34/44	30/44	40/64	32/44
Minimum Concentration[2]	1.99E-04 U	1.93E-04 U	1.02E-04 U	1.17E-04 U	1.10E-04 U
Median Concentration[3]	6.42E-04	6.25E-04	6.32E-04	6.06E-04	6.97E-04
Maximum Concentration[4]	1.63E-03 J	1.68E-03 J	1.58E-03 J	1.38E-03 J	1.65E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

[1] Number of detections / number of samples. U-coded results were counted as not detected.
[2] Includes lowest reported value among both U-coded and non-U-coded results.
[3] Median concentration among U-coded and non-U-coded results.
[4] Maximum detected (non-U-coded) concentration.

SUMMARY STATISTICS OF GROSS BETA RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	44/44	44/44	44/44	64/64	44/44
Minimum Concentration	1.15E-02	4.13E-03 J	1.32E-02 J	1.16E-02 J	1.21E-02 J
Median Concentration	1.98E-02	2.05E-02	2.04E-02	1.87E-02	1.93E-02
Maximum Concentration	3.95E-02	4.36E-02	3.96E-02	4.15E-02	4.31E-02

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result

[1] Number of detections / number of samples (no gross beta results are U-coded).

SUMMARY STATISTICS OF URANIUM-238 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	19/44	24/44	22/44	21/64	14/44
Minimum Concentration[2]	-1.61E-04 U	-8.55E-05 U	-4.42E-05 U	-1.34E-05 U	-2.39E-05 U
Median Concentration[3]	9.38E-05	1.24E-04	1.12E-04	1.03E-04	1.02E-04
Maximum Concentration[4]	6.22E-04 J	1.08E-03 J	3.86E-04 J	3.07E-04 J	2.25E-04 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

[1] Number of detections / number of samples. U-coded results were counted as not detected.
[2] Includes lowest reported value among both U-coded and non-U-coded results.
[3] Median concentration among U-coded and non-U-coded results.
[4] Maximum detected (non-U-coded) concentration.

Table 2-16: Summary of EPA Off-site Air Monitoring Results

SUMMARY STATISTICS OF THORIUM-230 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	42/44	39/44	42/44	55/64	42/44
Minimum Concentration[2]	1.77E-04 U	2.63E-04 J	1.37E-04 J	1.81E-04 J	2.71E-04 U
Median Concentration[3]	4.71E-04	5.66E-04	5.10E-04	5.38E-04	5.17E-04
Maximum Concentration[4]	4.37E-03	1.36E-03 J	8.86E-04 J	1.80E-03 J	1.99E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

[1] Number of detections / number of samples. U-coded results were counted as not detected.
[2] Includes lowest reported value among both U-coded and non-U-coded results.
[3] Median concentration among U-coded and non-U-coded results.
[4] Maximum detected (non-U-coded) concentration.

SUMMARY STATISTICS OF TOTAL ALPHA-EMITTING RADIUM RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	3/43	4/43	3/43	3/63	2/43
Minimum Concentration[2]	-2.50E-04 U	-6.83E-04 U	-1.56E-04 U	-4.86E-04 U	-4.34E-04 U
Median Concentration[3]	4.49E-04	4.55E-04	3.50E-04	4.58E-04	4.68E-04
Maximum Concentration[4]	1.10E-03 J	1.80E-03 J	2.01E-03	1.38E-03 J	4.40E-03

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)
J Indicates an estimated result
U Indicates a non-detected result

[1] Number of detections / number of samples. U-coded results were counted as not detected.
[2] Includes lowest reported value among both U-coded and non-U-coded results.
[3] Median concentration among U-coded and non-U-coded results.
[4] Maximum detected (non-U-coded) concentration.

Table 2-16: Summary of EPA Off-site Air Monitoring Results

SUMMARY STATISTICS OF RADON-222 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Number of Measurements	43	43	43	41	42
Minimum Concentration	0.19	0.15	0.12	0.09	0.11
Median Concentration	0.28	0.24	0.27	0.21	0.30
Maximum Concentration	1.01	1.81 LV2	1.88 LV1	0.95 E1	1.45 LV1

Notes:

All concentrations in picoCuries per liter (pCi/L)

E Indicates one of three replicate measurements yielded a negative radon concentration. The negative radon value was not included in the reported mean radon concentration.

LV Indicates one (LV1) or two (LV2) of the three replicate measurements were not used in the calculation of the reported mean ^{222}Rn concentration because the measurement derived from an electret showing a reading below 200 volts.

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Gross Alpha					Gross Beta				
		pCi/L					pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16										
NCC-001	4/6/16	16.535	5.310		3.696	4.858	14.683	4.182		13.771	6.162
NCC-001	5/10/16	13.728	4.707	J	0.475	3.795	20.764	4.735	S-	9.249	5.920
NCC-001	7/6/16	10.268	5.515	J	1.834	8.633	13.604	5.593	U	16.978	9.771
NCC-001	8/15/16	6.894	3.703	J	1.315	5.797	9.601	4.056	U	18.551	7.212
NCC-001	9/9/16	4.499	3.083	U	4.553	5.572	7.732	2.892	U	9.068	4.867
NCC-001	11/3/16	4.103	3.749	J	0.713	7.128	13.459	3.484		10.374	4.954
OU-1-001	1/20/17	7.892	8.636	J	2.405	16.764	22.331	9.302	U	25.608	16.266
OU-1-001	2/21/17	-3.903	8.564	UJ+	9.993	22.189	28.907	10.098	U	35.720	16.640
OU-1-001	3/1/17	0.000	6.880	U	8.463	16.499	13.523	7.651	U	23.189	14.386
OU-1-001	4/5/17	6.288	3.061		0.551	4.779	8.822	2.457		5.844	3.620
OU-1-001	5/3/17	3.061	1.495	U	3.181	2.167	19.154	3.501		5.957	3.136
OU-1-001	6/15/17	3.229	3.422	J	2.933	6.675	8.006	3.288	U	10.322	5.833
OU-1-001	7/27/17	0.960	2.029	J	0.510	4.366	6.628	2.172		5.746	3.529
OU-1-001	8/17/17	1.662	2.775	U	2.410	5.823	9.193	2.675		5.551	4.013
OU-1-001	10/10/17	3.670	3.619	J	2.079	6.955	14.986	5.587	U	21.549	9.681
NCC-002	3/30/16										
NCC-002	4/11/16	38.990	13.195	J	7.849	14.068	22.483	8.707	U	32.583	14.782
NCC-002	5/11/16	17.150	20.669	U	17.588	40.983	44.912	34.067	UJ-	130.43	66.626
NCC-002	7/6/16	40.216	11.983		1.209	10.158	53.074	10.656		15.563	10.881
NCC-002	8/15/16	16.963	7.284		1.716	10.187	19.552	6.268	U	23.542	9.921
NCC-002	9/9/16	10.832	4.273		4.483	5.449	16.162	4.733		11.734	7.063
NCC-002	11/3/16	14.562	6.646		1.185	9.280	17.604	5.643	U	19.529	8.915
OU-1-002	1/20/17	17.914	9.252	J	2.617	14.549	19.821	8.552	U	28.458	15.136
OU-1-002	3/27/17	13.231	8.229	J	1.956	14.383	22.745	6.969		19.248	10.949
OU-1-002	4/5/17	10.067	6.457	J	1.033	11.290	18.246	5.375		14.021	8.345
OU-1-002	5/3/17	10.468	4.013		1.858	5.239	18.079	3.647		5.429	3.832
OU-1-002	6/15/17	5.291	4.527	J	3.115	8.529	11.769	3.724		9.856	5.998
OU-1-002	7/27/17	19.489	5.418	J	0.552	4.790	10.375	3.114		7.201	4.692
OU-1-002	8/17/17	13.467	5.319		2.915	7.077	18.526	4.274		8.361	5.438
OU-1-002	10/10/17	8.979	5.758	J	1.946	10.069	17.176	5.408		14.703	8.478
NCC-003	3/30/16										
NCC-003	4/6/16	7.190	6.211	J	5.483	11.658	12.319	5.180	U	20.601	9.156
NCC-003	5/11/16	38.355	11.337		1.572	13.139	33.998	8.308	J-	19.783	11.257
NCC-003	7/6/16	89.195	26.027		4.906	31.481	97.124	20.734		41.407	24.031
NCC-003	8/15/16	3.513	1.814	J	0.836	2.853	6.178	2.101	U	9.104	3.436
NCC-003	9/9/16	11.688	4.094		3.102	5.211	16.581	3.822		8.698	4.887
NCC-003A	9/16/16	7.079	4.698	J	4.871	8.364	14.998	4.108		9.599	5.895
NCC-003A	11/3/16	15.966	4.641		0.568	3.831	19.507	4.105		9.633	4.480
OU-1-003A	1/20/17	14.715	9.767	J	2.334	17.253	12.526	7.351	U	24.627	13.824
OU-1-003A	3/1/17	8.482	5.122	J	4.836	6.700	11.613	5.468	U	14.599	9.881
OU-1-003A	4/5/17	5.936	3.939	J	0.669	7.014	17.270	3.628		5.993	4.099
OU-1-003A	5/3/17	4.838	1.947		2.248	2.177	10.693	2.636		6.397	3.600
NCC-004	5/12/16	39.595	10.775		1.709	8.261	45.021	10.355	J	31.614	12.858

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Gross Alpha pCi/L					Gross Beta pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	-0.170	1.081	U	1.709	2.530	6.625	2.109	U	8.872	3.431
OU-1-004	5/3/17	1.635	1.521	U	3.000	2.863	10.034	2.431		5.485	3.197
OU-1-004	5/3/17										
OU-1-006	4/29/17	3.649	1.369	U	4.303	1.587	6.074	1.969	U	6.287	3.116
NCC-007	11/3/16	5.275	2.795	J	0.551	4.443	15.050	3.176		8.356	3.714
OU-1-007	1/20/17	7.346	4.511	J	0.726	7.593	13.344	3.707		8.380	5.510
OU-1-007	2/21/17	2.349	4.966	UJ+	5.334	10.684	29.891	7.142		22.280	9.624
OU-1-007	3/1/17	2.207	2.534	J	1.729	5.020	15.088	3.286		6.590	4.055
OU-1-007	4/5/17	5.743	2.074		0.401	1.764	10.221	2.670		7.101	3.809
OU-1-007	5/3/17	4.610	2.580	J	2.416	4.194	6.547	2.375	U	7.240	3.996
OU-1-007	6/15/17	2.583	2.510	J	2.171	4.833	11.767	2.766		5.696	3.606
OU-1-007	7/27/17	3.358	2.036	J	0.367	3.164	8.554	2.262		4.930	3.226
OU-1-008	3/30/17	3.142	3.572	J	0.701	7.117	19.207	3.824		5.928	4.034
OU-1-008	4/5/17	10.453	5.268	J	0.754	8.197	23.682	5.201		10.095	6.356
OU-1-008	5/3/17	0.671	2.440	U	2.779	5.437	10.917	3.091		8.203	4.688
OU-1-009	4/30/17	0.426	2.831	U	1.886	6.330	11.812	2.787		5.822	3.695
OU-1-009	5/4/17	14.495	5.815		2.847	7.813	28.312	6.062		9.887	6.931
OU-1-010	4/30/17	53.677	19.166		15.942	26.523	36.294	14.345	U	40.205	24.127
OU-1-010	5/4/17	27.901	9.348		5.799	11.536	13.139	5.877	U	18.326	10.400
OU-1-011	4/30/17	17.537	5.117		2.584	6.189	13.340	3.372		7.983	4.646
OU-1-011	5/4/17	9.347	3.071		2.182	3.853	7.130	2.135		5.478	3.234
BUFFER ZONE	4/26/16	5.302	2.517		1.603	3.181	10.366	2.660		7.935	3.772
FRAC TANK	1/11/16	41.805	6.862		2.463	2.949	17.750	3.523		6.688	3.588
OUTFALL 008	4/30/17	34.491	11.761	J	3.635	10.274	27.380	7.329		14.767	7.980
OUTFALL 008	4/30/17	9.584	5.366	J	0.902	8.328	23.06	4.443	J-	6.167	4.465

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Radium-226 pCi/L					Radium-228 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16	0.863	0.585	J	0.013	0.427	-0.043	0.823	UJ	0.186	1.761
NCC-001	4/6/16	0.142	0.338	J	0.077	0.652	1.469	0.888	J	1.342	1.592
NCC-001	5/10/16	0.473	0.311	J	0.009	0.237	0.541	0.564	U	0.838	1.119
NCC-001	7/6/16	0.436	0.360	J	0.031	0.415	0.928	0.506	J	0.744	0.882
NCC-001	8/15/16	0.116	0.206	J	0.030	0.370	-0.072	0.228	U	0.711	0.519
NCC-001	9/9/16	0.583	0.358	J	0.011	0.267	0.409	0.394	J+	0.088	0.775
NCC-001	11/3/16	0.579	0.361	J+	0.022	0.314	2.268	0.765	J+	0.128	0.979
OU-1-001	1/20/17	0.300	0.271	J	0.019	0.316	2.039	0.730		0.131	0.998
OU-1-001	2/21/17	0.373	0.328	J	0.019	0.363	0.419	0.507	U	0.783	1.019
OU-1-001	3/1/17	0.368	0.285	J	0.010	0.258	0.819	0.494	J+	0.102	0.894
OU-1-001	4/5/17	1.390	0.613		0.020	0.324	0.330	0.415	U	0.615	0.837
OU-1-001	5/3/17	0.281	0.213	J	0.011	0.207	4.220	1.105	J	0.602	0.788
OU-1-001	6/15/17	0.312	0.258	J	0.022	0.297	0.289	0.435	UJ	0.745	0.888
OU-1-001	7/27/17	0.349	0.274	J	0.025	0.308	0.683	0.410	J	0.641	0.737
OU-1-001	8/17/17	0.298	0.242	J	0.007	0.214	0.341	0.412	U	0.708	0.828
OU-1-001	10/10/17	0.296	0.234	J	0.020	0.250	0.033	0.389	U	0.737	0.829
NCC-002	3/30/16	0.621	0.368	J	0.011	0.263	0.571	0.494	U	0.807	0.953
NCC-002	4/11/16	1.017	0.520	J	0.026	0.371	0.242	0.377	J	0.090	0.771
NCC-002	5/11/16	0.709	0.431	J	0.026	0.374	0.740	0.485	J	0.630	0.896
NCC-002	7/6/16	0.594	0.385	J	0.029	0.371	0.430	0.388	UJ	0.726	0.754
NCC-002	8/15/16	1.190	0.541	J	0.009	0.255	0.316	0.256	UJ	0.624	0.480
NCC-002	9/9/16	0.770	0.409	J	0.006	0.221	0.709	0.418	J+	0.087	0.749
NCC-002	11/3/16	2.967	1.205	J+	0.013	0.434	0.850	0.543	J+	0.131	0.993
OU-1-002	1/20/17	0.764	0.519	J	0.024	0.450	0.623	0.688	J	0.169	1.372
OU-1-002	3/27/17	0.590	0.418	J	0.046	0.455	-0.238	0.475	U	0.643	1.027
OU-1-002	4/5/17	0.573	0.340	J	0.011	0.243	0.813	0.420	J	0.589	0.712
OU-1-002	5/3/17	0.287	0.261	J	0.031	0.338	0.558	0.396	UJ	0.586	0.738
OU-1-002	6/15/17	0.590	0.373	J	0.020	0.310	0.364	0.499	U	0.786	1.013
OU-1-002	7/27/17	0.629	0.347	J	0.019	0.248	0.262	0.365	U	0.716	0.741
OU-1-002	8/17/17	0.740	0.412	J	0.012	0.272	0.348	0.386	U	0.620	0.769
OU-1-002	10/10/17	0.504	0.325	J	0.031	0.327	-0.255	0.421	U	0.682	0.913
NCC-003	3/30/16	0.374	0.358	J	0.032	0.454	0.457	0.865	UJ	1.395	1.786
NCC-003	4/6/16	0.964	0.577	J	0.011	0.364	0.901	0.737	UJ	1.069	1.416
NCC-003	5/11/16	1.914	0.930	J	0.028	0.542	2.972	1.125		1.371	1.598
NCC-003	7/6/16	2.951	1.303		0.058	0.763	1.640	0.940	J	1.465	1.661
NCC-003	8/15/16	-0.010	0.142	UJ	0.038	0.376	0.477	0.387	U	0.691	0.737
NCC-003	9/9/16	0.858	0.444	J	0.007	0.232	0.834	0.443	J+	0.087	0.768
NCC-003A	9/16/16	0.368	0.304	J	0.027	0.350	0.756	0.447	J	0.100	0.796
NCC-003A	11/3/16	0.240	0.217	J+	0.009	0.229	2.947	0.868	J+	0.119	0.892
OU-1-003A	1/20/17	0.354	0.285	J	0.026	0.330	0.378	0.379	J	0.103	0.748
OU-1-003A	3/1/17	0.355	0.282	J	0.013	0.274	1.078	0.503	J+	0.105	0.821
OU-1-003A	4/5/17	0.264	0.232	J	0.014	0.257	1.057	0.478		0.621	0.762
OU-1-003A	5/3/17	0.089	0.258	J	0.060	0.514	0.185	0.380	UJ	0.583	0.787
NCC-004	5/12/16	2.055	0.739	J	0.038	0.366	1.799	0.628	J	0.088	0.841

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Radium-226 pCi/L					Radium-228 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	0.164	0.187	J	0.016	0.260	0.719	0.464	J	0.557	0.854
OU-1-004	5/3/17						2.050	0.659		0.635	0.778
OU-1-004	5/3/17	0.301	0.316	J+	0.010	0.328					
OU-1-006	4/29/17	0.462	0.292	J	0.009	0.211	0.571	0.398	J	0.084	0.743
NCC-007	11/3/16	-0.340	1.039	UJ+	0.129	2.824	2.024	0.762	J+	0.138	1.095
OU-1-007	1/20/17	0.301	0.303	J	0.016	0.352	1.983	0.848	J	0.177	1.326
OU-1-007	2/21/17	0.315	0.294	J	0.039	0.390	0.378	0.385	UJ	0.669	0.760
OU-1-007	3/1/17	0.144	0.151	J	0.004	0.157	0.561	0.478	J+	0.104	0.924
OU-1-007	4/5/17	0.637	0.419	J	0.032	0.395	1.354	0.597		0.706	0.950
OU-1-007	5/3/17	0.064	0.147	J	0.029	0.286	0.291	0.417	UJ	0.589	0.848
OU-1-007	6/15/17	0.328	0.257	J	0.031	0.298	0.962	0.469	J	0.651	0.789
OU-1-007	7/27/17	0.525	0.335	J	0.009	0.202	0.604	0.637	UJ	1.132	1.264
OU-1-008	3/30/17	0.105	0.143	J	0.015	0.222	0.596	0.410	J	0.573	0.763
OU-1-008	4/5/17	0.335	0.283	J	0.030	0.337	0.472	0.452	U	0.675	0.886
OU-1-008	5/3/17	0.013	0.128	UJ	0.025	0.316	0.387	0.441	UJ	0.626	0.883
OU-1-009	4/30/17	0.280	0.260	J	0.023	0.317	0.269	0.434	J	0.094	0.890
OU-1-009	5/4/17	0.574	0.396	J	0.021	0.362	0.607	0.395	J	0.574	0.722
OU-1-010	4/30/17	1.226	0.571	J	0.022	0.339	0.269	0.358	J	0.084	0.725
OU-1-010	5/4/17	0.341	0.283	J	0.011	0.275	0.265	0.407	UJ	0.578	0.832
OU-1-011	4/30/17	0.815	0.416	J	0.016	0.270	0.589	0.429	J	0.084	0.810
OU-1-011	5/4/17	0.668	0.368	J	0.017	0.263	0.341	0.370	UJ	0.552	0.736
BUFFER ZONE	4/26/16	1.198	0.537		0.024	0.322	1.044	0.590	J	0.871	1.040
FRAC TANK	1/11/16	1.741	0.681		0.009	0.250	0.631	0.428	U	0.789	0.785
OUTFALL 008	4/30/17	2.231	2.088	J	0.115	2.366	1.526	0.627	J	0.103	0.962
OUTFALL 008	4/30/17										

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Thorium-228					Thorium-230				
		pCi/L					pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16										
NCC-001	4/6/16	0.307	0.203	J	0.023	0.168	1.337	0.476	J	0.151	0.122
NCC-001	5/10/16	0.615	0.477	J	0.170	0.546	1.292	0.675	J+	0.384	0.384
NCC-001	7/6/16	-0.020	0.065	U	0.051	0.215	0.217	0.175	J+	0.184	0.195
NCC-001	8/15/16	0.106	0.153	J	0.047	0.248	0.315	0.226	J	0.196	0.174
NCC-001	9/9/16	0.058	0.104	J	0.033	0.186	0.664	0.307	J	0.152	0.121
NCC-001	11/3/16	0.058	0.096	J+	0.038	0.168	0.136	0.126	UJ+	0.138	0.154
OU-1-001	1/20/17	0.044	0.095	J+	0.025	0.187	0.253	0.200	J	0.191	0.214
OU-1-001	2/21/17	2.099	0.610		0.020	0.151	6.829	1.618	J+	0.129	0.126
OU-1-001	3/1/17	0.058	0.124	J+	0.050	0.241	0.309	0.223	J+	0.161	0.206
OU-1-001	4/5/17	0.061	0.169	U	0.083	0.347	0.223	0.233	UJ+	0.280	0.306
OU-1-001	5/3/17	0.035	0.088	J+	0.028	0.182	0.140	0.158	UJ+	0.207	0.234
OU-1-001	6/15/17	-0.112	0.128	UJ+	0.113	0.428	0.077	0.187	UJ+	0.334	0.374
OU-1-001	7/27/17	0.312	0.514	J+	0.197	0.897	1.022	0.739	J+	0.652	0.631
OU-1-001	8/17/17	-0.099	0.098	U	0.137	0.363	0.312	0.233	J	0.207	0.211
OU-1-001	10/10/17	0.278	0.283	J	0.037	0.325	0.333	0.306	J	0.328	0.318
NCC-002	3/30/16										
NCC-002	4/11/16	0.087	0.209	UJ	0.094	0.419	0.721	0.435	J	0.324	0.303
NCC-002	5/11/16	0.044	0.105	UJ+	0.048	0.211	0.232	0.179	J+	0.180	0.183
NCC-002	7/6/16	0.059	0.133	UJ	0.098	0.251	0.135	0.137	UJ+	0.174	0.187
NCC-002	8/15/16	0.098	0.160	J	0.042	0.274	0.080	0.156	UJ	0.274	0.291
NCC-002	9/9/16	0.167	0.154	J	0.037	0.189	0.123	0.128	U	0.163	0.160
NCC-002	11/3/16	0.029	0.073	J+	0.024	0.151	0.365	0.203	J+	0.126	0.119
OU-1-002	1/20/17	0.220	0.202	J+	0.061	0.257	0.970	0.420		0.183	0.193
OU-1-002	3/27/17	-0.030	0.064	UJ+	0.033	0.188	0.313	0.202	J	0.151	0.140
OU-1-002	4/5/17	0.123	0.129	J	0.008	0.134	0.200	0.171	J+	0.174	0.178
OU-1-002	5/3/17	0.010	0.062	UJ+	0.023	0.169	0.215	0.166	J+	0.155	0.151
OU-1-002	6/15/17	0.050	0.125	J+	0.039	0.259	0.510	0.316	J+	0.227	0.233
OU-1-002	7/27/17	0.128	0.137	J	0.039	0.188	0.101	0.121	U	0.162	0.175
OU-1-002	8/17/17	0.132	0.174	J	0.093	0.281	0.244	0.193	J	0.189	0.206
OU-1-002	10/10/17	0.071	0.106	J	0.023	0.172	0.243	0.184	J	0.171	0.178
NCC-003	3/30/16										
NCC-003	4/6/16	0.116	0.145	J	0.045	0.219	1.142	0.444		0.172	0.164
NCC-003	5/11/16	1.645	0.656	J+	0.065	0.341	2.528	0.871	J+	0.320	0.334
NCC-003	7/6/16	2.907	1.019		0.146	0.500	7.621	2.075	J+	0.394	0.422
NCC-003	8/15/16	0.089	0.124	J	0.021	0.187	0.339	0.227	J	0.179	0.144
NCC-003	9/9/16	0.585	0.267	J	0.003	0.153	1.227	0.423	J	0.132	0.105
NCC-003A	9/16/16	0.148	0.159	J	0.046	0.219	0.083	0.108	UJ	0.165	0.149
NCC-003A	11/3/16	0.104	0.123	J+	0.035	0.180	0.233	0.166	J+	0.136	0.129
OU-1-003A	1/20/17	0.150	0.163	J+	0.063	0.235	1.595	0.549		0.199	0.230
OU-1-003A	3/1/17	-0.038	0.093	UJ+	0.041	0.265	0.482	0.316	J+	0.240	0.259
OU-1-003A	4/5/17	-0.114	0.152	UJ	0.118	0.493	0.449	0.390	J+	0.396	0.434
OU-1-003A	5/3/17	0.059	0.114	J+	0.040	0.213	0.259	0.192	J+	0.173	0.176
NCC-004	5/12/16	2.544	0.843	J+	0.030	0.264	3.902	1.158	J	0.264	0.207

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Thorium-228					Thorium-230				
		pCi/L					pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	0.167	0.189	J	0.079	0.280	0.297	0.225	J+	0.213	0.236
OU-1-004	5/3/17	0.271	0.189	J+	0.022	0.164	0.405	0.229	J+	0.150	0.147
OU-1-004	5/3/17										
OU-1-006	4/29/17	-0.049	0.065	UJ+	0.051	0.213	0.238	0.177	J	0.158	0.162
NCC-007	11/3/16	0.103	0.118	J+	0.018	0.154	0.270	0.189	J+	0.156	0.163
OU-1-007	1/20/17	0.673	0.322	J+	0.029	0.190	0.519	0.276	J	0.157	0.149
OU-1-007	2/21/17	2.657	0.820	J	0.003	0.215	3.182	0.965	J+	0.184	0.199
OU-1-007	3/1/17	0.144	0.145	J+	0.019	0.169	0.408	0.248	J+	0.180	0.198
OU-1-007	4/5/17	0.123	0.129	J	0.008	0.134	0.510	0.278	J+	0.180	0.189
OU-1-007	5/3/17	0.278	0.199	J+	0.058	0.218	0.277	0.184	J+	0.149	0.151
OU-1-007	6/15/17	0.156	0.150	J+	0.027	0.182	0.256	0.179	J+	0.144	0.121
OU-1-007	7/27/17	0.086	0.124	J	0.038	0.201	0.142	0.133	UJ	0.149	0.123
OU-1-008	3/30/17	0.027	0.096	UJ+	0.042	0.216	0.514	0.278	J	0.162	0.135
OU-1-008	4/5/17	0.159	0.139	J	0.012	0.134	0.349	0.208	J+	0.142	0.132
OU-1-008	5/3/17	0.072	0.118	J+	0.046	0.207	0.256	0.182	J+	0.159	0.167
OU-1-009	4/30/17	-0.053	0.097	UJ+	0.057	0.294	0.221	0.218	J	0.213	0.265
OU-1-009	5/4/17	0.270	0.230	J+	0.049	0.261	0.972	0.442	J+	0.204	0.200
OU-1-010	4/30/17	0.568	0.372	J+	0.070	0.335	0.047	0.140	UJ	0.281	0.304
OU-1-010	5/4/17	0.113	0.157	J+	0.060	0.253	0.048	0.137	UJ+	0.245	0.277
OU-1-011	4/30/17	0.053	0.127	UJ+	0.085	0.245	0.197	0.176	UJ	0.204	0.232
OU-1-011	5/4/17	0.035	0.104	UJ+	0.039	0.226	0.384	0.250	J+	0.196	0.206
BUFFER ZONE	4/26/16	0.196	0.166	J	0.036	0.189	0.192	0.163	J	0.178	0.186
FRAC TANK	1/11/16	0.124	0.141	J	0.034	0.196	27.451	6.046		0.187	0.209
OUTFALL 008	4/30/17	1.549	0.468	J	0.033	0.162	1.110	0.382	J+	0.143	0.159
OUTFALL 008	4/30/17										

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Thorium-232 pCi/L					Uranium-234 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16						1.748	0.525	J	0.058	0.153
NCC-001	4/6/16	0.107	0.117	J	0.013	0.139	2.467	0.782	J+	0.079	0.315
NCC-001	5/10/16	0.486	0.445	J	0.224	0.593	1.539	0.511	J-	0.038	0.186
NCC-001	7/6/16	0.019	0.057	J	0.012	0.136	2.292	0.872	J+	0.045	0.429
NCC-001	8/15/16	0.060	0.103	J	0.015	0.174	2.725	0.663	J+	0.043	0.171
NCC-001	9/9/16	0.072	0.101	J	0.017	0.152	1.903	0.618	J+	0.054	0.227
NCC-001	11/3/16	0.010	0.085	UJ+	0.061	0.196	2.811	0.700	J+	0.074	0.226
OU-1-001	1/20/17	0.042	0.115	U	0.058	0.238	6.226	1.236	J+	0.028	0.191
OU-1-001	2/21/17	2.170	0.616		0.011	0.126	3.880	1.118	J+	0.084	0.307
OU-1-001	3/1/17	0.034	0.095	J+	0.002	0.206	3.122	0.729	J+	0.027	0.173
OU-1-001	4/5/17	-0.024	0.095	UJ+	0.027	0.243	3.754	0.788		0.039	0.147
OU-1-001	5/3/17	-0.025	0.066	UJ+	0.057	0.221	1.481	0.446		0.037	0.145
OU-1-001	6/15/17	0.069	0.151	J+	0.039	0.296	2.394	0.756	J	0.060	0.239
OU-1-001	7/27/17	0.199	0.340	J+	0.049	0.574	1.816	1.045	J-	0.118	0.686
OU-1-001	8/17/17	-0.039	0.086	U	0.079	0.291	1.743	0.554		0.015	0.213
OU-1-001	10/10/17	0.282	0.276	J	0.024	0.290	1.612	0.518		0.036	0.192
NCC-002	3/30/16						0.858	0.378		0.070	0.181
NCC-002	4/11/16	0.048	0.115	J	0.016	0.240	18.490	3.203		0.125	0.324
NCC-002	5/11/16	-0.005	0.058	UJ	0.008	0.121	6.096	1.160	J-	0.031	0.151
NCC-002	7/6/16	-0.005	0.055	UJ	0.032	0.167	13.873	2.594	J+	0.047	0.248
NCC-002	8/15/16	0.073	0.125	J	0.018	0.211	6.031	1.329	J+	0.075	0.265
NCC-002	9/9/16	0.217	0.163	J	0.012	0.135	4.215	0.880	J+	0.047	0.175
NCC-002	11/3/16	-0.013	0.051	UJ+	0.015	0.130	7.323	1.375	J+	0.064	0.210
OU-1-002	1/20/17	0.004	0.125	U	0.102	0.299	10.912	1.750	J+	0.026	0.104
OU-1-002	3/27/17	-0.020	0.061	UJ+	0.022	0.165	10.130	1.746	J+	0.027	0.174
OU-1-002	4/5/17	0.058	0.089	J+	0.007	0.132	9.401	1.532		0.049	0.159
OU-1-002	5/3/17	0.019	0.058	J+	0.012	0.137	4.525	1.038		0.072	0.239
OU-1-002	6/15/17	0.110	0.143	J+	0.017	0.197	4.663	1.085	J	0.044	0.185
OU-1-002	7/27/17	0.040	0.075	J	0.015	0.139	2.295	0.551	J	0.068	0.195
OU-1-002	8/17/17	0.176	0.168	J	0.044	0.214	5.350	1.132		0.021	0.141
OU-1-002	10/10/17	-0.001	0.063	U	0.032	0.187	3.523	0.820		0.075	0.241
NCC-003	3/30/16						3.931	0.839	J	0.056	0.146
NCC-003	4/6/16	0.108	0.142	J	0.051	0.222	5.111	1.164	J+	0.103	0.266
NCC-003	5/11/16	1.612	0.632	J	0.014	0.211	3.924	1.061	J-	0.069	0.315
NCC-003	7/6/16	2.396	0.882		0.095	0.421	2.368	0.796	J+	0.102	0.373
NCC-003	8/15/16	0.029	0.069	J	0.008	0.144	2.741	0.808	J+	0.110	0.329
NCC-003	9/9/16	0.267	0.170	J	0.010	0.120	1.565	0.433	J+	0.024	0.116
NCC-003A	9/16/16	0.015	0.064	UJ	0.018	0.163	4.342	0.909	J	0.087	0.233
NCC-003A	11/3/16	0.049	0.075	J+	0.007	0.112	5.796	1.185	J+	0.046	0.185
OU-1-003A	1/20/17	0.220	0.181	J	0.048	0.210	10.904	1.755	J+	0.030	0.120
OU-1-003A	3/1/17	-0.007	0.086	UJ+	0.010	0.180	4.625	1.048	J+	0.064	0.214
OU-1-003A	4/5/17	-0.078	0.143	UJ+	0.083	0.433	4.347	1.006	J	0.042	0.174
OU-1-003A	5/3/17	0.005	0.065	UJ+	0.029	0.186	1.561	0.453		0.035	0.140
NCC-004	5/12/16	2.989	0.925	J	0.030	0.259	2.403	0.802		0.053	0.276

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Thorium-232 pCi/L					Uranium-234 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	0.171	0.170	J+	0.037	0.216	0.367	0.234	J	0.046	0.184
OU-1-004	5/3/17	0.065	0.097	J+	0.021	0.158	0.535	0.268	J	0.046	0.174
OU-1-004	5/3/17										
OU-1-006	4/29/17	0.066	0.100	J+	0.021	0.161	1.328	0.534	J	0.075	0.273
NCC-007	11/3/16	-0.005	0.062	UJ+	0.037	0.191	1.925	0.568	J+	0.035	0.160
OU-1-007	1/20/17	0.166	0.154	J	0.024	0.176	3.300	0.738	J+	0.033	0.132
OU-1-007	2/21/17	2.620	0.801	J	0.021	0.185	4.125	1.373	J+	0.157	0.505
OU-1-007	3/1/17	0.015	0.064	UJ+	0.018	0.165	1.620	0.452	J+	0.045	0.151
OU-1-007	4/5/17	0.015	0.064	UJ+	0.018	0.165	1.753	0.457	J	0.046	0.152
OU-1-007	5/3/17	0.138	0.133	J+	0.025	0.160	0.631	0.290		0.024	0.180
OU-1-007	6/15/17	0.038	0.103	UJ+	0.051	0.213	1.026	0.416		0.083	0.256
OU-1-007	7/27/17	0.137	0.132	J	0.012	0.141	0.417	0.248	J	0.039	0.191
OU-1-008	3/30/17	0.081	0.113	J+	0.019	0.170	3.082	0.774	J+	0.037	0.142
OU-1-008	4/5/17	0.105	0.110	J+	0.007	0.115	3.635	0.787	J	0.046	0.163
OU-1-008	5/3/17	0.040	0.115	UJ+	0.073	0.234	1.419	0.446	J	0.034	0.139
OU-1-009	4/30/17	-0.007	0.088	UJ+	0.010	0.184	1.804	0.522	J	0.065	0.204
OU-1-009	5/4/17	0.444	0.276	J+	0.015	0.182	2.463	0.629		0.054	0.185
OU-1-010	4/30/17	-0.049	0.103	UJ+	0.052	0.304	34.822	5.650		0.082	0.325
OU-1-010	5/4/17	0.011	0.068	UJ+	0.025	0.186	14.021	2.790	J	0.047	0.200
OU-1-011	4/30/17	0.045	0.076	J+	0.011	0.129	6.480	1.453	J	0.053	0.228
OU-1-011	5/4/17	0.045	0.098	J+	0.026	0.194	2.643	0.590		0.034	0.129
BUFFER ZONE	4/26/16	0.079	0.129	J	0.065	0.225	2.928	0.863		0.122	0.312
FRAC TANK	1/11/16	1.426	0.499		0.065	0.236	1.288	0.420		0.057	0.123
OUTFALL 008	4/30/17	1.422	0.430	J+	0.013	0.118	1.267	0.595	J	0.116	0.400
OUTFALL 008	4/30/17										

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Uranium-235 pCi/L					Uranium-238 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16	0.210	0.193	J	0.027	0.223	1.528	0.486		0.013	0.191
NCC-001	4/6/16	0.118	0.181	J	0.017	0.270	1.297	0.540	J	0.032	0.218
NCC-001	5/10/16	0.029	0.088	J	0.016	0.209	1.098	0.422		0.045	0.211
NCC-001	7/6/16	0.707	0.529	J	0.009	0.530	1.331	0.640		0.069	0.341
NCC-001	8/15/16	0.094	0.122	J	0.013	0.169	1.155	0.391	J	0.033	0.150
NCC-001	9/9/16	0.033	0.100	J	0.019	0.237	0.841	0.390		0.026	0.240
NCC-001	11/3/16	0.411	0.254	J+	0.010	0.158	2.135	0.583	J+	0.032	0.147
OU-1-001	1/20/17	0.197	0.191	J	0.004	0.236	2.781	0.703		0.022	0.167
OU-1-001	2/21/17	0.167	0.233	J	0.034	0.352	1.336	0.577	J	0.028	0.259
OU-1-001	3/1/17	0.166	0.159	J	0.013	0.171	1.842	0.520	J	0.007	0.173
OU-1-001	4/5/17	0.203	0.170	J	0.020	0.181	1.704	0.473		0.036	0.171
OU-1-001	5/3/17	0.085	0.118	J	0.017	0.179	0.804	0.316		0.030	0.165
OU-1-001	6/15/17	0.375	0.299	J	0.021	0.269	1.490	0.573	J-	0.065	0.299
OU-1-001	7/27/17	0.147	0.352	J	0.040	0.738	0.617	0.638	J	0.128	0.805
OU-1-001	8/17/17	0.424	0.280	J	0.016	0.210	1.198	0.441		0.013	0.148
OU-1-001	10/10/17	0.063	0.119	J	0.021	0.221	0.926	0.383		0.064	0.249
NCC-002	3/30/16	0.054	0.134	J	0.038	0.280	0.810	0.367		0.036	0.198
NCC-002	4/11/16	0.554	0.400	J	0.018	0.295	11.328	2.194		0.064	0.322
NCC-002	5/11/16	0.224	0.187	J	0.023	0.200	3.813	0.827		0.027	0.150
NCC-002	7/6/16	0.768	0.489	J	0.038	0.384	7.552	1.665		0.047	0.247
NCC-002	8/15/16	0.314	0.264	J	0.033	0.280	3.394	0.887	J	0.039	0.192
NCC-002	9/9/16	0.268	0.193	J	0.008	0.143	1.979	0.531	J	0.027	0.132
NCC-002	11/3/16	0.195	0.186	J+	0.030	0.227	4.680	0.985	J+	0.047	0.183
OU-1-002	1/20/17	0.577	0.280	J	0.033	0.202	7.213	1.253	J	0.021	0.140
OU-1-002	3/27/17	0.529	0.281	J	0.008	0.149	6.335	1.205	J	0.012	0.120
OU-1-002	4/5/17	0.631	0.287		0.023	0.179	5.252	0.973		0.026	0.144
OU-1-002	5/3/17	0.246	0.219	J	0.022	0.235	2.755	0.741		0.033	0.204
OU-1-002	6/15/17	0.381	0.286	J	0.005	0.286	2.648	0.740	J-	0.015	0.161
OU-1-002	7/27/17	0.258	0.186	J	0.031	0.193	1.561	0.430	J	0.029	0.149
OU-1-002	8/17/17	0.139	0.167	J	0.027	0.236	4.433	0.989		0.030	0.190
OU-1-002	10/10/17	0.146	0.151	J	0.009	0.159	2.246	0.612		0.069	0.240
NCC-003	3/30/16	0.131	0.136	J	0.009	0.143	2.420	0.608	J	0.055	0.197
NCC-003	4/6/16	0.504	0.349	J	0.023	0.278	3.257	0.875		0.053	0.265
NCC-003	5/11/16	0.378	0.337	J	0.035	0.361	3.296	0.952	J	0.061	0.313
NCC-003	7/6/16	0.104	0.198	J	0.036	0.367	2.988	0.907		0.093	0.355
NCC-003	8/15/16	0.536	0.358	J	0.006	0.321	1.015	0.444	J	0.049	0.227
NCC-003	9/9/16	0.134	0.133	J	0.015	0.157	0.787	0.290	J	0.024	0.115
NCC-003A	9/16/16	0.093	0.121	J	0.014	0.168	2.199	0.577	J	0.057	0.194
NCC-003A	11/3/16	0.804	0.373	J+	0.010	0.169	4.353	0.964	J+	0.056	0.206
OU-1-003A	1/20/17	0.496	0.259	J	0.003	0.186	6.776	1.198	J	0.013	0.120
OU-1-003A	3/1/17	0.265	0.232	J	0.004	0.265	2.835	0.750		0.027	0.187
OU-1-003A	4/5/17	0.238	0.220	J	0.029	0.253	2.724	0.736	J	0.033	0.204
OU-1-003A	5/3/17	0.148	0.147	J	0.017	0.173	1.564	0.451		0.010	0.111
NCC-004	5/12/16	0.474	0.376	J	0.026	0.340	2.230	0.765		0.039	0.240

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Uranium-235 pCi/L					Uranium-238 pCi/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	0.129	0.170	J	0.004	0.259	0.249	0.198	J	0.037	0.209
OU-1-004	5/3/17	0.070	0.107	J	0.009	0.159	0.235	0.174	J	0.017	0.147
OU-1-004	5/3/17										
OU-1-006	4/29/17	0.093	0.159	J	0.020	0.269	0.967	0.446	J	0.041	0.256
NCC-007	11/3/16	0.171	0.185	J+	0.033	0.247	1.446	0.479	J+	0.040	0.174
OU-1-007	1/20/17	0.164	0.151	J	0.008	0.142	2.077	0.548	J	0.042	0.188
OU-1-007	2/21/17	0.346	0.379	J	0.036	0.452	0.674	0.468	J	0.026	0.319
OU-1-007	3/1/17	0.103	0.125	J	0.020	0.176	0.653	0.271	J	0.032	0.158
OU-1-007	4/5/17	0.190	0.151	J	0.010	0.136	0.894	0.308	J	0.033	0.152
OU-1-007	5/3/17	0.031	0.074	J	0.008	0.155	0.509	0.259	J	0.007	0.179
OU-1-007	6/15/17	0.474	0.298	J	0.017	0.213	0.777	0.349	J-	0.020	0.172
OU-1-007	7/27/17	-0.001	0.089	U	0.038	0.263	0.123	0.152	J	0.053	0.231
OU-1-008	3/30/17	0.495	0.293	J	0.010	0.175	2.348	0.649	J	0.025	0.177
OU-1-008	4/5/17	0.100	0.136	J	0.031	0.212	1.957	0.525	J	0.034	0.171
OU-1-008	5/3/17	0.174	0.160	J	0.008	0.150	1.099	0.382	J	0.011	0.121
OU-1-009	4/30/17	0.159	0.164	J	0.024	0.207	1.243	0.418	J	0.037	0.187
OU-1-009	5/4/17	0.181	0.175	J	0.003	0.217	1.591	0.478	J	0.021	0.153
OU-1-010	4/30/17	1.591	0.721		0.017	0.319	18.891	3.385		0.108	0.438
OU-1-010	5/4/17	0.817	0.454	J	0.013	0.247	8.518	1.866	J	0.027	0.228
OU-1-011	4/30/17	0.336	0.326	J	0.006	0.403	4.172	1.088	J	0.021	0.227
OU-1-011	5/4/17	0.108	0.112	J	0.006	0.118	1.962	0.487		0.005	0.137
BUFFER ZONE	4/26/16	0.171	0.222	J	0.026	0.308	1.246	0.535		0.025	0.311
FRAC TANK	1/11/16	0.241	0.192	J	0.014	0.173	1.014	0.367		0.020	0.140
OUTFALL 008	4/30/17	0.403	0.384	J	0.061	0.469	0.978	0.513	J	0.046	0.331
OUTFALL 008	4/30/17										

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Total Uranium ug/L					Total Uranium (TEKLAB) ug/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
NCC-001	3/10/16										
NCC-001	4/6/16										
NCC-001	5/10/16	2.424	0.279		1.081	1.081					
NCC-001	7/6/16	2.711	0.847		1.000	1.000	3.000	0.059		0.024	0.193
NCC-001	8/15/16	5.307	1.655		1.000	1.000	5.400	0.107		0.024	0.193
NCC-001	9/9/16	3.349	1.043		1.000	1.000					
NCC-001	11/3/16	5.504	1.713		1.000	1.000					
OU-1-001	1/20/17	10.908	3.463		1.000	1.000					
OU-1-001	2/21/17	2.078	0.649		1.000	1.000					
OU-1-001	3/1/17	4.269	1.328		1.000	1.000					
OU-1-001	4/5/17	5.331	1.659			1.000	4.970	0.112		0.036	0.385
OU-1-001	5/3/17	1.301	0.405		1.000	1.000	1.940	0.070		0.036	0.193
OU-1-001	6/15/17	2.714	0.847		1.036	1.036					
OU-1-001	7/27/17	0.900	0.281	U	1.000	1.000					
OU-1-001	8/17/17	2.677	0.835		1.036	1.036					
OU-1-001	10/10/17	4.305	1.341		1.000	1.000					
NCC-002	3/30/16										
NCC-002	4/11/16										
NCC-002	5/11/16	10.490	1.190		1.093	1.093					
NCC-002	7/6/16	27.768	9.008		1.000	1.000	21.700	0.416		0.024	0.964
NCC-002	8/15/16	8.214	2.558		1.000	1.000	10.500	0.208		0.024	0.385
NCC-002	9/9/16	7.357	2.293		1.000	1.000					
NCC-002	11/3/16	10.103	3.144		1.000	1.000					
OU-1-002	1/20/17	27.776	8.767		1.000	1.000					
OU-1-002	3/27/17	21.909	6.816			1.000	16.000	0.441		0.036	0.771
OU-1-002	4/5/17	18.630	5.798			1.000	13.200	0.284		0.036	0.385
OU-1-002	5/3/17	7.585	2.361		1.000	1.000	7.490	0.266		0.036	0.193
OU-1-002	6/15/17	7.214	2.253		1.036	1.036					
OU-1-002	7/27/17	3.843	1.198		1.000	1.000					
OU-1-002	8/17/17	9.449	2.946		1.036	1.036					
OU-1-002	10/10/17	10.096	3.144		1.000	1.000					
NCC-003	3/30/16										
NCC-003	4/6/16										
NCC-003	5/11/16	5.054	0.582		1.093	1.093					
NCC-003	7/6/16	2.827	0.882		1.000	1.000	6.190	0.135		0.024	1.927
NCC-003	8/15/16	3.637	1.134		1.000	1.000	3.150	0.064		0.024	0.193
NCC-003	9/9/16	2.924	0.911		1.000	1.000					
NCC-003A	9/16/16	6.188	1.931		1.000	1.000					
NCC-003A	11/3/16	10.300	3.233		1.000	1.000					
OU-1-003A	1/20/17	24.162	7.630		1.000	1.000					
OU-1-003A	3/1/17	8.736	2.718		1.000	1.000					
OU-1-003A	4/5/17	7.845	2.441			1.000	6.520	0.141		0.036	0.385
OU-1-003A	5/3/17	3.091	0.962		1.000	1.000	3.320	0.120		0.036	0.193
NCC-004	5/12/16	1.873	0.218		1.048	1.048					

Table 2-17: OU-1 Stormwater Monitoring Results - Radionuclides

		Total Uranium ug/L					Total Uranium (TEKLAB) ug/L				
Client ID	Date	Result	CSU	Final Q	CV	MDA	Result	CSU	Final Q	CV	MDA
OU-1-004	4/5/17	-0.619	0.193			1.000	0.176	0.007		0.036	0.385
OU-1-004	5/3/17	-0.327	0.102	U	1.000	1.000	0.521	0.020		0.036	0.193
OU-1-004	5/3/17										
OU-1-006	4/29/17	1.124	0.350		1.024	1.024	1.190	0.032		0.036	0.193
NCC-007	11/3/16	3.004	0.936		1.000	1.000					
OU-1-007	1/20/17	11.629	3.618		1.000	1.000					
OU-1-007	2/21/17	0.895	0.279	U	1.000	1.000					
OU-1-007	3/1/17	2.025	0.631		1.000	1.000					
OU-1-007	4/5/17	1.808	0.563			1.000	2.310	0.053		0.036	0.385
OU-1-007	5/3/17	0.044	0.014	U	1.000	1.000	1.250	0.048		0.036	0.193
OU-1-007	6/15/17	1.997	0.624		1.036	1.036					
OU-1-007	7/27/17	1.969	0.615		1.000	1.000					
OU-1-008	3/30/17	6.573	2.045			1.000					
OU-1-008	4/5/17	5.685	1.769			1.000	6.170	0.136		0.036	0.385
OU-1-008	5/3/17	2.158	0.672		1.000	1.000	2.780	0.102		0.036	0.193
OU-1-009	4/30/17	3.617	1.126		1.024	1.024	3.560	0.093		0.036	0.193
OU-1-009	5/4/17	4.397	1.369		1.000	1.000	4.660	0.165		0.036	0.193
OU-1-010	4/30/17	62.652	19.495		1.024	1.024	57.800	1.505		0.036	1.927
OU-1-010	5/4/17	20.794	6.472		1.000	1.000	20.900	0.743		0.036	0.771
OU-1-011	4/30/17	11.265	3.505		1.024	1.024	10.700	0.277		0.036	0.385
OU-1-011	5/4/17	5.148	1.603		1.000	1.000	4.400	0.157		0.036	0.193
BUFFER ZONE	4/26/16										
FRAC TANK	1/11/16										
OUTFALL 008	4/30/17	2.224	0.693		1.000	1.000					
OUTFALL 008	4/30/17										

Notes: pCi/L = picoCuries per liter; ug/L = micrograms per liter
CSU = combined standard uncertainty; CV = critical value
Q = data qualifier; MDA = minimum detectable activity

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Total Suspended Solids			Solids, Settleable			pH			Biochemical Oxygen Demand			Chemical Oxygen Demand		
		mg/L			mg/L			s.u.			mg/L			mg/L		
Reporting Limits		6			6			n/a			5			50		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	127		27	0.1		0.1				125		5	367		50
NCC-001	4/6/16	303		20	0.3		0.1	7.54		1	49		5	205		50
NCC-001	5/10/16	329		22	0.2		0.1	7.48		1	92		5	371		50
NCC-001	7/6/16	34		6	ND	U	0.1	7.51		1	18	J	5	97		50
NCC-001	8/15/16	10		6	0.1		0.1	7.78		1	ND	U	5	ND	U	50
NCC-001	9/9/16	143		6	0.2		0.1	7.73		1	11		5	115		50
NCC-001	11/3/16	5	J	6	0.1		0.1	8.00		1	ND	U	5	51		50
OU-1-001	1/20/17	ND	U	6	ND	U	0.1	7.78		1	27		5	95		50
OU-1-001	2/21/17	22		6	ND	U	0.1	7.65		1	399		5	692		50
OU-1-001	3/1/17	18		6	ND	U	0.1	8.14		1	21		5	90		50
OU-1-001	4/5/17	8		6	ND	U	0.1	7.94		1	ND	U	5	34		50
OU-1-001	5/3/17	27		6	ND	U	0.1	8.01		1	7		5	25	J	50
OU-1-001	6/15/17	36		6	0.1		0.1	7.93		1	17		5	104		50
OU-1-001	7/27/17	88		6	ND	U	0.1	7.64		1	14		5	104		50
OU-1-001	8/17/17	ND	U	6	ND	U	0.1	7.95		1	7		5	82		50
NCC-002	3/30/16	72		6	0.3		0.1	6.7		1	8		5	105		50
NCC-002	4/11/16	7		6	0.1		0.1	7.06		1	14		5	57		50
NCC-002	5/11/16	ND	U	6	ND	U	0.1	7.6		1	5	UJ-	5	ND	U	50
NCC-002	7/6/16	5	J	6	ND	U	0.1	7.67		1	8		5	51		50
NCC-002	8/15/16	ND	U	6	ND	U	0.1	7.39		1	ND	U	5	ND	U	50
NCC-002	9/9/16	16		6	ND	U	0.1	7.8		1	ND	U	5	ND	U	50
NCC-002	11/3/16	50		6	0.1		0.1	7.57		1	5		5	36	J	50
OU-1-002	1/20/17	9		6	0.1		0.1	8.46		1	ND	U	5	ND	U	50
OU-1-002	3/27/17	ND	U	6	ND	U	0.1	7.90		1	ND	U	5	25	J	50
OU-1-002	4/5/17	31		6	1.1		0.1	7.62		1	ND	UJ-	5	25	J	50
OU-1-002	5/3/17	ND	U	6	0.1		0.1	7.60		1	ND	U	5	21	J	50
OU-1-002	6/15/17	ND	U	6	ND	U	0.1	8.27		1	ND	U	5	ND	U	50
OU-1-002	7/27/17	15		6	0.1		0.1	8.37		1	ND		5	ND		50
OU-1-002	8/17/17	11		6	0.1		0.1	8.25		1	5		5	87		50
NCC-003	3/30/16	140		6	0.1		0.1	6.35		1	ND	U	5	68		50

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Total Suspended Solids			Solids, Settleable			pH			Biochemical Oxygen Demand			Chemical Oxygen Demand		
		mg/L			mg/L			s.u.			mg/L			mg/L		
Reporting Limits		6			6			n/a			5			50		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	124		13	0.1		0.1	7.54		1	ND	U	5	ND	U	50
NCC-003	5/11/16	548		194	4.5		0.1	7.26		1	5	UJ-	5	60		50
NCC-003	7/6/16	1760		286	21		0.1	7.34		1	19		5	259		50
NCC-003	8/15/16	10		6	ND	U	0.1	7.94		1	ND	U	5	ND	U	50
NCC-003	9/9/16	309		17	0.1		0.1	8.08		1	ND	U	5	58		50
NCC-003a	9/16/16	35		6	0.1		0.1	8.12		1	ND	U	5	ND	U	50
NCC-003a	11/3/16	14		6	0.1		0.1	8.09		1	ND	U	5	46	J	50
OU-1-003A	1/20/17	29		6	0.1		0.1	7.58		1	ND	U	5	ND	U	50
OU-1-003A	3/1/17	10	J	6	ND	U	0.1	8.17		1	66		5	31	J	50
OU-1-003A	4/5/17	ND	U	6	ND	U	0.1	8.16		1	ND	UJ-	5	32	J	50
OU-1-003A	5/3/17	43		6	0.1		0.1	8.23		1	ND	U	5	25	J	50
NCC-004	5/12/16	520		60	0.3		0.1	7.29		1	7	J-	5	126		50
OU-1-004	4/5/17	ND	U	6	ND	U	0.1	7.85		1	ND	UJ-	5	44	J	50
OU-1-004	5/3/17	230		60	0.2		0.1	7.94		1	6		5	35	J	50
OU-1-006	4/29/17	151		12	0.4	J-	0.1	9.35		1	ND	R	5	25	J	50
NCC-007	11/3/16	40		6	ND	U	0.1	7.44		1	117		5	246		50
OU-1-007	1/20/17	105		6	ND	U	0.1	7.99		1	66		5	148		50
OU-1-007	2/21/17	37		6	0.3		0.1	7.15		1	1160		50	1560		100
OU-1-007	3/1/17	69		6	ND	U	0.1	8.03		1	117		5	195		50
OU-1-007	4/5/17	50		6	ND	U	0.1	8.18		1	5	J-	5	51		50
OU-1-007	5/3/17	132		6	0.3		0.1	8.19		1	103		5	189		50
OU-1-007	6/15/17	109		6	0.1		0.1	7.75		1	77		5	207		50
OU-1-007	7/27/17	160		6	0.1		0.1	7.89		1	80		5	200		50
OU-1-007	8/17/17	28		6	0.1		0.1	7.77		1	76		5	178		50
OU-1-008	3/30/17	ND	U	6	ND	U	0.1	8.19		1	ND	U	5	30	J	50
OU-1-008	4/5/17	73		6	0.5		0.1	8.48		1	ND	UJ-	5	22	J	50
OU-1-008	5/3/17	640		60	1.8		0.1	8.05		1	ND	U	5	56		50
OU-1-009	4/30/17	34		6	0.2		0.1	7.97		1	ND	U	5	25	J	50
OU-1-009	5/4/17	14		6	ND	U	0.1	7.65		1	ND	U	5	ND	U	50
OU-1-010	4/30/17	45		6	0.6		0.1	7.30		1	ND	U	5	23	J	50

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Total Suspended Solids			Solids, Settleable			pH			Biochemical Oxygen Demand			Chemical Oxygen Demand		
		mg/L			mg/L			s.u.			mg/L			mg/L		
Reporting Limits		6			6			n/a			5			50		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	47		6	ND	U	0.1	7.32		1	ND	U	5	ND	U	50
OU-1-011	4/30/17	36		6	ND	U	0.1	8.30		1	ND	U	5	ND	U	50
OU-1-011	5/4/17	82		6	0.1		0.1	7.72		1	ND	U	5	ND	U	50
BUFFER ZONE	4/26/16	142		6	0.1		0.1				5	UJ	5	ND	U	50

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chloride, Total			Nitrogen, Ammonia, Total			Sulfate, Total			Hardness, as (CaCO3)			Aluminum, Total		
		mg/L			mg/L			mg/L			mg/L			ug/L		
Reporting Limits		5			0.1			10			1			25		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	928		250	0.13		0.1	204		100	523		1	3.71	J+	0.025
NCC-001	4/6/16	197		50	0.17		0.1	121	J-	100	371		1	5.26		0.025
NCC-001	5/10/16	160		50	0.14	J-	0.1	136		50	423		1	6.25		0.025
NCC-001	7/6/16	88		50	0.32	J-	0.2	508	J-	500	608		1	0.586		0.025
NCC-001	8/15/16	20	J	5	0.14		0.1	305		100	474		1	0.537		0.025
NCC-001	9/9/16	23		5	ND	UJ-	0.1	198		100	338		1	1.06		0.025
NCC-001	11/3/16	83		50	0.05	J-	0.1	343		100	504		1	ND	U	0.025
OU-1-001	1/20/17	713		250	ND	UJ-	0.1	474		100	778		1	0.0300		0.025
OU-1-001	2/21/17	845		100	0.56		0.2	454		200	867		1	0.313		0.025
OU-1-001	3/1/17	666		250	0.08		0.1	379		200	566		1	0.0610		0.025
OU-1-001	4/5/17	31		5	0.04		0.1	171		100	365		1	0.260		0.025
OU-1-001	5/3/17	9		5	0.14		0.1	73		50	191		1	0.646		0.025
OU-1-001	6/15/17	58		10	0.15	J-	0.1	214	J-	200	375		1	0.448		0.025
OU-1-001	7/27/17	42		10	0.19	J-	0.1	110		50	249		1	1.68		0.025
OU-1-001	8/17/17	102		50	0.20		0.1	205		100	360		1	0.0477		0.025
NCC-002	3/30/16	8		5	0.2		0.1	ND	UJ-	10	90.2		1	1.09		0.025
NCC-002	4/11/16	31		10	0.1	J-	0.1	1190		1000	1580		1	0.0648		0.025
NCC-002	5/11/16	11		5	0.29	J-	0.2	1010		1000	1020		1	0.046		0.025
NCC-002	7/6/16	13		5	0.77		0.1	1130		500	1300		1	0.0315		0.025
NCC-002	8/15/16	10	J	5	0.93	J-	0.2	580		500	917		1	ND	U	0.025
NCC-002	9/9/16	ND	U	5	ND	U	0.1	428		200	533		1	0.0935		0.025
NCC-002	11/3/16	12		5	0.34		0.2	705		200	1010		1	ND	U	0.025
OU-1-002	1/20/17	78		50	ND	U	0.1	818		200	1060		1	0.154		0.025
OU-1-002	3/27/17	48		10	0.36	J	0.1	745	J+	500	1060		1	0.0720		0.025
OU-1-002	4/5/17	20		10	0.07	J	0.1	715		200	988		1	0.246		0.025
OU-1-002	5/3/17	6		5	0.08	J	0.1	321		200	557		1	0.108		0.025
OU-1-002	6/15/17	10		5	0.08	J	0.1	366		200	572		1	0.025	J	0.025
OU-1-002	7/27/17	4	J	5	0.05	J	0.1	395		200	517		1	0.113		0.025
OU-1-002	8/17/17	17		10	0.24		0.1	560		200	757		1	0.0594		0.025
NCC-003	3/30/16	31		5	0.25		0.1	515		500	677		1	1.12		0.025

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chloride, Total			Nitrogen, Ammonia, Total			Sulfate, Total			Hardness, as (CaCO3)			Aluminum, Total		
		mg/L			mg/L			mg/L			mg/L			ug/L		
Reporting Limits		5			0.1			10			1			25		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	31		10	0.21		0.1	629		200	849		1	1.36		0.025
NCC-003	5/11/16	12		5	0.12		0.1	166		50	359		1	32.1		0.025
NCC-003	7/6/16	18		5	0.22		0.1	294		200	1190		1	53.8		0.025
NCC-003	8/15/16	8	J	5	0.1		0.1	89		20	235		1	0.82		0.025
NCC-003	9/9/16	5		5	ND	U	0.1	126		100	254		1	7.93		0.025
NCC-003a	9/16/16	19		5	ND	UJ-	0.1	419		200	476		1	0.531		0.025
NCC-003a	11/3/16	30		5	0.05	J	0.1	264		200	390		1	0.134		0.025
OU-1-003A	1/20/17	55		50	ND	U	0.2	815		500	1020		1	0.0688		0.025
OU-1-003A	3/1/17	34		5	0.12		0.1	968	J+	500	988		1	0.210		0.025
OU-1-003A	4/5/17	34		5	0.04	J	0.1	222		100	303		1	0.467		0.025
OU-1-003A	5/3/17	18		5	0.13	J-	0.1	189		100	164		1	0.669		0.025
NCC-004	5/12/16	ND	U	5	ND	U	0.1	22	J-	10	153		1	4.96		0.025
OU-1-004	4/5/17	2	J	5	0.07	J	0.1	20		10	122		1	1.19		0.025
OU-1-004	5/3/17	1	J	5	0.08	J	0.1	89		50	267		1	0.768		0.025
OU-1-006	4/29/17	ND	U	5	0.11		0.1	5	J-	10	152		1	0.476		0.025
NCC-007	11/3/16	26		5	0.13		0.1	185		100	383		1	0.461		0.025
OU-1-007	1/20/17	151		50	0.20		0.1	170		100	412		1	1.92		0.025
OU-1-007	2/21/17	330		50	1.57		1	268		100	520		1	0.715		0.025
OU-1-007	3/1/17	89		50	0.30		0.1	244	J+	100	377		1	1.58		0.025
OU-1-007	4/5/17	18		5	0.07	J	0.1	86		50	260		1	1.94		0.025
OU-1-007	5/3/17	40		5	0.30		0.1	78		50	341		1	2.89		0.025
OU-1-007	6/15/17	30		5	0.15		0.1	108		100	258		1	1.78		0.025
OU-1-007	7/27/17	25		5	0.36		0.1	124		50	306		1	2.63		0.025
OU-1-007	8/17/17	41		5	0.17		0.1	146		50	276		1	0.395		0.025
OU-1-008	3/30/17	38		10	0.08	J	0.1	130		100	622		1	0.359		0.025
OU-1-008	4/5/17	29		5	0.06	J	0.1	212		100	744		1	0.882		0.025
OU-1-008	5/3/17	13		5	0.08	J	0.1	143		100	510		1	4.45		0.025
OU-1-009	4/30/17	11		5	0.05	J	0.1	115		100	421		1	0.669		0.025
OU-1-009	5/4/17	11		5	0.06	J	0.1	159		100	468		1	0.170		0.025
OU-1-010	4/30/17	10		5	0.09	J	0.1	1480		500	2180		1	0.266		0.025

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chloride, Total			Nitrogen, Ammonia, Total			Sulfate, Total			Hardness, as (CaCO3)			Aluminum, Total		
		mg/L			mg/L			mg/L			mg/L			ug/L		
Reporting Limits		5			0.1			10			1			25		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	4	J	5	0.09	J	0.1	731		200	1370		1	0.752		0.025
OU-1-011	4/30/17	2	J	5	0.07	J-	0.1	315		100	523		1	0.893		0.025
OU-1-011	5/4/17	3	J	5	0.12		0.1	92		50	350		1	1.75		0.025
BUFFER ZONE	4/26/16	ND	U	5	0.35		0.1	304	J-	200	528		1	0.991		0.025

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Antimony, Total			Arsenic, Total			Beryllium, Total			Cadmium, Total			Trivalent Chromium		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		50			25			0.5			2			10		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.05
NCC-001	4/6/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.05
NCC-001	5/10/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.1
NCC-001	7/6/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-001	8/15/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-001	9/9/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-001	11/3/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-001	1/20/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-001	2/21/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	0.0006	J	0.002	ND	U	0.01
OU-1-001	3/1/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-001	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-001	5/3/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-001	6/15/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
OU-1-001	7/27/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	0.009	J	0.01
OU-1-001	8/17/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-002	3/30/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
NCC-002	4/11/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
NCC-002	5/11/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-002	7/6/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-002	8/15/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-002	9/9/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-002	11/3/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	1/20/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	3/27/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	5/3/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	6/15/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-002	7/27/17	ND		0.05	ND		0.025	ND		0.0005	ND		0.002	ND		0.005
OU-1-002	8/17/17	ND		0.05	ND		0.025	ND		0.0005	ND		0.002	ND		0.005
NCC-003	3/30/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Antimony, Total			Arsenic, Total			Beryllium, Total			Cadmium, Total			Trivalent Chromium		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		50			25			0.5			2			10		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.05
NCC-003	5/11/16	ND	U	0.05	ND	U	0.025	0.001		0.0005	ND	U	0.002	0.054		0.025
NCC-003	7/6/16	ND	U	0.05	0.0401		0.025	0.003		0.0005	0.0022		0.002	0.103		0.05
NCC-003	8/15/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	0.005	UJ-	0.005
NCC-003	9/9/16	ND	U	0.05	ND	U	0.025	0.000		0.0005	ND	U	0.002	ND	U	0.005
NCC-003a	9/16/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
NCC-003a	11/3/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-003A	1/20/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-003A	3/1/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-003A	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	0.006		0.005
OU-1-003A	5/3/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	0.004	J	0.005
NCC-004	5/12/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
OU-1-004	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.025
OU-1-004	5/3/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
OU-1-006	4/29/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	R	0.005
NCC-007	11/3/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.025
OU-1-007	1/20/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.025
OU-1-007	2/21/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	0.0005	J	0.002	ND	U	0.01
OU-1-007	3/1/17	ND	U	0.05	0.010	J	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-007	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	0.004	J	0.005
OU-1-007	5/3/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
OU-1-007	6/15/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.025
OU-1-007	7/27/17	ND		0.05	ND		0.025	ND		0.0005	ND		0.002	ND		0.025
OU-1-007	8/17/17	ND		0.05	ND		0.025	ND		0.0005	ND		0.002	ND		0.005
OU-1-008	3/30/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-008	4/5/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-008	5/3/17	ND	U	0.05	ND	U	0.025	0.000	J	0.0005	ND	U	0.002	0.006		0.005
OU-1-009	4/30/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	R	0.005
OU-1-009	5/4/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-010	4/30/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	R	0.005

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Antimony, Total			Arsenic, Total			Beryllium, Total			Cadmium, Total			Trivalent Chromium		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		50			25			0.5			2			10		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.005
OU-1-011	4/30/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	R	0.005
OU-1-011	5/4/17	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.01
BUFFER ZONE	4/26/16	ND	U	0.05	ND	U	0.025	ND	U	0.0005	ND	U	0.002	ND	U	0.05

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chromium, Hexavalent			Chromium, Total			Cobalt, Total			Copper, Total			Iron, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			n/a			5			5			20		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	ND	U	0.025				0.0055		0.005	0.0546		0.005	4.54		0.02
NCC-001	4/6/16	ND	U	0.025				ND	U	0.005	0.0486		0.005	7.47		0.02
NCC-001	5/10/16	ND	U	0.05				0.0055		0.005	0.101		0.005	10.4		0.02
NCC-001	7/6/16	ND	U	0.005				ND	U	0.005	0.0327		0.005	0.729		0.02
NCC-001	8/15/16	ND	U	0.005				ND	U	0.005	0.0066		0.005	0.47		0.02
NCC-001	9/9/16	ND	U	0.005				ND	U	0.005	0.022		0.005	1.6		0.02
NCC-001	11/3/16	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.0172		0.005	0.0339		0.02
OU-1-001	1/20/17	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.0108		0.005	0.580		0.02
OU-1-001	2/21/17	ND	U	0.01				0.0072		0.005	0.0887		0.005	0.397		0.02
OU-1-001	3/1/17	ND	U	0.005				ND	U	0.005	0.0319		0.005	0.0924		0.02
OU-1-001	4/5/17	0.005		0.005				ND	U	0.005	0.0061		0.005	0.356		0.02
OU-1-001	5/3/17	ND	U	0.005				ND	U	0.005	0.0078		0.005	0.822		0.02
OU-1-001	6/15/17	ND	U	0.01				0.0038	J	0.005	0.0122		0.005	1.05		0.02
OU-1-001	7/27/17	ND	U	0.01	0.0088		0.005	0.0022	J	0.005	0.0343		0.005	2.55		0.02
OU-1-001	8/17/17	ND	U	0.005				ND	U	0.005	0.0225		0.005	0.122		0.02
NCC-002	3/30/16	ND	U	0.005				ND	U	0.005	0.0242		0.005	1.36		0.02
NCC-002	4/11/16	ND	U	0.005				0.0243		0.005	0.0096		0.005	0.132		0.02
NCC-002	5/11/16	ND	U	0.005				ND	U	0.005	ND	U	0.005	0.095		0.02
NCC-002	7/6/16	ND	U	0.005				0.0022	J	0.005	0.0051		0.005	0.249		0.02
NCC-002	8/15/16	ND	U	0.005				ND	U	0.005	ND	U	0.005	0.266		0.02
NCC-002	9/9/16	ND	U	0.005				ND	U	0.005	ND	U	0.005	0.13		0.02
NCC-002	11/3/16	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.0046	J	0.005	0.183		0.02
OU-1-002	1/20/17	ND	U	0.005	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.186		0.02
OU-1-002	3/27/17	ND	U	0.005				ND	U	0.005	0.0046	J	0.005	0.188		0.02
OU-1-002	4/5/17	ND	U	0.005				0.0020	J	0.005	0.0058		0.005	0.640		0.02
OU-1-002	5/3/17	ND	U	0.005				ND	U	0.005	0.0030	J	0.005	0.231		0.02
OU-1-002	6/15/17	ND	U	0.005				ND	U	0.005	0.0043	J	0.005	0.0258		0.02
OU-1-002	7/27/17	ND		0.005	ND		0.005	ND		0.005	0.0043	J	0.005	0.206		0.02
OU-1-002	8/17/17	ND		0.005				ND		0.005	0.0099		0.005	0.170		0.02
NCC-003	3/30/16	ND	U	0.005				ND	U	0.005	0.0065		0.005	1.69		0.02

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chromium, Hexavalent			Chromium, Total			Cobalt, Total			Copper, Total			Iron, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			n/a			5			5			20		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	ND	U	0.025				ND	U	0.005	0.0061		0.005	1.98		0.02
NCC-003	5/11/16	ND	U	0.025				0.0179		0.005	0.0498		0.005	42.6		0.02
NCC-003	7/6/16	ND	U	0.05				0.0371		0.005	0.156		0.005	78.4		0.02
NCC-003	8/15/16	0.005	UJ-	0.005				ND	U	0.005	0.0051		0.005	0.737		0.02
NCC-003	9/9/16	ND	U	0.125				0.0052		0.005	0.0157		0.005	10.4		0.02
NCC-003a	9/16/16	ND	U	0.005	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.486		0.02
NCC-003a	11/3/16	0.004	J	0.005	0.0043	J	0.005	ND	U	0.005	0.0046	J	0.005	0.131		0.02
OU-1-003A	1/20/17	ND	U	0.005	ND	U	0.005	ND	U	0.005	ND	U	0.005	0.121		0.02
OU-1-003A	3/1/17	ND	U	0.005				ND	U	0.005	ND	U	0.005	0.146	J+	0.02
OU-1-003A	4/5/17	ND	U	0.005				ND	U	0.005	0.0048	J	0.005	0.411		0.02
OU-1-003A	5/3/17	ND	U	0.005				ND	U	0.005	0.0035	J	0.005	0.493		0.02
NCC-004	5/12/16	ND	U	0.01				ND	U	0.005	0.0205		0.005	7		0.02
OU-1-004	4/5/17	ND	U	0.025				ND	U	0.005	0.0042	J	0.005	1.18		0.02
OU-1-004	5/3/17	ND	U	0.01				ND	U	0.005	0.0029	J	0.005	0.865		0.02
OU-1-006	4/29/17	ND	R	0.005				ND	U	0.005	0.0022	J	0.005	0.588		0.02
NCC-007	11/3/16	ND	U	0.025	0.0048	J	0.005	ND	U	0.005	0.0132		0.005	0.696		0.02
OU-1-007	1/20/17	ND	U	0.025	0.0072		0.005	ND	U	0.005	0.0140		0.005	2.54		0.02
OU-1-007	2/21/17	0.008	J-	0.01				0.0067		0.005	0.0714		0.005	2.34		0.02
OU-1-007	3/1/17	0.015	J-	0.005				ND	U	0.005	0.0335		0.005	2.15		0.02
OU-1-007	4/5/17	ND	U	0.005				ND	U	0.005	0.0096		0.005	2.18		0.02
OU-1-007	5/3/17	ND	U	0.01				0.0022	J	0.005	0.0214		0.005	3.67		0.02
OU-1-007	6/15/17	ND	U	0.025				0.0031	J	0.005	0.0147		0.005	2.24		0.02
OU-1-007	7/27/17	ND		0.025	0.0077		0.005	0.0031	J	0.005	0.0285		0.005	3.56		0.02
OU-1-007	8/17/17	ND		0.005				ND		0.005	0.0144		0.005	0.760		0.02
OU-1-008	3/30/17	ND	U	0.005				ND	U	0.005	0.0024	J	0.005	0.353		0.02
OU-1-008	4/5/17	ND	U	0.005				ND	U	0.005	0.0039	J	0.005	1.23		0.02
OU-1-008	5/3/17	ND	U	0.005				0.0036	J	0.005	0.0072		0.005	7.36	J-	0.02
OU-1-009	4/30/17	ND	R	0.005				ND	U	0.005	0.0027	J	0.005	0.849		0.02
OU-1-009	5/4/17	ND	U	0.005				ND	U	0.005	ND	U	0.005	0.166		0.02
OU-1-010	4/30/17	ND	R	0.005				0.0106		0.005	ND	U	0.005	1.22		0.02

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Chromium, Hexavalent			Chromium, Total			Cobalt, Total			Copper, Total			Iron, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			n/a			5			5			20		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	ND	U	0.005				0.0068		0.005	ND	U	0.005	2.31		0.02
OU-1-011	4/30/17	ND	R	0.005				ND	U	0.005	ND	U	0.005	0.716		0.02
OU-1-011	5/4/17	ND	U	0.01				ND	U	0.005	0.0016	J	0.005	1.44		0.02
BUFFER ZONE	4/26/16	ND	U	0.025	ND	U	0.005	ND	U	0.005	ND	U	0.005	1.42		0.02

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Lead, Total			Mercury, Total			Nickel, Total			Selenium, Total			Silver, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		15			0.2			5			40			5		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	0.019		0.015	0.00033		0.0002	0.0244		0.005	ND	U	0.04	ND	U	0.005
NCC-001	4/6/16	0.0288		0.015	0.00031		0.0002	0.0195		0.005	ND	U	0.04	ND	U	0.005
NCC-001	5/10/16	0.0923		0.015	0.00041		0.0002	0.0267		0.005	ND	U	0.04	ND	U	0.005
NCC-001	7/6/16	ND	U	0.015	ND	U	0.0002	0.0143		0.005	ND	U	0.04	ND	U	0.005
NCC-001	8/15/16	ND	U	0.015	ND	U	0.0002	0.0085		0.005	ND	U	0.04	ND	U	0.005
NCC-001	9/9/16	ND	U	0.015	ND	U	0.0002	0.0062		0.005	ND	U	0.04	ND	U	0.005
NCC-001	11/3/16	ND	U	0.015	ND	U	0.0002	0.0063		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	1/20/17	ND	U	0.015	ND	U	0.0002	0.0095		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	2/21/17	ND	U	0.015	0.00006	J	0.0002	0.0321		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	3/1/17	ND	U	0.015	ND	U	0.0002	0.0091		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	4/5/17	ND	U	0.015	ND	U	0.0002	0.0087		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	5/3/17	ND	U	0.015	ND	U	0.0002	0.0048	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-001	6/15/17	ND	U	0.015	ND	U	0.0002	0.0112		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	7/27/17	0.0159		0.015	ND	U	0.0002	0.0107		0.005	ND	U	0.04	ND	U	0.005
OU-1-001	8/17/17	ND	U	0.015	ND	U	0.0002	0.0105		0.005	ND	U	0.04	ND	U	0.005
NCC-002	3/30/16	ND	U	0.015	ND	U	0.0002	ND	U	0.005	ND	U	0.04	ND	U	0.005
NCC-002	4/11/16	ND	U	0.015	ND	U	0.0002	0.0536		0.005	ND	U	0.04	ND	U	0.005
NCC-002	5/11/16	ND	U	0.015	ND	U	0.0002	0.0226		0.005	ND	U	0.04	ND	U	0.005
NCC-002	7/6/16	ND	U	0.015	ND	U	0.0002	0.0538		0.005	0.133		0.04	ND	U	0.005
NCC-002	8/15/16	ND	U	0.015	ND	U	0.0002	0.0262		0.005	ND	U	0.04	ND	U	0.005
NCC-002	9/9/16	ND	U	0.015	ND	U	0.0002	0.0116		0.005	ND	U	0.04	ND	U	0.005
NCC-002	11/3/16	ND	U	0.015	ND	U	0.0002	0.0189		0.005	ND	U	0.04	ND	U	0.005
OU-1-002	1/20/17	ND	U	0.015	ND	U	0.0002	0.0148		0.005	ND	U	0.04	ND	U	0.005
OU-1-002	3/27/17	ND	U	0.015	ND	U	0.0002	0.0247		0.005	0.022	J	0.04	ND	U	0.005
OU-1-002	4/5/17	ND	U	0.015	ND	U	0.0002	0.0290		0.005	ND	U	0.04	ND	U	0.005
OU-1-002	5/3/17	ND	U	0.015	ND	U	0.0002	0.0149		0.005	ND	U	0.04	ND	U	0.005
OU-1-002	6/15/17	ND	U	0.015	ND	U	0.0002	0.0087		0.005	ND	U	0.04	ND	U	0.005
OU-1-002	7/27/17	ND		0.015	ND		0.0002	0.0085		0.005	ND		0.04	ND		0.005
OU-1-002	8/17/17	ND		0.015	ND		0.0002	0.0124		0.005	ND		0.04	ND		0.005
NCC-003	3/30/16	ND	U	0.015	0.00117		0.0002	0.0082		0.005	ND	U	0.04	ND	U	0.005

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Lead, Total			Mercury, Total			Nickel, Total			Selenium, Total			Silver, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		15			0.2			5			40			5		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	ND	U	0.015	0.00027		0.0002	0.0096		0.005	ND	U	0.04	ND	U	0.005
NCC-003	5/11/16	0.0373		0.015	0.00035		0.0002	0.0727		0.005	ND	U	0.04	ND	U	0.005
NCC-003	7/6/16	0.112		0.015	0.00312		0.0002	0.14		0.005	ND	U	0.04	ND	U	0.005
NCC-003	8/15/16	ND	U	0.015	ND	U	0.0002	ND	U	0.005	ND	U	0.04	ND	U	0.005
NCC-003	9/9/16	ND	U	0.015	0.00025		0.0002	0.0196		0.005	ND	U	0.04	ND	U	0.005
NCC-003a	9/16/16	ND	U	0.015	ND	U	0.0002	0.0070		0.005	ND	U	0.04	ND	U	0.005
NCC-003a	11/3/16	ND	U	0.015	ND	U	0.0002	0.0051		0.005	ND	U	0.04	ND	U	0.005
OU-1-003A	1/20/17	ND	U	0.015	ND	U	0.0002	0.0170		0.005	ND	U	0.04	ND	U	0.005
OU-1-003A	3/1/17	ND	U	0.015	ND	U	0.0002	0.0080		0.005	ND	U	0.04	ND	U	0.005
OU-1-003A	4/5/17	ND	U	0.015	ND	U	0.0002	0.0049	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-003A	5/3/17	ND	U	0.015	ND	U	0.0002	0.0029	J	0.005	ND	U	0.04	ND	U	0.005
NCC-004	5/12/16	ND	U	0.015	ND	U	0.0002	0.0115		0.005	ND	U	0.04	ND	U	0.005
OU-1-004	4/5/17	ND	U	0.015	ND	U	0.0002	0.0030	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-004	5/3/17	ND	U	0.015	ND	U	0.0002	0.0029	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-006	4/29/17	ND	U	0.015	ND	U	0.0002	0.0046	J	0.005	ND	U	0.04	ND	U	0.005
NCC-007	11/3/16	0.0097	J	0.015	0.00009	J	0.0002	0.0068		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	1/20/17	ND	U	0.015	ND	U	0.0002	0.0069		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	2/21/17	0.013	J	0.015	ND	U	0.0002	0.0270		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	3/1/17	0.0082	J	0.015	0.00032		0.0002	0.0080		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	4/5/17	ND	U	0.015	0.00009	J	0.0002	0.0063		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	5/3/17	0.013	J	0.015	0.00020		0.0002	0.0080		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	6/15/17	0.0088	J	0.015	0.00024		0.0002	0.0082		0.005	ND	U	0.04	ND	U	0.005
OU-1-007	7/27/17	0.0249		0.015	0.00029		0.0002	0.0110		0.005	ND		0.04	ND		0.005
OU-1-007	8/17/17	ND		0.015	ND		0.0002	0.0078		0.005	ND		0.04	ND		0.005
OU-1-008	3/30/17	ND	U	0.015	ND	U	0.0002	0.0069		0.005	ND	U	0.04	ND	U	0.005
OU-1-008	4/5/17	ND	U	0.015	ND	U	0.0002	0.0072		0.005	ND	U	0.04	ND	U	0.005
OU-1-008	5/3/17	0.0047	J	0.015	ND	U	0.0002	0.0105		0.005	ND	U	0.04	ND	U	0.005
OU-1-009	4/30/17	ND	U	0.015	ND	U	0.0002	0.0031	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-009	5/4/17	ND	U	0.015	ND	U	0.0002	0.0040	J	0.005	ND	U	0.04	ND	U	0.005
OU-1-010	4/30/17	ND	U	0.015	ND	U	0.0002	0.0499		0.005	1.01		0.04	ND	U	0.005

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Lead, Total			Mercury, Total			Nickel, Total			Selenium, Total			Silver, Total		
		ug/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		15			0.2			5			40			5		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	ND	U	0.015	ND	U	0.0002	0.0299		0.005	ND	U	0.04	ND	U	0.005
OU-1-011	4/30/17	ND	U	0.015	ND	U	0.0002	0.0171		0.005	ND	U	0.04	ND	U	0.005
OU-1-011	5/4/17	ND	U	0.015	ND	U	0.0002	0.0111		0.005	ND	U	0.04	ND	U	0.005
BUFFER ZONE	4/26/16	ND	U	0.015	ND	U	0.0002	0.013		0.005	ND	U	0.04	ND	U	0.005

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Thallium, Total			Zinc, Total		
		ug/L			ug/L		
Reporting Limits		50			10		
		Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	ND	U	0.05	0.152		0.01
NCC-001	4/6/16	ND	U	0.05	0.167		0.01
NCC-001	5/10/16	ND	U	0.05	0.328		0.01
NCC-001	7/6/16	ND	U	0.05	0.0465		0.01
NCC-001	8/15/16	ND	U	0.05	0.0349		0.01
NCC-001	9/9/16	ND	U	0.05	0.0752		0.01
NCC-001	11/3/16	ND	U	0.05	0.0203		0.01
OU-1-001	1/20/17	ND	U	0.05	0.0909		0.01
OU-1-001	2/21/17	ND	U	0.05	0.188		0.01
OU-1-001	3/1/17	ND	U	0.05	0.0413		0.01
OU-1-001	4/5/17	ND	U	0.05	0.0358		0.01
OU-1-001	5/3/17	ND	U	0.05	0.0362		0.01
OU-1-001	6/15/17	ND	U	0.05	0.0609		0.01
OU-1-001	7/27/17	ND	U	0.05	0.102		0.01
OU-1-001	8/17/17	ND	U	0.05	0.0271		0.01
NCC-002	3/30/16	ND	U	0.05	0.0679		0.01
NCC-002	4/11/16	ND	U	0.05	0.0398		0.01
NCC-002	5/11/16	ND	U	0.05	ND	U	0.01
NCC-002	7/6/16	ND	U	0.05	0.0119		0.01
NCC-002	8/15/16	ND	U	0.05	0.0108		0.01
NCC-002	9/9/16	ND	U	0.05	ND	U	0.01
NCC-002	11/3/16	ND	U	0.05	0.0110		0.01
OU-1-002	1/20/17	ND	U	0.05	0.0129		0.01
OU-1-002	3/27/17	ND	U	0.05	0.0220		0.01
OU-1-002	4/5/17	ND	U	0.05	0.0382		0.01
OU-1-002	5/3/17	ND	U	0.05	0.0164		0.01
OU-1-002	6/15/17	ND	U	0.05	0.0045	J	0.01
OU-1-002	7/27/17	ND		0.05	0.0154		0.01
OU-1-002	8/17/17	ND		0.05	0.0077		0.01
NCC-003	3/30/16	ND	U	0.05	0.0271		0.01

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Thallium, Total			Zinc, Total		
		ug/L			ug/L		
Reporting Limits		50			10		
		Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	ND	U	0.05	0.0278		0.01
NCC-003	5/11/16	ND	U	0.05	0.181		0.01
NCC-003	7/6/16	ND	U	0.05	0.647		0.01
NCC-003	8/15/16	ND	U	0.05	0.0146		0.01
NCC-003	9/9/16	ND	U	0.05	0.0589		0.01
NCC-003a	9/16/16	ND	U	0.05	0.109		0.01
NCC-003a	11/3/16	ND	U	0.05	0.0121		0.01
OU-1-003A	1/20/17	ND	U	0.05	0.621		0.01
OU-1-003A	3/1/17	0.016	J	0.05	0.0821		0.01
OU-1-003A	4/5/17	ND	U	0.05	0.0433		0.01
OU-1-003A	5/3/17	ND	U	0.05	0.0092	J	0.01
NCC-004	5/12/16	ND	U	0.05	0.0803		0.01
OU-1-004	4/5/17	ND	U	0.05	0.0142		0.01
OU-1-004	5/3/17	ND	U	0.05	0.0221		0.01
OU-1-006	4/29/17	ND	U	0.05	0.0147		0.01
NCC-007	11/3/16	ND	U	0.05	0.0850		0.01
OU-1-007	1/20/17	ND	U	0.05	0.108		0.01
OU-1-007	2/21/17	ND	U	0.05	0.863		0.01
OU-1-007	3/1/17	ND	U	0.05	0.106		0.01
OU-1-007	4/5/17	ND	U	0.05	0.0353		0.01
OU-1-007	5/3/17	ND	U	0.05	0.0961		0.01
OU-1-007	6/15/17	ND	U	0.05	0.0811		0.01
OU-1-007	7/27/17	ND		0.05	0.109		0.01
OU-1-007	8/17/17	ND		0.05	0.0653		0.01
OU-1-008	3/30/17	ND	U	0.05	0.0333		0.01
OU-1-008	4/5/17	ND	U	0.05	0.0184		0.01
OU-1-008	5/3/17	ND	U	0.05	0.0278		0.01
OU-1-009	4/30/17	ND	U	0.05	0.0209		0.01
OU-1-009	5/4/17	ND	U	0.05	0.0556		0.01
OU-1-010	4/30/17	ND	U	0.05	0.213		0.01

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Thallium, Total			Zinc, Total		
		ug/L			ug/L		
Reporting Limits		50			10		
		Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	ND	U	0.05	0.150		0.01
OU-1-011	4/30/17	ND	U	0.05	0.0124		0.01
OU-1-011	5/4/17	ND	U	0.05	0.0227		0.01
BUFFER ZONE	4/26/16	ND	U	0.05	0.0308		0.01

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Hexane Extractable Materia			Benzene			Ethyl Benzene			Toluene			Xylenes, Total		
		mg/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			2			5			n/a			n/a		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-001	3/10/16	15		5	ND	U	2	ND	U	5	ND	U	5	ND	U	5
NCC-001	4/6/16	5		5	ND	U	2	ND	U	5	ND	U	5	ND	U	5
NCC-001	5/10/16	13		5	ND	U	2	ND	U	5						
NCC-001	7/6/16	7		5	ND	U	2	ND	U	5						
NCC-001	8/15/16	ND	U	5	ND	U	2	ND	U	5						
NCC-001	9/9/16	ND	U	5	ND	U	2	ND	U	5						
NCC-001	11/3/16	ND	U	6	ND	U	2	ND	U	5						
OU-1-001	1/20/17	ND	U	5	ND	U	2	ND	U	5						
OU-1-001	2/21/17	6		6	ND	U	2	ND	U	5						
OU-1-001	3/1/17	4		5	ND	U	2	ND	U	5						
OU-1-001	4/5/17	4		5	ND	U	2	ND	U	5						
OU-1-001	5/3/17	5	J	5	ND	U	2	ND	U	5						
OU-1-001	6/15/17	4	J	5	ND	U	2	ND	U	5						
OU-1-001	7/27/17	5	J	5	ND	UJ-	2	ND	UJ-	5						
OU-1-001	8/17/17	2	J	5	ND	U	2	ND	U	5						
NCC-002	3/30/16	ND	U	5	ND	U	2	ND	U	5	ND	U	5	ND	U	5
NCC-002	4/11/16	ND	U	5	ND	U	2	ND	U	5	ND	U	5	ND	U	5
NCC-002	5/11/16	ND	U	5	ND	U	2	ND	U	5						
NCC-002	7/6/16	6		5	ND	U	2	ND	U	5						
NCC-002	8/15/16	ND	U	5	ND	U	2	ND	U	5						
NCC-002	9/9/16	10		6	ND	U	2	ND	U	5						
NCC-002	11/3/16	3	J	6	ND	U	2	ND	U	5						
OU-1-002	1/20/17	ND	U	5	ND	U	2	ND	U	5						
OU-1-002	3/27/17	5	J	6	ND	U	2	ND	U	5						
OU-1-002	4/5/17	5	J	5	ND	U	2	ND	U	5						
OU-1-002	5/3/17	5	J	5	ND	U	2	ND	U	5						
OU-1-002	6/15/17	4	J	5	ND	U	2	ND	U	5						
OU-1-002	7/27/17	4	J	5	ND		2	ND		5						
OU-1-002	8/17/17	3		5	ND		2	ND		5						
NCC-003	3/30/16	ND	U	5	ND	U	2	ND	U	5	ND	U	5	ND	U	5

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Hexane Extractable Materia			Benzene			Ethyl Benzene			Toluene			Xylenes, Total		
		mg/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			2			5			n/a			n/a		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
NCC-003	4/6/16	ND	U	5	ND	U	2	ND	U	5	ND	U	5	ND	U	5
NCC-003	5/11/16	ND	U	5	ND	U	2	ND	U	5						
NCC-003	7/6/16	6		6	2	Uj	2	5	Uj	5						
NCC-003	8/15/16	ND	U	6	ND	U	2	ND	U	5						
NCC-003	9/9/16	ND	U	6	ND	U	2	ND	U	5						
NCC-003a	9/16/16	7		5	ND	U	2	ND	U	5						
NCC-003a	11/3/16	3	J	5	ND	U	2	ND	U	5						
OU-1-003A	1/20/17	ND	U	5	ND	U	2	ND	U	5						
OU-1-003A	3/1/17	3	J	5	ND	U	2	ND	U	5						
OU-1-003A	4/5/17	4	J	6	ND	U	2	ND	U	5						
OU-1-003A	5/3/17	2	J	5	ND	U	2	ND	U	5						
NCC-004	5/12/16	6		6	ND	U	2	ND	U	5						
OU-1-004	4/5/17	4	J	5	ND	U	2	ND	U	5						
OU-1-004	5/3/17	4	J	5	ND	U	2	ND	U	5						
OU-1-006	4/29/17	8		6	ND	U	2	ND	U	5						
NCC-007	11/3/16	2	J	6	ND	U	2	ND	U	5						
OU-1-007	1/20/17	ND	U	6	ND	U	2	ND	U	5						
OU-1-007	2/21/17	9		5	ND	U	2	ND	U	5						
OU-1-007	3/1/17	6		5	ND	U	2	ND	U	5						
OU-1-007	4/5/17	7		5	ND	U	2	ND	U	5						
OU-1-007	5/3/17	14		5	ND	U	2	ND	U	5						
OU-1-007	6/15/17	8		5	ND	U	2	ND	U	5						
OU-1-007	7/27/17	5	J	6	ND		2	ND		5						
OU-1-007	8/17/17	2		6	ND		2	ND		5						
OU-1-008	3/30/17	6		5	ND	U	2	ND	U	5						
OU-1-008	4/5/17	3	J	5	ND	U	2	ND	U	5						
OU-1-008	5/3/17	2	J	6	ND	U	2	ND	U	5						
OU-1-009	4/30/17	5	J	6	ND	U	2	ND	U	5						
OU-1-009	5/4/17	3	J	5	ND	U	2	ND	U	5						
OU-1-010	4/30/17	5	J	6	ND	U	2	ND	U	5						

Table 2-18 - OU-1 Stormwater Monitoring Results - Physical and Chemical Parameters

Sample Number	Date	Hexane Extractable Materia			Benzene			Ethyl Benzene			Toluene			Xylenes, Total		
		mg/L			ug/L			ug/L			ug/L			ug/L		
Reporting Limits		5			2			5			n/a			n/a		
		Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL	Result	Final Q	RL
OU-1-010	5/4/17	2	J	5	ND	U	2	ND	U	5						
OU-1-011	4/30/17	7		6	ND	U	2	ND	U	5						
OU-1-011	5/4/17	3	J	5	ND	U	2	ND	U	5						
BUFFER ZONE	4/26/16	6		5	ND	U	2	ND	U	5						

Notes:
RL = reporting limit; Q = data qualifier
mg/L - milligrams per liter, ug/L - micrograms per liter,
ND - non detect, U - not detected at the reported level,
J - estimated value, J+ estimated value biased high, J- estimated value biased low, n/a - not established

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Actinium-227				Actinium-228				Bismuth-214			
All results in picoCuries per gram (pCi/g)		Result	Final Q	CSU	CV	Result	Final Q	CSU	CV	Result	Final Q	CSU	CV
SED-1	5/17/1997	2.23	U							1.07	U		
SED-1 FD	5/17/1997	2.83	U							1.55	U		
SED-1	1/8/2016	0.10	J	0.08	0.00	0.81		0.21	0.19	1.04	J+	0.18	0.11
SED-1_(ES)	1/8/2016	0.25	U	0.76	0.61	0.62		0.27	0.20	1.08		0.23	0.06
SED-2	5/17/1997	1.16	U							0.72	U		
SED-2	1/8/2016	0.03	J	0.05	0.01	0.78		0.21	0.18	1.05	J+	0.18	0.10
SED-2_(ES)	1/8/2016	0.39	U	0.72	0.56	1.08		0.30	0.04	1.50		0.30	0.07
SED-2	11/3/2016	0.03	J	0.05	0.01	0.78		0.21	0.34	1.00		0.19	0.11
SED-2 (Nov 16)_(ES)	11/3/2016	-0.38	U	1.01	0.82	0.85		0.24	0.15	0.97		0.21	0.05
SED-2 FD	11/3/2016	0.14	J	0.10	0.03	0.88		0.29	0.29	1.36		0.24	0.14
SED-2 (Nov 16)_FD_(ES)	11/3/2016	0.07	U	1.03	0.71	1.04		0.35	0.06	1.17		0.32	0.11
SED-3	5/17/1997	2.69	U							1.11	U		
SED-4	5/17/1997	1.27	U							1.08	U		
SED-4	1/8/2016	0.15	J	0.10	0.01	0.79		0.22	0.17	1.61	J+	0.22	0.11
SED-4 (Jan 2016)_(ES)	1/8/2016	0.14	U	0.78	0.63	0.89		0.25	0.12	1.68		0.34	0.09
SED-4	6/10/2016	0.11	J	0.07	0.01	0.98		0.22	0.19	1.27		0.18	0.11
SED-4 (June 2016)_(ES)	6/10/2016	0.35	U	0.74	0.78	1.17		0.30	0.06	1.14		0.30	0.10
SED-6	6/10/2016	0.19	J	0.09	0.00	0.91		0.21	0.16	1.09		0.18	0.11
SED-6_(ES)	6/10/2016	0.41	U	0.56	0.43	0.78		0.24	0.11	0.96		0.22	0.07
SED-6 FD	6/10/2016	0.08	J	0.06	0.00	1.31		0.49	0.43	1.25		0.32	0.23
SED-7	6/10/2016	0.15	J	0.08	0.02	0.84		0.24	0.17	0.91		0.17	0.09
SED-7_(ES)	6/10/2016	0.60	U	1.27	1.03	0.75		0.26	0.19	1.07		0.27	0.09
SED-8	6/10/2016	0.11	J	0.06	0.01	1.16		0.42	0.48	1.71		0.38	0.24
SED-8_(ES)	6/10/2016	1.14		1.09	0.68	0.92		0.33	0.14	1.42		0.34	0.10
SED-9	1/19/2017	0.17	J	0.11	0.01	1.04		0.31	0.28	1.16		0.21	0.13
SED-9_(ES)	1/19/2017	-0.12	U	0.24	1.56	0.94		0.44	0.25	1.31		0.30	0.10
SED-10	1/19/2017	0.06	J	0.06	0.01	0.86		0.26	0.19	1.20		0.21	0.16
SED-10_(ES)	1/19/2017	0.38	U	0.78	0.94	0.51	U	0.49	0.27	1.38		0.40	0.15
SEDIMENT 2016-03-16A	3/16/2016	0.20	J	0.11	0.01	1.30		0.30	0.27	1.70		0.24	0.11
SEDIMENT 2016-03-16A_(ES)	3/16/2016	0.05	U	1.00	0.82	0.52		0.33	0.24	1.52		0.33	0.06
SEDIMENT 2016-03-16B	3/16/2016	0.30	J	0.15	0.01	1.08		0.21	0.18	1.13		0.19	0.12
SEDIMENT 2016-03-16B_(ES)	3/16/2016	-0.13	U	0.64	0.52	0.62		0.29	0.15	1.11		0.24	0.04
SEDIMENT 2016-03-16B FD	3/16/2016	0.20	J	0.13	0.04	0.92		0.25	0.24	1.32		0.22	0.12

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Lead-210				Lead-212				Lead-214			
All results in picoCuries per gram (pCi/g)		Result	Final Q	CSU	CV	Result	Final Q	CSU	CV	Result	Final Q	CSU	CV
SED-1	5/17/1997	2,000	U			0.7		0.44		1.06	U		
SED-1 FD	5/17/1997	2,640	U			0.69	U			1.26	U		
SED-1	1/8/2016	1.94	J	1.56	1.25	0.85		0.13	0.11	1.24		0.18	0.11
SED-1_(ES)	1/8/2016	1.99	J	1.70	1.19	0.77		0.19	0.08	1.27		0.24	0.09
SED-2	5/17/1997	2.22	U			0.38	U			0.60	U		
SED-2	1/8/2016	4.69		2.25	1.71	0.74		0.13	0.12	1.01		0.16	0.12
SED-2_(ES)	1/8/2016	3.91	J	1.86	1.20	0.73		0.23	0.09	1.33		0.25	0.09
SED-2	11/3/2016	4.33		1.70	1.27	1.08	J	0.22	0.11	1.04	J	0.20	0.10
SED-2 (Nov 16)_(ES)	11/3/2016	1.98		1.26	0.79	0.59		0.13	0.05	1.12		0.20	0.02
SED-2 FD	11/3/2016	6.54		2.33	1.71	1.10		0.18	0.14	1.36		0.23	0.19
SED-2 (Nov 16)_FD_(ES)	11/3/2016	3.82		2.30	1.33	0.63		0.17	0.08	1.01		0.26	0.13
SED-3	5/17/1997	1,980	U			0.91	U			1.12	U		
SED-4	5/17/1997	3.72	U			0.84		0.33		0.83		0.41	
SED-4	1/8/2016	4.68		2.32	1.78	0.90		0.14	0.11	1.66		0.26	0.23
SED-4 (Jan 2016)_(ES)	1/8/2016	3.95	J	2.27	1.40	0.78		0.19	0.07	1.94		0.34	0.09
SED-4	6/10/2016	2.07		0.96	0.76	1.03		0.18	0.10	1.21		0.20	0.10
SED-4 (June 2016)_(ES)	6/10/2016	0.04	U	2.66	1.87	0.88		0.19	0.06	1.17		0.26	0.10
SED-6	6/10/2016	2.36	J	1.57	1.25	0.95		0.14	0.11	1.16		0.18	0.15
SED-6_(ES)	6/10/2016	1.13	U	1.68	1.30	0.91		0.19	0.06	1.21		0.26	0.09
SED-6 FD	6/10/2016	1.28	J	1.00	0.81	1.03		0.22	0.17	0.99		0.29	0.24
SED-7	6/10/2016	1.58	J	1.44	1.16	0.99		0.14	0.12	0.81		0.17	0.14
SED-7_(ES)	6/10/2016	-1.56	U	1.74	2.73	0.76		0.17	0.06	1.39		0.24	0.08
SED-8	6/10/2016	1.82	J	1.03	0.81	1.53		0.36	0.23	1.23		0.34	0.29
SED-8_(ES)	6/10/2016	3.66		2.66	1.62	1.04		0.24	0.08	1.62		0.31	0.12
SED-9	1/19/2017	3.03		1.30	0.99	1.17		0.17	0.16	1.29		0.19	0.16
SED-9_(ES)	1/19/2017	6.70		3.24	1.80	1.08		0.24	0.10	1.70		0.32	0.12
SED-10	1/19/2017	5.91		2.14	1.54	0.95		0.16	0.13	1.04		0.19	0.12
SED-10_(ES)	1/19/2017	6.40		3.09	1.79	0.71		0.25	0.15	1.32		0.32	0.11
SEDIMENT 2016-03-16A	3/16/2016	3.32	J	2.15	1.71	1.21		0.19	0.17	1.86		0.26	0.16
SEDIMENT 2016-03-16A_(ES)	3/16/2016	4.98		2.68	1.37	0.96		0.28	0.11	1.61		0.35	0.09
SEDIMENT 2016-03-16B	3/16/2016	2.84		1.41	1.08	0.97		0.15	0.12	1.20		0.16	0.12
SEDIMENT 2016-03-16B_(ES)	3/16/2016	3.00		1.69	1.01	0.83		0.18	0.06	1.30		0.24	0.08
SEDIMENT 2016-03-16B FD	3/16/2016	1.59	J	1.61	1.31	1.09		0.15	0.13	1.38		0.18	0.12

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Potassium-40				Protactinium-231				Thallium-208			
All results in picoCuries per gram (pCi/g)		Result	Final Q	CSU	CV	Result	Final Q	CSU	CV	Result	Final Q	CSU	CV
SED-1	5/17/1997					8.85	U			0.42	U		
SED-1 FD	5/17/1997					8.79	U			0.52	U		
SED-1	1/8/2016	13.68		1.94	0.50	-0.25	U	1.33	1.01	0.91		0.21	0.18
SED-1_(ES)	1/8/2016	9.17		2.03	0.74	-0.15	U	1.40	1.14	0.32		0.09	0.04
SED-2	5/17/1997					5.84	U			0.28	U		
SED-2	1/8/2016	11.66		1.92	0.52	-0.21	U	1.93	1.17	0.65		0.16	0.18
SED-2_(ES)	1/8/2016	10.00		2.06	0.51	0.23	U	0.50	1.06	0.28		0.09	0.02
SED-2	11/3/2016	11.78		1.81	0.22	-3.05	U	2.38	1.20	0.73		0.16	0.14
SED-2 (Nov 16)_(ES)	11/3/2016	9.96		2.22	0.60	-0.92	U	3.06	2.49	0.24	J	0.07	0.02
SED-2 FD	11/3/2016	14.95		2.36	0.51	2.55	J	2.32	1.82	0.85		0.21	0.19
SED-2 (Nov 16)_FD_(ES)	11/3/2016	10.70		2.50	0.45	-0.86	U	4.55	3.72	0.31	J	0.11	0.04
SED-3	5/17/1997					8.80	U			0.57	U		
SED-4	5/17/1997					5.90	U			0.21	U		
SED-4	1/8/2016	17.55		2.50	0.43	-2.73	U	2.28	1.22	0.75		0.15	0.16
SED-4 (Jan 2016)_(ES)	1/8/2016	15.00		2.66	0.40	0.69	U	1.70	1.35	0.24		0.09	0.03
SED-4	6/10/2016	17.92		2.38	0.40	0.13	U	1.05	0.97	0.88		0.16	0.10
SED-4 (June 2016)_(ES)	6/10/2016	13.50		2.74	0.44	-1.65	U	4.78	3.88	0.37	J	0.12	0.04
SED-6	6/10/2016	15.07		2.17	0.59	1.38	J	1.74	1.31	0.70		0.17	0.16
SED-6_(ES)	6/10/2016	17.00		2.73	0.42	0.00	U	3.54	2.92	0.36	J	0.12	0.04
SED-6 FD	6/10/2016	15.87		3.29	1.35	-1.06	U	2.50	2.17	0.97		0.26	0.22
SED-7	6/10/2016	16.25		2.37	0.72	0.13	U	1.83	1.28	0.79		0.17	0.16
SED-7_(ES)	6/10/2016	16.20		2.79	0.26	0.57	U	2.29	3.56	0.34	J	0.10	0.03
SED-8	6/10/2016	17.31		3.52	1.20	0.03	U	3.21	2.57	1.14		0.32	0.35
SED-8_(ES)	6/10/2016	17.00		3.43	0.54	-1.57	U	4.39	3.54	0.40	J	0.11	0.02
SED-9	1/19/2017	15.38		2.26	0.75	3.03	J	2.11	1.63	1.04		0.22	0.22
SED-9_(ES)	1/19/2017	16.50		3.03	0.49	0.83	U	2.79	3.82	0.43		0.12	0.04
SED-10	1/19/2017	12.87		2.23	0.68	-1.43	U	2.37	1.34	0.92		0.20	0.14
SED-10_(ES)	1/19/2017	13.20		2.98	0.62	1.19	U	2.66	2.94	0.40		0.13	0.04
SEDIMENT 2016-03-16A	3/16/2016	15.89		2.36	0.44	0.58	U	1.00	1.89	0.94		0.22	0.21
SEDIMENT 2016-03-16A_(ES)	3/16/2016	10.90		2.61	0.66	0.05	U	0.70	1.83	0.31		0.11	0.04
SEDIMENT 2016-03-16B	3/16/2016	13.22		2.00	0.50	1.15	U	1.64	1.35	0.70		0.15	0.19
SEDIMENT 2016-03-16B_(ES)	3/16/2016	9.11		2.01	0.59	0.23	U	0.56	1.12	0.34		0.10	0.03
SEDIMENT 2016-03-16B FD	3/16/2016	14.34		2.05	0.18	1.09	U	2.06	1.50	0.73		0.18	0.20

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Radium-226				Radium-228				Thorium-228			
All results in picoCuries per gram (pCi/g)		**Result**	**Final Q**	**CSU**	**CV**	**Result**	**Final Q**	**CSU**	**CV**	**Result**	**Final Q**	**CSU**	**CV**
SED-1	5/17/1997	5.08	U			1.44	U			0.56		0.17	
SED-1 FD	5/17/1997	8.22	U			1.94	U			0.65		0.20	
SED-1	1/8/2016	1.04	J+	0.18	0.11	0.81		0.21	0.19	0.67	J	0.23	0.02
SED-1_(ES)	1/8/2016	1.08		0.23	0.06	0.62		0.27	0.20	0.70		0.16	0.02
SED-2	5/17/1997	3.90	U			0.85	U			0.20		0.09	
SED-2	1/8/2016	1.05	J+	0.18	0.10	0.78		0.21	0.18	0.65	J	0.24	0.02
SED-2_(ES)	1/8/2016	1.50		0.30	0.07	1.08		0.30	0.04	0.74		0.17	0.03
SED-2	11/3/2016	1.00		0.19	0.11	0.78		0.21	0.34	0.79	J	0.28	0.02
SED-2 (Nov 16)_(ES)	11/3/2016	0.97		0.21	0.05	0.85		0.24	0.15	0.80	J	0.18	0.03
SED-2 FD	11/3/2016	1.36		0.24	0.14	0.88		0.29	0.29	0.81	J	0.27	0.07
SED-2 (Nov 16)_FD_(ES)	11/3/2016	1.17		0.32	0.11	1.04		0.35	0.06	0.73	J	0.17	0.03
SED-3	5/17/1997	6.17	U			1.68	U			1.17		0.31	
SED-4	5/17/1997	5.40		2.82		1.83	U			0.74		0.22	
SED-4	1/8/2016	1.61	J+	0.22	0.11	0.79		0.22	0.17	0.91	J	0.27	0.02
SED-4 (Jan 2016)_(ES)	1/8/2016	1.68		0.34	0.09	0.89		0.25	0.12	0.90		0.19	0.02
SED-4	6/10/2016	1.27		0.18	0.11	0.98		0.22	0.19	0.78		0.23	0.01
SED-4 (June 2016)_(ES)	6/10/2016	1.14		0.30	0.10	1.17		0.30	0.06	1.01	J	0.17	0.03
SED-6	6/10/2016	1.09		0.18	0.11	0.91		0.21	0.16	0.68	J	0.20	0.01
SED-6_(ES)	6/10/2016	0.96		0.22	0.07	0.78		0.24	0.11	1.07	J	0.18	0.02
SED-6 FD	6/10/2016	1.25		0.32	0.23	1.31		0.49	0.43	0.73	J	0.21	0.01
SED-7	6/10/2016	0.91		0.17	0.09	0.84		0.24	0.17	0.76		0.22	0.03
SED-7_(ES)	6/10/2016	1.07		0.27	0.09	0.75		0.26	0.19	0.73	J	0.13	0.02
SED-8	6/10/2016	1.71		0.38	0.24	1.16		0.42	0.48	0.70	J	0.20	0.01
SED-8_(ES)	6/10/2016	1.42		0.34	0.10	0.92		0.33	0.14	1.07	J	0.18	0.02
SED-9	1/19/2017	1.16		0.21	0.13	1.04		0.31	0.28	0.88	J	0.30	0.01
SED-9_(ES)	1/19/2017	1.31		0.30	0.10	0.94		0.44	0.25	1.03		0.21	0.03
SED-10	1/19/2017	1.20		0.21	0.16	0.86		0.26	0.19	0.76		0.25	0.01
SED-10_(ES)	1/19/2017	1.38		0.40	0.15	0.51	U	0.49	0.27	0.76		0.16	0.03
SEDIMENT 2016-03-16A	3/16/2016	1.70		0.24	0.11	1.30		0.30	0.27	0.68	J	0.22	0.02
SEDIMENT 2016-03-16A_(ES)	3/16/2016	1.52		0.33	0.06	0.52		0.33	0.24	1.14	J	0.21	0.03
SEDIMENT 2016-03-16B	3/16/2016	1.13		0.19	0.12	1.08		0.21	0.18	1.08	J	0.33	0.01
SEDIMENT 2016-03-16B_(ES)	3/16/2016	1.11		0.24	0.04	0.62		0.29	0.15	0.84	J	0.18	0.03
SEDIMENT 2016-03-16B FD	3/16/2016	1.32		0.22	0.12	0.92		0.25	0.24	0.62	J	0.24	0.06

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Thorium-230				Thorium-232				Thorium-234			
All results in picoCuries per gram (pCi/g)		Result	Final Q	CSU	CV	Result	Final Q	CSU	CV	Result	Final Q	CSU	CV
SED-1	5/17/1997	2.71		0.56		0.47		0.15					
SED-1 FD	5/17/1997	3.18		0.66		0.52		0.17					
SED-1	1/8/2016	2.70		0.67	0.07	0.92		0.28	0.01	2.40	J	1.35	0.92
SED-1_(ES)	1/8/2016	3.25		0.42	0.02	0.69		0.16	0.01	1.28		1.52	1.22
SED-2	5/17/1997	1.70		0.37		0.24		0.10					
SED-2	1/8/2016	2.74	J	0.70	0.08	0.81	J	0.27	0.01	1.73	J	1.67	1.36
SED-2_(ES)	1/8/2016	3.33		0.44	0.01	0.65		0.16	0.01	0.22	U	0.43	1.37
SED-2	11/3/2016	2.93		0.77	0.09	1.07	J	0.34	0.02	2.04		0.88	0.73
SED-2 (Nov 16)_(ES)	11/3/2016	2.39		0.35	0.01	0.66		0.16	0.01	1.08	U	1.03	0.78
SED-2 FD	11/3/2016	3.14	J	0.76	0.10	0.85	J	0.27	0.01	4.23	J	2.41	1.93
SED-2 (Nov 16)_FD_(ES)	11/3/2016	2.60		0.36	0.01	0.69		0.16	0.01	1.00	U	0.80	1.13
SED-3	5/17/1997	3.06		0.66		0.92		0.26					
SED-4	5/17/1997	4.04		0.83		0.84		0.24					
SED-4	1/8/2016	14.70	J	3.06	0.07	1.46	J	0.38	0.00	1.21	J	0.96	0.75
SED-4 (Jan 2016)_(ES)	1/8/2016	19.80		1.84	0.02	0.83		0.18	0.01	0.47	U	0.88	1.35
SED-4	6/10/2016	3.23		0.75	0.05	0.65	J	0.19	0.01	1.05	J	0.89	0.68
SED-4 (June 2016)_(ES)	6/10/2016	3.56		0.40	0.01	1.04		0.17	0.01	2.37		1.75	1.03
SED-6	6/10/2016	2.12	J	0.51	0.05	0.74	J	0.21	0.00	3.25		1.22	0.86
SED-6_(ES)	6/10/2016	2.82		0.34	0.01	1.19		0.19	0.01	0.83	U	0.75	1.00
SED-6 FD	6/10/2016	2.15	J	0.52	0.05	0.71	J	0.20	0.00	1.60	J	1.22	0.95
SED-7	6/10/2016	2.38		0.57	0.07	0.64		0.19	0.01	0.85	U	1.37	0.87
SED-7_(ES)	6/10/2016	2.45	J	0.30	0.01	0.66	J	0.12	0.01	0.97	U	0.75	0.97
SED-8	6/10/2016	3.27	J	0.73	0.04	0.75	J	0.21	0.01	2.51	J	2.10	1.72
SED-8_(ES)	6/10/2016	3.77		0.42	0.01	1.11		0.18	0.01	-1.10	U	1.68	1.87
SED-9	1/19/2017	4.46	J+	1.09	0.08	1.04	J+	0.33	0.01	2.43	J	1.46	1.00
SED-9_(ES)	1/19/2017	4.50		0.54	0.01	0.84		0.18	0.01	1.22	U	1.81	1.40
SED-10	1/19/2017	2.32	J+	0.59	0.07	1.18	J+	0.33	0.01	1.94	J	1.63	1.31
SED-10_(ES)	1/19/2017	2.35		0.32	0.01	0.78		0.16	0.01	1.56	U	2.09	1.43
SEDIMENT 2016-03-16A	3/16/2016	6.98	J+	1.49	0.07	0.82	J	0.24	0.01	1.43	J	1.67	1.09
SEDIMENT 2016-03-16A_(ES)	3/16/2016	5.87		0.65	0.01	0.70		0.16	0.01	3.27		1.82	1.39
SEDIMENT 2016-03-16B	3/16/2016	4.53	J+	1.08	0.08	0.74		0.25	0.00	1.09	J	1.46	0.93
SEDIMENT 2016-03-16B_(ES)	3/16/2016	3.85		0.47	0.01	0.60		0.15	0.01	1.32		1.31	1.05
SEDIMENT 2016-03-16B FD	3/16/2016	4.39	J+	1.06	0.10	0.84		0.28	0.03	2.01	J	1.71	1.39

Table 2-19: Radionuclide Results for Sediment Samples

Client ID	Date	Uranium-234				Uranium-235				Uranium-238			
All results in picoCuries per gram (pCi/g)		Result	Final Q	CSU	CV	Result	Final Q	CSU	CV	Result	Final Q	CSU	CV
SED-1	5/17/1997	16.3		2.8						3.14		0.62	
SED-1 FD	5/17/1997	1.04		0.24						1.17		0.26	
SED-1	1/8/2016	1.10	J	0.34	0.06	0.10	J	0.11	0.00	1.06		0.33	0.02
SED-1_(ES)	1/8/2016	0.75		0.19	0.02	0.03		0.05	0.02	0.74		0.19	0.01
SED-2	5/17/1997	0.58		0.16						0.71		0.19	
SED-2	1/8/2016	0.88		0.27	0.04	0.28	J	0.16	0.01	0.90		0.27	0.01
SED-2_(ES)	1/8/2016	0.97		0.23	0.02	0.03		0.04	0.01	0.94		0.23	0.02
SED-2	11/3/2016	1.05	J	0.28	0.02	0.12	J	0.10	0.01	1.23	J+	0.31	0.01
SED-2 (Nov 16)_(ES)	11/3/2016	0.86		0.24	0.01	0.11	U	0.09	0.01	0.70		0.22	0.01
SED-2 FD	11/3/2016	0.87	J	0.24	0.01	0.06	J	0.06	0.00	1.01	J+	0.26	0.01
SED-2 (Nov 16)_FD_(ES)	11/3/2016	1.02		0.28	0.04	0.03	U	0.06	0.03	0.76		0.24	0.05
SED-3	5/17/1997	0.81		0.19						0.78		0.19	
SED-4	5/17/1997	0.69		0.21						0.53		0.18	
SED-4	1/8/2016	0.89	J	0.25	0.06	0.18	J	0.11	0.01	0.96	J	0.26	0.02
SED-4 (Jan 2016)_(ES)	1/8/2016	0.78		0.20	0.02	0.03		0.05	0.02	0.88		0.21	0.01
SED-4	6/10/2016	0.83	J+	0.22	0.01	0.05	J	0.05	0.00	0.70		0.19	0.01
SED-4 (June 2016)_(ES)	6/10/2016	0.77		0.15	0.02	0.05		0.04	0.01	0.81		0.15	0.01
SED-6	6/10/2016	0.94	J+	0.21	0.01	0.06	J	0.05	0.00	0.80	J	0.19	0.01
SED-6_(ES)	6/10/2016	0.66		0.13	0.01	0.04		0.03	0.01	0.82		0.15	0.01
SED-6 FD	6/10/2016	0.67	J+	0.18	0.01	0.13	J	0.08	0.00	0.70		0.19	0.01
SED-7	6/10/2016	0.53	J+	0.15	0.01	0.05	J	0.05	0.00	0.62	J	0.16	0.01
SED-7_(ES)	6/10/2016	0.51		0.12	0.01	0.03		0.03	0.01	0.79		0.16	0.01
SED-8	6/10/2016	0.78	J+	0.20	0.01	0.15	J	0.09	0.00	0.66	J	0.18	0.01
SED-8_(ES)	6/10/2016	0.76		0.16	0.02	0.03		0.03	0.01	0.83		0.16	0.01
SED-9	1/19/2017	1.19	J+	0.35	0.02	0.05	J	0.08	0.00	0.95	J	0.30	0.01
SED-9_(ES)	1/19/2017	1.04		0.22	0.01	0.05		0.05	0.01	1.09		0.23	0.01
SED-10	1/19/2017	1.26	J+	0.31	0.02	0.14	J	0.10	0.01	0.92	J	0.25	0.01
SED-10_(ES)	1/19/2017	1.05		0.22	0.01	0.08		0.06	0.01	1.10		0.22	0.01
SEDIMENT 2016-03-16A	3/16/2016	0.95	J	0.26	0.03	0.10	J	0.09	0.01	1.11	J	0.29	0.01
SEDIMENT 2016-03-16A_(ES)	3/16/2016	1.16		0.24	0.02	0.07		0.07	0.02	0.95		0.22	0.02
SEDIMENT 2016-03-16B	3/16/2016	0.93		0.27	0.04	0.11	J	0.10	0.01	1.00	J	0.28	0.01
SEDIMENT 2016-03-16B_(ES)	3/16/2016	0.62		0.17	0.03	0.02	U	0.04	0.02	0.62		0.17	0.02
SEDIMENT 2016-03-16B FD	3/16/2016	0.93		0.29	0.06	0.16	J	0.12	0.01	0.68	J	0.23	0.01

Notes: Q = data qualifier; CSU = combined standard uncertainty; CV = critical value
U - non-detect; J - estimated value; J+ - estimated value, biased high
Blank cells - analysis not performed or value not provided by laboratory.

Table 2-20: Summary of Potential Exposure Pathways and Receptors

Condition	Receptor Group	Receptor	Consistent with Land Use	Exposure Route: Inhalation of Fugitive Dust	Exposure Route: Inhalation of Radon	Exposure Route: Direct Radiation from Soil	Exposure Route: Direct Radiation from Submersion in Air	Exposure Route: Incidental Soil Ingestion	Exposure Route: Dermal Contact With soil	Selected for Quantitative Evaluation [a]
Current / Near-Term Conditions	**On-Site Receptors**	Farmer	No							
		Resident	No							
		Commercial Building User	No							
		Construction Worker	No							
		Grounds Keeper	No							
		Recreational User	No							
		Trespasser	No							
	On-Property Receptors	Farmer	No							
		Resident	No							
		Storage Yard Worker	No							
		Commercial Building User	Yes	1	•	• [b]	1	1	1	**Yes**
		Construction Worker	No							
		Trespasser	No							
		Recreational/Intermittent User	No							
		Grounds Keeper	Yes	1	•	• [b]	1	1	1	**Yes**
	Off-Property Receptors	Farmer[c]	No							
		Resident	Yes	1	•	1	1	1	1	**Yes**
		Commercial Building User	Yes	1	•	1	1	1	1	**Yes**
		Recreational/Intermittent User	Yes	1	•	1	1	1	1	No, 2
		Grounds Keeper	Yes	1	•	1	1	1	1	No, 2
Future 1,000-Year Conditions	**Landfill Receptors**	Farmer	No							
		Resident	No							
		Storage Yard Worker	Yes	•	•	•	•	•	•	**Yes**
		Commercial Building User	Yes	•	•	• [d]	•	1	1	No, 2
		Construction Worker	Yes	•	•	• [b]	•	1	1	No, 2
		Trespasser	Yes	•	•	•	•	•	•	No, 2
		Recreational/Intermittent User	Yes	•	•	•	•	•	•	No, 2
		Grounds Keeper	Yes	•	•	•	•	•	•	**Yes**
	Off-Property Receptors	**Farmer**	Yes	•	•	1	•	1	1	**Yes**
		Resident	Yes	•	•	1	•	1	1	No, 2
		Commercial Building User	Yes	•	•	1	•	1	1	**Yes**
		Recreational/Intermittent User	Yes	•	•	1	•	1	1	No, 2
		Grounds Keeper	Yes	•	•	1	•	1	1	No, 3

[a] For scenarios with one or more release mechanism and exposure route combination(s) that is not selected for quantitative evaluation, justification is provided with "No" in this column.
[b] The receptor is adjacent to OU1 and is exposed proximally to direct radiation from soil at the edges of Areas 1 and 2.
[c] Under current conditions, no farms producing staple crops have been identified near the Landfill.
[d] The grounds keeper is located on OU1 and the commercial building user is only located part time on OU1.
• Indicates a completed exposure pathway exists.
▩ A shaded box indicates that the receptor/exposure route combination was not selected due to inconsistency with current or reasonably anticipated future land uses.
1 Incomplete pathway; the receptor has no access to on-site waste materials.
2 At least one other receptor in this land-use scenario has equal or higher intake rate(s) and/or longer exposure time(s).
3 Although this receptor is unique, the on-property grounds keeper is assumed to be in closer proximity to the waste materials and both of the other receptors in the future off-property scenario have higher exposure parameters than the off-property grounds keeper.

Table 2-21: Summary of Risks and Hazard Indices for All Receptor Scenarios Evaluated by the West Lake OU-1 Baseline Risk Assessment

Current Receptor[a]	Total LCR	Hazard Index	Total LCR Without Radon	Radon-222 and Daughters Percentage of Total LCR [b]
On-Property Grounds Keeper Area 1 and Area 2	1.7E-06	-	1.6E-06	5%
On-Property Commercial Building User Area 1	8.7E-06	-	8.3E-06	5%
On-Property Commercial Building User Area 2	1.9E-05	-	1.8E-05	6%
Off-Property Resident Off-Property Southeast	5.4E-08	-	0.0E+00	100%
Off-Property Resident Off-Property South	2.2E-08	-	0.0E+00	100%
Off-Property Commercial Building User Off-Property North	6.2E-07	-	0.0E+00	100%
Off-Property Commercial Building User Off-Property West	3.5E-07	-	0.0E+00	100%
Off-Property Commercial Building User Adjacent Property, Lot 2A2	4.0E-07	-	0.0E+00	100%

Future Receptor[a]	Total LCR	Hazard Index	Total LCR Without Radon	Radon-222 and Daughters Percentage of Total LCR [b]
Future Landfill Storage Yard Worker Area 1	2.0E-02	3.37	2.0E-02	1%
Future Landfill Storage Yard Worker Area 2	2.2E-02	32.04	2.2E-02	2%
Future Landfill Grounds Keeper Area 1	2.3E-03	0.16	2.3E-03	1%
Future Landfill Grounds Keeper Area 2	2.5E-03	1.54	2.5E-03	1%
Future Landfill Grounds Keeper Buffer Zone	2.8E-04	0.005	2.7E-04	5%
Future Off-Property Farmer Off-Property North	4.1E-04	0.11	3.5E-05	92%
Future Off-Property Farmer Off-Property Southeast	2.9E-05	0.003	9.7E-07	97%
Future Off-Property Farmer Off-Property South	1.1E-05	0.0007	2.2E-07	98%
Future Off-Property Farmer Off-Property West	2.3E-04	0.049	1.5E-05	93%
Future Off-Property Commercial Building User Off-Property North	2.0E-04	0.027	1.5E-05	92%
Future Off-Property Commercial Building User Off-Property West	1.1E-04	0.012	6.5E-06	94%
Future Off-property Commercial Building User Adjacent Property, Lot 2A2	1.3E-04	0.025	1.4E-05	90%

[a] Receptors are identified by being on the landfill property or off of the landfill property, then by the type of receptor (grounds keeper, building user, or resident), and then by their more specific location. On-property refers to areas that are within the boundary of the West Lake Landfill, whereas off-property refers to areas that are outside of the Landfill. Current receptors have no access to OU-1. Landfill receptors (future) have access to OU-1.

[b] The radon percentage of the total lifetime cancer risk (LCR) is from modeled activities that are essentially equivalent to background.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart A, Standards for the Control of Residual Radioactive Material from Inactive Uranium Processing Sites 40 C.F.R. 192.02	Radon-222	Air	The annual average release rate of radon-222 to the atmosphere applied over the entire surface of a disposal site should not exceed 20 pCi/m2-s, and the annual average concentration of radon-222 in air at or above any location outside the disposal site should not be increased by more than 0.5 pCi/L. Protection standards also include the requirement that the control of the radioactive materials be designed to be effective for up to 1,000 years, as far as reasonably achievable, but at a minimum, 200 years. 40 C.F.R. 192.02.	Not applicable but potentially relevant and appropriate	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site; therefore, this requirement would not be applicable. The radiologically impacted materials at the Site are a small fraction of an overall matrix of municipal solid waste, debris and fill materials. Therefore, the waste materials at the Site are not similar to uranium mill tailings. These regulations are applicable to uncontrolled areas, whereas the current and future uses of Areas 1 and 2 are restricted. As these regulations address radon emissions, which is a concern for OU-1, they are considered potentially relevant and appropriate to the ROD-selected remedy and the partial excavation alternatives.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart A, Standards for the Control of Residual Radioactive Material from Inactive Uranium Processing Sites 40 C.F.R. 192.03-192.04, and Table 1 to Subpart A	Radium, Uranium, and trace metals	Ground-water	Establishes maximum concentration for groundwater protection. Maximum constituent concentration: Combined Ra_{226} and Ra_{228} — 5 pCi/L Combined U_{234} and U_{238} — 30 pCi/L Gross alpha (excluding radon & uranium) — 15 pCi/L Arsenic — 0.05 mg/L Barium — 1.0 mg/L Cadmium — 0.01 mg/L Chromium — 0.05 mg/L Lead — 0.05 mg/L Mercury — 0.002 mg/L Selenium — 0.01 mg/L Silver — 0.05 mg/L Nitrate (as N) — 10 mg/L Molybdenum — 0.1 mg/L Monitoring standards are substantially more general and merely provide that a groundwater monitoring plan be implemented and carried out over a period of time adequate to demonstrate that the future performance of the disposal system can be expected to be in accordance with certain design requirements. 40 C.F.R. 192.03.	Not applicable but potentially relevant and appropriate	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site; therefore, this requirement would not be applicable. As potential leaching of radionuclides and trace metals from the radiologically impacted materials at the Site is a possible issue of concern, these standards are potentially relevant and appropriate to the ROD-selected remedy and the partial excavation alternatives.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart B, Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites 40 C.F.R. 192.12(a) 40 C.F.R. 192.12(b)	Radium-226 (Radium-228)	Soil	Residual concentrations of radium-226 in soil at a designated uranium processing site should not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15 cm layer below the top layer, averaged over an area of 100 m^2. (Similar limits are indirectly indicated for radium-228 in Subpart E, which addresses thorium by-product material.) 40 C.F.R. 192.12(a). That in any occupied or habitable building: (1) The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration shall not exceed 0.03 WL, and (2) The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour. 40 C.F.R. 192.12(b).	Neither applicable nor relevant and appropriate to Areas 1, 2 and the Buffer Zone Potentially relevant and appropriate for radiologically impacted soil on the Crossroads Lot 2A2 Property	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site; therefore this requirement would not be applicable. The radiologically impacted materials at the Site are a small fraction of an overall matrix of municipal solid waste, debris and fill materials. Therefore, the waste materials at the Site are not similar to uranium mill tailings. These regulations are applicable to uncontrolled areas whereas current and future uses of Areas 1 and 2 are restricted. Consequently, these regulations are not relevant and appropriate to Areas 1 and 2 (including the Buffer Zone). They are potentially relevant and appropriate for impacted soil on the Crossroads Lot 2A2 property.
40 C.F.R. 192 Subpart C (Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 C.F.R. 192, Subpart C - Implementation)) 40 C.F.R. § 192.21(c)	Radium, Uranium, and trace metals	Soil	40 C.F.R. 192.21(c) comes into play when the estimated cost of remedial action to satisfy § 192.12(a) at a "vicinity" site (described under section 101(6)(B) of the Act) is unreasaonbly high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a "vicinity" site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under § 192.12(a).	Not applicable but potentially relevant and appropriate	40 C.F.R. 192 Subparts A and B would not be applicable. Given that Subpart C purports to guide the implementation of Subparts A and B where applied to a site, Subpart C is inapplicable as well. However, given that Subparts A and B may be relevant and potentially appropriate, the implementation standards of Subpart C may have bearing on any remedy that considers or is based off of the standards in Subparts A and B. In particular, this could apply if inaccessible RIM is identified during the course of the Remedial Design (particularly on "vicinity" properties).
Health and Environmental Protection Standards for Uranium and Thorium Mill	Radiation	Any	Processing operations during and prior to the end of the closure period at a facility managing uranium and thorium by-product materials should be conducted in a manner that	Neither applicable but potentially	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site; therefore, this requirement would not be applicable.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
Tailings (40 CFR 192), Subpart D, Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended; Subpart E, Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended 40 C.F.R. § 192.32 40 C.F.R. § 192.41			provides reasonable assurance that the annual dose equivalent does not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive material to the general environment (excluding radon-222, radon-220, and their decay products). Subpart E applies the standards of 40 C.F.R. 192 Subpart D to thorium byproduct materials, save for the provisions of § 192.32(a)(4) (setting forth monitoring standards following placement of permanent radon barrier).	relevant and appropriate	The radiologically impacted materials at the Site are a small fraction of an overall matrix of municipal solid waste, debris and fill materials. Therefore, the waste materials at the Site are not similar to uranium mill tailings. As alpha and gamma radiation is a potential exposure route for OU-1, these regaulations are considered to be potentially relevant and appropriate. However, these subparts may be relevant and appropriate to the extent that they identify performance standards for disposal areas, specifically mandating that a design must be effective for 1,000 years, to the extent reasaonbly achievable, and, in any case, 200 years, and limit releases of radon-222 into the atmosphere from disposal areas exceeding an average release rate of 20 pCi/(m^2-sec).
National Emissions Standards for Hazardous Air Pollutants (40 CFR 61), Subpart T, National Emissions Standards for Radon Emissions from disposal of Uranium Mill Tailings 40 C.F.R. § 61.222(a)	Radon-222	Air	Radon-222 emissions to ambient air from uranium mill tailings piles that are no longer operational should not exceed 20 pCi/(m^2-sec) (1.9 pCi/(ft^2-sec)) of radon-222. 40 C.F.R. § 61.222(a).	Potentially relevant and appropriate	The West Lake Landfill OU-1 Site is not a designated uranium mill tailings site, so this requirement would not be applicable; however it could be considered relevant and appropriate because a portion of the waste materials at the Site do emit radon. 40 C.F.R. § 61.222(a)'s limit of 20 pCi/(m^2-sec) (1.9 pCi/(ft^2-sec)) of radon-222 may be potentially relevant and appropriate to the capping and partial excavation alternatives.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement			Preliminary Determination	Remarks
National Primary Drinking Water Regulations 40 CFR Part 141	Various	Water	Establishes standards including maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for public drinking water systems			Potentially relevant and appropriate	These standards are only applicable to public drinking water systems; however, MCLs and non-zero MCLGs may potentially be relevent and appropriate standards for groundwater.
40 C.F.R. § 141.50			Contaminant	MCLG (mg/L)	MCL (mg/L)		
40 C.F.R. § 141.51			Trace metals				
40 C.F.R. § 141.52			Antimony	0.006	0.006		
40 C.F.R. § 141.53			Asbestos	7 x 10^6 fibers/liter	7 mfl		
40 C.F.R. § 141.54			Barium	2	2		
40 C.F.R. § 141.55			Beryllium	0.004	0.004		
			Cadmium	0.005	0.005		
			Chromium (total)	0.1	0.1		
			Copper	1.3	1.3		
			Cyanide	0.2	0.2		
			Fluoride	4.0	4.0		
			Lead	0.015	zero		
			Mercury (inorganic)	0.002	0.002		
			Nitrate (as N)	10	10		
			Nitrite (as N)	1	1		
			Selenium	0.05	0.05		
			Thallium	0.0005	0.002		
			Organic Chemicals				
			Alachlor	zero	0.002		
			Atrazine	0.003	0.003		
			Benzene	zero	0.005		
			Benzo(a)pyrene (PAHs)	zero	0.0002		
			Carbofuran	0.04	0.04		
			Carbon tetrachloride	zero	0.005		
			Chlordane	zero	0.002		
			Chlorobenzene	0.1	0.1		
			2,4-D	0.07	0.07		
			Dalapon	0.2	0.2		
			1,2-Dibromo-3-chloropropane	zero	0.0002		
			o-Dichlorobenzene	0.6	0.6		
			p-Dichlorobenzene	0.075	0.075		
			1,2-Dichloroethane	zero	0.005		
			1,1-Dichloroethylene	0.007	0.007		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement			Preliminary Determination	Remarks
National Primary Drinking Water Regulations 40 CFR Part 141 (cont.)			cis-1,2-Dichloroethene	0.07	0.07		
			trans-1,2-Dichloroethene	0.1	0.1		
			Dichloromethane	zero	0.005		
			1,2-Dichloropropane	zero	0.005		
			Di(2-ethylhexyl) adipate	0.4	0.4		
			Di(2-ethylhexyl) phthalate	zero	0.006		
			Dinoseb	0.007	0.007		
			Dioxin (2,3,7,8-TCDD)	zero	0.00000003		
			Diquat	0.02	0.02		
			Endothall	0.1	0.1		
			Endrin	0.002	0.002		
			Ethylbenzene	0.7	0.7		
			Ethylene dibromide	zero	0.00005		
			Glyphosate	0.7	0.7		
			Heptachlor	zero	0.0004		
			Heptachlor epoxide	zero	0.0002		
			Hexachlorobenzene	zero	0.001		
			Hexachlorocyclopentadiene	0.05	0.05		
			Lindane	0.0002	0.0002		
			Methoxychlor	0.04	0.04		
			Oxamyl (Vydate)	0.2	0.2		
			PCBs	zero	0.0005		
			Pentachlorophenol	zero	0.001		
			Picloram	0.5	0.5		
			Simazine	0.004	0.004		
			Styrene	0.1	0.1		
			Tetrachloroethylene	zero	0.005		
			Toluene	1	1		
			Toxaphene	zero	0.003		
			2,4,5-TP (Silvex)	0.05	0.05		
			1,2,4-Trichlorobenzene	0.07	0.07		
			1,1,1-Trichloroethane	0.2	0.2		
			1,1,2-Trichloroethane	0.003	0.005		
			Trichloroethylene	zero	0.005		
			Vinyl chloride	zero	0.002		
			Xylenes (total)	10	10		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
National Primary Drinking Water Regulations 40 CFR Part 141 (cont.)			Radionuclides (picocuries per liter [pCi/L]) Alpha particles — zero — 15 Beta particles and photon emitters (millirems per year) — zero — 4 Radium 226 and Radium 228 (combined) — 5 Uranium (ug/L) — zero — 30		
NRC Standards for Protection Against Ionizing Radiation (10 CFR 20 Subpart C), Maximum Permissible Exposure Limits 10 C.F.R. 20.1201(a)	Radiation	Any	For persons inside a controlled area, the maximum permissible whole-body dose due to all external sources of radiation within a controlled area is limited to 5 rems/year or the sum of the deep-dose equivalent and the committed dose equivalent to any indvidual organ or tissue other than the lens of the eye being equal to 50 rems. The annual limits to the lens of the eye , to the skin of the whole body, and the skin of the extremities are a lends dose equivalent of 15 rems and a shallow-dose equivalent of 50 rem to the skin of the whole body or to the skin of any extremity. (Note: a controlled area is an area that requires control of access, occupancy, and working conditions for radiation protection purposes.)	Potentially relevant and appropriate	Because the site is not licensed by NRC, these requirements are not applicable. As these regulations address sources of ionizing radiation, they are potentially relevant and appropriate as they provide standards for protection from radiation for workers inside Areas 1 and 2 during any remedial actions that may be undertaken.
NRC Standards for Protection Against Ionizing Radiation (10 CFR 20 Subpart D), Maximum Permissible Exposure Limits 10 C.F.R. 20.1301(a)	Radiation	Any	For persons outside a controlled area, the maximum permissible whole-body dose due to sources in or migrating from the controlled area is limited to 0.002 rem in any 1 hour, and 0.1 rem in any one hour. (Notes: a controlled area is an area that requires control of access, occupancy, and working conditions for radiation protection purposes; 0.5 rem = 500 mrem.)	Potentially relevant and appropriate	Because the site is not licensed by NRC, these requirements are not applicable. As these regulations address sources of ionizing radiation, they are potentially relevant and appropriate of workers and the public outside of Areas 1 and 2 during any remedial actions that may be taken. (Note: 10 C.F.R. 20.1301 was the only section from 10 C.F.R. 20 specifically listed as an "Other Potential Federal ARARs for Consideration".)

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
NRC Standards for Protection Against Ionizing Radiation (10 CFR 20 Appendix B) Annual Limits on Intake (ALIs) Derived Air Concentrations (DACs) Effluent Concentrations (Tables 1 and 2)	Specific radionuclides (see table)	Air	The concentrations above natural background of radionuclides in air ouside a controlled area, averaged over any calendar quarter, should not exceed the following limits: Effluent Concentration Limit (uCi/mL) Isotope — Air — Water Actinium-227 — 1 x 10-15 — 5 x 10-9 Lead-210 — 6 x 10-13 — 1 x 10-8 Protactinium-231 — 8 x 10-15 — 6 x 10-9 Radium-226 — 9 x 10-13 — 6 x 10-8 Radium-228 — 2 x 10-12 — 6 x 10-8 Radon-222 — 1 x 10-8 — NA Thorium-230 — 3 x 10-14 — 1 x 10-7 Thorium-232 — 6 x 10-15 — 3 x 10-8 Uranium-234 — 5 x 10-14 — 3 x 10-7 Uranium-235 — 6 x 10-14 — 3 x 10-7 Uranium-238 — 6 x 10-14 — 3 x 10-7 NA = not applicable because radon-222 is a gas.	Potentially relevant and appropriate	Because the site is not licensed by NRC, these requirements are not applicable. These requirements would be potentially relevant and appropriate to protection of the public during implementation of any remedial action. Specifically, these regulations potentially may require perimeter monitoring to be undertaken during any activities that may expose or disturb the radiologically-impacted materials at the Site.
10 C.F.R. 40 Appendix A, Criterion 6(6): Criteria for Disposal of Wastes from Processing Source Material	Uranium processing waste material (Radon, radium, thorium, etc.)	Soil	Criterion 6(6) addresses the lack of remediation standards for residual radionuclides, other than radium in soil, for decomissioning of lands and structures (excluding radon) at uranium recovery facilities. Criterion 6(6) uses the existing soil radium standard (5 pCi/g surface and 15 pCi/g subsurface) to derive a dose criterion (benchmark approach) for cleaning up byproduct material, and for cleanup of surface activity on structures to be released for unrestricted use. The radium dose benchmark approach of the Criterion 6(6) rule requires licensees subject to the rule to calculate the potential peak effective dose equivalent (excluding radon) to an individual at the Site within 1,000 years from exposure to the residual levels allowed under the radium soil standard.	Not applicable. Potentially relevant and appropriate for Lot 2A2. Potentially relevant, but not appropriate for Areas 1 and 2 or the Buffer Zone.	Because this Site is not licensed in conjunction with uranium and thorium milling, nor is it a site where milling operations generated byproduct material, these requirements are not applicable. Because the cleanup standards in 40 C.F.R. 192.12 are relevant, but not appropriate for Areas 1 and 2 or the Buffer Zone, Criterion 6(6) is not an ARAR for these areas. However, depending on the results of future testing on the Crossroads Lot 2A2 Property, if 40 C.F.R. Part 192.12(a) is found to be relevant and appropriate for that property, then Criterion 6(6) could potentially be relevant and appropriate for the cleanup of that area.
Missouri Water Quality Standards 10 CSR 20-7.031(5)	Inorganics Trace metals Organics Pesticides Man-made Volatiles PAHs Phthalates	Ground-water	Water contaminants shall not cause or contribute to an exceedance of the following (Table A) standards: Inorganics (mg/L) Fluoride — 4 Nitrate — 10 Trace metals (ug/L)		These standards are only applicable to public drinking water systems; however, these standards may potentially be relevent and appropriate standards for groundwater.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
	Others		Antimony	6		
			Arsenic	50		
			Barium	2,000		
			Beryllium	4		
			Boron	2,000		
			Cadmium	5		
			Chromium III	100		
			Cobalt	1,000		
			Copper	1,300		
			Iron	300		
			Lead	15		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Water Quality Standards 10 CSR 20-7.031(5) (cont.)			Manganese	50		
			Mercury	2		
			Nickel	100		
			Selenium	50		
			Silver	50		
			Thallium	2		
			Zinc	5,000		
			Organics (ug/L)			
			Acrolein	320		
			Bis-2-chloroisopropyl ether	1,400		
			2, chlorophenol	0.1		
			2,4-dichlorophenol	93		
			2,4-dinitrophenol	70		
			2,4-dimethylphenol	540		
			2,4,5-trichlorophenol	2,600		
			2,4,6-trichlorophenol	2		
			2-methyl-4,6-dinitrophenol	13		
			Ethylbenzene	700		
			Hexachlorocyclopentadiene	50		
			Isophorone	36		
			Nitrobenzene	17		
			Phenol	300		
			Dichloropropene	87		
			Para(1,4)-dichlorobenzene	75		
			Other Dichlorobenzenes	600		
			1,2,4-trichlorobenzene	70		
			1,2,4,5-tetrachlorobenzene	2.3		
			pentachlorobenzene	3.5		
			1,1,1-trichloroethane	200		
			1,1,2-trichloroethane	0.04		
			2,4-dinitrotoluene	0.04		
			1,2-diphenylhydrazine	0.04		
			di (2-ethylhexyl) adipate	400		
			Pesticides (ug/L)			
			2,4-D	70		
			2,4,5-TP	50		
			Alachlor	2		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Water Quality Standards 10 CSR 20-7.031(5) (cont.)			Atrazine	3		
			Carbofuran	40		
			Dalapon	200		
			Dibromochloropropane	0.2		
			Dinoseb	7		
			Diquat	20		
			Endothall	100		
			Ethylene dibromide	0.05		
			Oxamyl (vydate)	200		
			Picloram	500		
			Simazine	4		
			Glyphosate	700		
			Bioaccumulatie Anthropogenic Toxics (ug/L)			
			PCBs	0.000045		
			DDT	0.00059		
			DDE	0.00059		
			DDD	0.00083		
			Endrin	2		
			Endrin aldehyde	0.75		
			Aldrin	0.00013		
			Dieldrin	0.00014		
			Heptachlor	0.4		
			Heptachlor epoxide	0.2		
i			Methoxychlor	40		
			Toxaphene	3		
			Lindane (gamma-BHC)	0.2		
			Alpha,beta,delta-BHC	0.0022		
			Chlordane	2		
			Benzidine	0.00012		
			2,3,7,8-TCDD (dioxin)	0.000000013		
			Pentachlorophenol	1		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Water Quality Standards 10 CSR 20-7.031(5) (cont.)			Anthropogenic Carcinogens (ug/L)			
			Acrylonitrile	0.058		
			Hexachlorobenzene	1		
			Bis (2-chloroethyl) ether	0.03		
			Bis (chloromethyl) ether	0.00013		
			Hexachloroethane	1.9		
			3,3'-dichlorobenzidine	0.04		
			Hexachlorobutadiene	0.456		
			n-nitrosodimethylamine	0.0007		
			Volatile Organic Compounds (ug/L)			
			Chlorobenzene	100		
			Carbon Tetrachloride	5		
			Trihalomethanes	80		
			Bromoform	4.3		
			Chlorodibromomethane	0.41		
			Dichlorobromomethane	0.56		
			Chloroform	5.7		
			Methyl Bromide	48		
			Methyl Chloride	5		
			Methylene Chloride	4.7		
			1,2-dichloroethane	5		
			1,1,2,2-tetrachloroethane	0.17		
			1,1-dichloroethylene	7		
			1,2-trans-dichloroethylene	100		
			1,2-cis-dichloroethylene	70		
			Trichloroethylene	5		
			Tetrachloroethylene	0.8		
			Benzene	5		
			Toluene	1,000		
			Xylenes (total)	10,000		
			Vinyl chloride	2		
			Styrene	100		
			1,2-dichloropropane	0.52		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Water Quality Standards 10 CSR 20-7.031(5) (cont.)			Polynuclear Aromatic Hydrocarbons (ug/L)			
			Anthracene	9,600		
			Fluoranthene	300		
			Fluorene	1,300		
			Pyrene	960		
			Benzo(a)pyrene	0.2		
			Other polynuclear aromatic hydrocarbons	0.0044		
			Acenaphthene	1,200		
			Phthalate Esters (ug/L)			
			Bis(2-ethylhexyl) phthalate	6		
			Butylbenzyl phthalate	3,000		
			Diethyl phthalate	23,000		
			Dimethyl phthalate	313,000		
			Di-n-butyl phthalate	2,700		
			Health Advisory Levels (ug/L)			
			Ametryn	60		
			Baygon	3		
			Bentazon	20		
			Bis-2-chloroisopropyl ether	300		
			Bromacil	90		
			Bromochloromethane	90		
			Bromomethane	10		
			Butylate	350		
			Carbaryl	700		
			Carboxin	700		
			Chloramben	100		
			o-chlorotoluene	100		
			p-chlorotoluene	100		
			Chlorpyrifos	20		
			DCPA (dacthal)	4,000		
			Diazinon	0.6		
			Dicamba	200		
			Diisopropyl methylphosphonate	600		
			Dimethyl methylphosphonate	100		
			1,3-dinitrobenzene	1		
			Diphenamid	200		
			Diphenylamine	200		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Water Quality Standards 10 CSR 20-7.031(5) (cont.)			Disulfoton	0.3		
			1,4-dithiane	80		
			Diuron	10		
			Fenamiphos	2		
			Fluometron	90		
			Fluorotrichloromethane	2,000		
			Fonofos	10		
			Hexazinone	200		
			Malathion	200		
			Maleic hydrazide	4,000		
			MCPA	10		
			Methyl parathion	2		
			Metolachlor	70		
			Metribuzin	100		
			Naphthalene	20		
			Nitroguanidine	700		
			p-nitrophenol	60		
			Paraquat	30		
			Pronamide	50		
			Propachlor	90		
			Propazine	10		
			Propham	100		
			2,4,5-T	70		
			Tebuthiuron	500		
			Terbacil	90		
			Terbufos	0.9		
			1,1,1,2-Tetrachloroethane	70		
			1,2,3-trichloropropane	40		
			Trifluralin	5		
			Trinitroglycerol	5		
			Trinitrotoluene	2		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Public Drinking Water Program - Contaminant Levels and Monitoring (10 CSR 60-4)	Inorganics, Synthetic Organic Compounds, Radionuclides, Secondary Contaminants, and Volatile Organic Compounds		Maximum contaminant levels for public water systems.		Not applicable Potentially relevant and appropriate	These standards apply to public water systems and therefore are not applicable to the West Lake Landfill OU-1 Site. As these standards provide for maximum concentrations in drinking water and the alluvial aquifer could be used for drinking water outside of the West Lake Landfill boundaries; these standards are potentially relevant and appropriate for groundwater at the Site.
			Maximum Contaminant Levels			
			Inorganics			
			Antimony	0.006 mg/L		
			Arsenic	0.01 mg/L		
			Asbestos	7 x 10^6 fibers/L		
			Barium	2 mg/L		
			Beryllium	0.004 mg/L		
			Cadmium	0.005 mg/L		
			Chromium	0.1 mg/L		
			Cyanide	0.2 mg/L		
			Fluoride	4.0 mg/L		
			Mercury	0.002 mg/L		
			Nitrate (as N)	10 mg/L		
			Nitrite (as N)	1 mg/L		
			Total Nitrate + Nitrite (as N)	10 mg/L		
			Selenium	0.05 mg/L		
			Thallium	0.002 mg/L		
			Synthetic Organic Compounds			
			Alachlor	0.002 mg/L		
			Atrazine	0.003 mg/L		
			Benzo(a)pyrene	0.0002 mg/L		
			Carbonfugran	0.04 mg/L		
			Chlordane	0.002 mg/L		
			Dalapon	0.2 mg/L		
			Di(2-ethylhexyl) adipate	0.4 mg/L		
			Dibromochloropropane (DBCP)	0.0002 mg/L		
			Di(2-ethylhexyl) phthalate	0.006 mg/L		
			Dinoseb	0.007 mg/L		
			Diquat	0.02 mg/L		
			Endothall	0.1 mg/L		
			Endrin	0.002 mg/L		
			2,4-D	0.07 mg/L		
			Ethylene dibromide (EDB)	0.00005 mg/L		
			Glyphosoate	0.7 mg/L		
			Heptachlor	0.0004 mg/L		
			Heptachlor Epoxide	0.0002 mg/L		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement		Preliminary Determination	Remarks
Missouri Public Drinking Water Program - Contaminant Levels and Monitoring (10 CSR 60-4) (cont.)			Hexachlorobenzene	0.001 mg/L		
			Hexachlorocyclopentadiene	0.05 mg/L		
			Lindane	0.0002 mg/L		
			Methoxychlor	0.04 mg/L		
			Oxamyl (Vydate)	0.2 mg/L		
			Picloram	0.5 mg/L		
			Polychlorinated biphenyls (PCBs)	0.0005 mg/L		
			Pentachlorophenol	0.001 mg/L		
			Simazine	0.004 mg/L		
			Toxaphene	0.003 mg/L		
			2,3,7,8-TCDD (Dioxin)	0.00000003 mg/L		
			2,4,5-TP (Silvex)	0.05 mg/L		
			Radionuclides			
			Combined Ra_{226} and Ra_{228}	5 pCi/L		
			Gross alpha (excluding radon & urnaium)	15 pCi/L		
			Uranium	30 ug/L		
			Secondary Contaminants			
			Aluminum	0.05 - 0.2 mg/L		
			Chloride	250 mg/L		
			Copper	1.0 mg/L		
			Fluoride	2.0 mg/L		
			Iron	0.3 mg/L		
			Manganese	0.05 mg/L		
			Silver	0.1 mg/L		
			Sulfate	250 mg/L		
			Total Dissolved Solid (TDS)	500 mg/L		
			Zinc	5 mg/L		
			Volatile Organic Compounds			
			Benzene	0.005 mg/L		
			Carbon tetrachloride	0.005 mg/L		
			1,2-dichloroethane	0.005 mg/L		
			1,1-dichloroethylene	0.007 mg/L		
			para-dichlorobenzene	0.075 mg/L		
			1,1,1-trichloroethane	0.2 mg/L		
			Trichloroethylene	0.005 mg/L		
			Vinyl chloride	0.002 mg/L		
			cis-1,2-dichloroethylene	0.07 mg/L		

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
Missouri Public Drinking Water Program - Contaminant Levels and Monitoring (10 CSR 60-4) (cont.)			Dichloromethane 0.005 mg/L 1,2-dichloropropane 0.005 mg/L Ethylbenzene 0.7 mg/L Monodichlorobenzene 0.1 mg/L o-dichlorobenzene 0.6 mg/L Styrene 0.1 mg/L Tetrachloroethylene 0.005 mg/L Toluene 1 mg/L 1,2,4-Trichlorobenzene 0.07 mg/L 1,1,2-Trichloroethane 0.005 mg/L trans-1,2-dischloroethylene 0.1 mg/L Xylenes (total) 10 mg/L		
OSWER Directive No. 9200.4-25 ("Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites" (EPA, 1998))	Radium-226 Radium-228 Thorium-230 Throium-228	Soil	Clarifies EPA's position on the use of the soil cleanup criteria in 40 CFR Part 192 at CERCLA sites with radioactive contamination. In particular it clarifies the intent of 40 CFR Part 192 in setting remediation levels for subsurface soil, Also, Thorium-230 and Thorium-232 should be cleaned up to the same concentrations as their radium progeny (5 and 15 pCi/g). Radium 226 +228 5 pCi/g plus background Thorium 230 +232 5 pCi/g plus background	Not an ARAR but potentially a TBC for the Buffer Zone/ Crossroads Lot 2A2 Property	As this is only guidance, it is not an ARAR. As 40 CFR 192 is considered to be potentially relevant and appropriate for the radiologically-impacted soil on the Crossroad Lot 2A2 Property (and potentially the Buffer Zone), this guidance would be a TBC for alternatives that include excavation of soil from
40 C.F.R. Part 61 Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities (40 C.F.R. 61.90-97) 40 C.F.R. 61.90-92	Radionuclides other than radon-222 and radon-220	Air	"Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent to 10 mrem/yr." 40 C.F.R. 61.92. Applies to any DOE facility that emits any radionuclide other than radon-222 and radon-220 into the air, except any disposal facility subject to 40 C.F.R. Part 191, Subpart B or 40 C.F.R. Part 192. "Facility" is defined as "all buildings, structures and operations on one contiguous site." 40 C.F.R. 61.91(b).	Not applicable, but potentially relevant and appropriate for portions of the Site that are "facilities" and not subject to 40 C.F.R. Part 192	Because the West Lake Landfill OU-1 Site is not a Department of Energy owned or operated facility, these standards are not applicable. As these regulations address standards for airborne effluents containing radionuclides, they are potentially relevant and appropriate to any buildings, structures or operations on OU-1 if 40 C.F.R. Part 192 does not otherwise apply.
40 C.F.R. Part 61 Subpart I (codified at 40 C.F.R. 61.100-61.109), National Emission Standards for Radionuclide	Radionuclides	Air	"Emissions of radionuclides, including iodine, to the ambient air from a facility regulated under this subpart shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr."	Not applicable, but potentially relevant and appropriate	Because the West Lake Landfill OU-1 Site is not owned or operated by any federal agency, these standards are not applicable. As these regulations address standards for airborne effluents containing radionuclides, they

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
Emissions from Federal Facilities other than Nuclear Regulatory Commission Licensees and not Covered by Subpart H 40 C.F.R. 61.102(a)			40 C.F.R. 61.102(a). "Emissions of iodine to the ambient air from a facility regulated under this subpart shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 3 mrem/yr." 40 C.F.R. 61.102(a). The provisions of this subpart apply to facilities owned or operated by any Federal agency other than the Department of Energy and not licensed by the Nuclear Regulatory Commission, except that this subpart does not apply to disposal at facilities regulated under 40 C.F.R. Part 191, Subpart B, or to any uranium mill tailings pile after it has been disposed of under 40 C.F.R. Part 192, or to low energy accelerators. [61 FR 68981, Dec. 30, 1996]	for portions of the Site that are "facilities" and not subject to 40 C.F.R. Part 192	are potentially relevant and appropriate to any buildings, structures or operations on OU-1 if 40 C.F.R. Part 192 does not otherwise apply.
15 U.S.C. 2605 *et seq* . (Toxic Substances Control Act) 15 U.S.C. 2661 15 U.S.C. 2664 15 U.S.C. 2643(h) 15 U.S.C. 2605(e)	Radon PCBs Asbestos	Waste	This provision of TSCA concerns indoor radon health risks, mandating that EPA publish a guide about radon health risks and to perform studies of radon levels in schools and federal buildings. "The national long-term goal of the United States with respect to radon levels in buildings is that the air within buildings in the United States should be as free of radon as the ambient air outside of buildings." 15 U.S.C. 2661. "The Administrator of the Environmental Protection Agency shall develop model construction standards and techniques for controlling radon levels within new buildings." 15 U.S.C. 2664. 15 U.S.C. 2643(h) – requires EPA to promulgate regulations which prescribe standards for transportation and disposal of asbestos-containing waste material to protect human health and the environment. Such regulations shall include such provisions related to the manner in which transportation vehicles are loaded and unloaded as will assure the physical integrity of containers of asbestos-containing waste material. 115 U.S.C. 2605(e) requires EPA to promulgate rules to prescribe methods for the disposal of polychlorinated biphenyls.	Not applicable nor relevant and appropriate	This statute offers no definable standards for the control of radon exposure or contamination at the West Lake Landfill. Further, the West Lake Landfill is neither a school nor does it contain federal buildings. Therefore, these provisions are neither applicable nor are they relevant and appropriate. PCBs, if encountered, will be addressed under 40 CFR Part 761. Asbestos, if encountered, will be addressed under the asbestos NESHAP (40 CFR Part 61) and Missouri state regulations.

Table 3-1: OSWER DIRECTIVES AND GUIDANCE DOCUMENTS AS POTENTIAL TBCs

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
OSWER Directive 9285.6-20 ("Radiation Risk Assessment at CERCLA Sites: Q&A")	Radon	Air	Specifies an ARAR protectiveness criteria evaluation recommendation of 12 mrem/yr in place of the 15 mrem/yr value previously specified in Directive 9200.4-18.	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR; however, this guidance would be a TBC for purposes of demonstrating compliance with UMTRCA where UMTRCA is identified as an ARAR for indoor radon exposure.
OSWER 9200.4-18 ("Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (EPA, 1997a))	Radioactive Contamination at CERCLA sites		Provide guidance on use of the UMTRCA standards as CERCLA cleanup levels. Cleanup of radionuclides is governed by the risk range for all carcinogens established in the NCP when ARARs are not available or are not sufficiently protective. Where ARARs are not available or are not sufficiently protective EPA generally sets site-specific remediation levels for: (1) carcinogens at a level that represents an exceedance of upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}; and, (2) non-carcinogens such that the cumulative risks from exposure will not result in adverse effects to human populations (including sensitive sub-populations) that may be exposed during a lifetime or part of a lifetime, incorporating an adequate margin of safety. If a dose assessment is conducted at the site, then a 15 millirem per year (mrem/yr) effective dose equivalent should generally be the maximum dose limit for humans. This equates to approximately 3 X 10^-4 increased lifetime risk of cancer and is consistent with levels generally considered protective in other governmental actions.	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR. EPA has defined . . . "complete rad removal" to mean attainment of the risk-based radiological clean levels specified in OSWER directives 9200.4-25 and 9200.4-18. These criteria are based on the UMTRCA standards (40 CFR Part 192 Subpart B) for cleanup of so-called 'vicinity property' (as opposed to the actual waste disposal units.) Although UMTRCA standards are neither applicable nor relevant and appropriate to the solid waste disposal units at the Site, they do represent standards that have been established by EPA for remediating radionuclide occurrences so as to allow for unrestricted use, which may be applicable here.
OSWER No. 9200.4-23 ("Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA")	Various	Various	This directive clarifies the relationship between 1) the requirement to protect human health and the environment, and 2) the requirement to attain, or waive if justified based on site-specific circumstances, ARARs. Specifically, this directive clarifies that EPA may establish preliminary remediation goals at levels that are more protective than required by ARARs.	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR. This guidance may be a TBC.
EPA Memo "Considering a Noncancer Oral Reference Dose for Uranium for Superfund Human Health Risk Assessments" (Dated December 1, 2016)	Soluble uranium	Various	This memorandum provides information and recommendations about an oral reference dose (RfD) for non-radiological toxicity of soluble uranium. This memorandum recommends the use of the ATSDR intermediate MRL for soluble uranium without further adjustment, in lieu of the RfD currently published in IRIS, for assessment of chronic exposures also. Specifically, evaluation of the non-carcinogenic risks posed by uranium should use a toxicity value of 0.0002 mg/kg-day.	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR. This guidance may be a TBC if soluble uranium is identified as a COPC.
OSWER 4283.1-14	Radionuclides	Ground-	OSWER Directive 9283.1-14 addresses the use of uranium	Not an ARAR;	As this is only guidance, it is not an ARAR. This guidance may

Table 3-1: OSWER DIRECTIVES AND GUIDANCE DOCUMENTS AS POTENTIAL TBCs

Citation	Chemical	Medium	Requirement	Preliminary Determination	Remarks
("Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites")		water	drinking water standards for groundwater remediation at CERCLA sites. This directive specifies that both the uranium MCL (40 CFR 141) and the UMTRCA standards (40 CFR 192) are potentially relevant and appropriate. This directive also provides guidance on the groundwater point of compliance standard in 40 CFR 192.02 (c)(4) relative to the CERCLA approach for conducting groundwater responses.	potentially a TBC	be a TBC, insofar as it specifies certain standards as ARARs.
EPA Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, OSWER 530-SW-89-047 (July 1989)	Hazardous Wastes	Hazardous Waste Landfills	Provides design guidance on final cover systems for hazardous waste landfills and surface impoundments. Addresses multilayer cover design to provide long-term protection from infiltration of precipitation.	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR. Although RCRA Subtitle C regulations are neither applicable nor relevant and appropriate to West Lake Landfill OU-1, EPA guidance on the design of landfill covers for RCRA and CERCLA sites may provide information useful for the design of a final cover system under any of the alternatives.
(Draft) Technical Guidance for RCRA/CERCLA Final Covers, EPA OSWER 540-R-04-007 (April 2004)	Hazardous Wastes and MSW	Hazardous Waste and MSW Landfills	Provides design information regarding cover systems for municipal solid waste (MSW) and hazardous waste (HW) landfills being remediated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA) Corrective Action, and sites regulated under the RCRA. This guidance includes updated information related to development of design criteria, use and types of geosynthetics such as geosynthetic clay liners, alternative materials and designs, performance monitoring, maintenance of cover systems, and other issues.	Not an ARAR; potentially a TBC	Although RCRA Subtitle C regulations are neither applicable nor relevant and appropriate to West Lake Landfill OU-1, EPA guidance on the design of landfill covers for RCRA and CERCLA sites may provide information useful for the design of a final cover system under any of the alternatives. Because proper design and construction of a final cover is key to long-term protection from infiltration of precipitation, these guidance documents may need to be considered during the remedial design phase in conjunction with design of the engineered landfill cover system.
OSWER Directive 9200.4-35P ("Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6)")	Uranium processing waste material (Radon, radium, thorium, etc.)	Soil	Clarifies the relationship between the UMTRCA soil standards under 40 CFR 192 and the NRC radium benchmark approach under the 10 CFR 40 Appendix A, I, Criterion 6(6) in setting remediation goals in soil and structures. OSWER Directive 9200.4-35P explains that "The Criterion 6(6) rule is a supplement to the radium standards of 40 CFR Part 192, to address other site-related radionuclides. Therefore, when the 5 pCi/g and 15 pCi/g standards under EPA's UMTRCA rule are not RARs for either radium-226 and/or radium-228, the Criterion 6(6) rule is generally not appropriate … Even if EPA's UMTRCA soil standards were used as TBCs, we recommend that the Criterion 6(6) rule's benchmark dose should not be used as a TBC."	Not an ARAR; potentially a TBC	As this is only guidance, it is not an ARAR. This guidance may be a TBC, insofar as it clarifies the relationship between the UMTRCA soil standards under 40 CFR 192 and the NRC radium benchmark approach under the 10 CFR 40 Appendix A, I, Criterion 6(6) in setting remediation goals in soil and structures, and further clarifies when Criterion 6(6) should be applied.

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
All chemicals, compounds or substances listed under CERCLA	Any release that exceeds the Reportable Quantity (RQ) listed under CERCLA	Any	CERCLA reporting requirements are incorporated by reference in MO state law and regulations. Any release in the excess of the RQ must be reported and cleaned up in accordance with state law and regulations	RSMo Sections 260.500-550; 10 CSR 24-1.010; 10 CSR 24-2.010; 10 CSR 24-3.010	(1) The Department of Natural Resources is authorized under sections 260.500-260.550, RSMo to administer the state's Hazardous Substance Emergency Response Office 10 CSR 24-2.010 Definitions10 CSR 24-3.010 Notification Procedures for Hazardous Substance Emergencies and for Emergency Notification of Releases of Hazardous Substances and Extremely Hazardous Substances	*No*	*No*	*Any chemicals that exceed the RQ would be Relevant and Appropriate under CERCLA, if excavated soil contained free liquids. Per discussion in Section 5.3.1.9, hazardous waste, if encountered will not be placed back in the landfill.May be Relevant and Appropriate if encountered.*
Petroleum (including but not limited to gasoline or diesel fuels)	Any release that exceeds the state RQ of 50 gallons	Any	MO state law and regulations require that any release of petroleum in excess of the RQ must be reported and cleaned up in accordance with state law and regulations	RSMo Sections 260.500-550; 10 CSR 24-1.010; 10 CSR 24-2.010; 10 CSR 24-3.010	See above	*No*	*No*	*Not applicable under CERCLA, but petroleum compounds that exceed the RQ would be Relevant and Appropriate, if dripping soils were excavated.*
Toxic Substances	Water contaminants shall not cause an exceedance of criteria in Tables A and B to be exceeded; Concentrations of these substances in bottom sediments or waters shall not harm benthic organism and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(B)(1)	10 CSR 20-7.031 Water Quality Standards (5) Specific Criteria. The specific criteria shall apply to waters contained in Tables G and H of this rule and the Missouri Use Designation Dataset. (B) Toxic Substances. 1. Water contaminants shall not cause the criteria in Tables A and B to be exceeded. Concentrations of these substances in bottom sediments or waters shall not harm benthic organisms and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded. More stringent criteria may be imposed if there is evidence of additive or synergistic effects.	*Yes*	*Yes*	*Potentially relevant and appropriate. These standards are only applicable to public drinking water systems; however, these standards may potentially Organics be relevant and appropriate standards for groundwater.*
					(5) Specific Criteria. (B) Toxic Substances.			

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Toxic Substances	Analysis methods for metals are specified.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(B)(1-3)	2. For compliance with this rule, metals shall be analyzed by the following methods: A. Aquatic life protection and human health protection—fish consumption. (I) Mercury—total recoverable metals. (II) All other metals—dissolved metals; B. Drinking water supply—total recoverable metals; and C. All other	No	Yes	*Not applicable under CERCLA, but analytical methods used to determine the concentrations of water contaminants would be Relevant and Appropriate.*
Toxic Substances	Other toxic substances for which sufficient toxicity data are not available may not be released to waters of the state until safe levels are demonstrated through studies.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(B)(1-3)	3. Other potentially toxic substances for which sufficient toxicity data are not available may not be released to waters of the state until safe levels are demonstrated through adequate bioassay studies	Yes	Yes	*Not applicable under CERCLA, but if contaminated media treatment generated free liquids that were discharged to a surface water body, these other contaminants in water would be Relevant and Appropriate.*
pH	Shall not cause pH to be outside the range of 6.5 - 9.0 standard units.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(E)	(E) pH. Water contaminants shall not cause pH to be outside of the range of 6.5 to 9.0 standard pH units.	Yes	Yes	*Not applicable under CERCLA, but if contaminated media treatment generated free liquids that were discharged to a surface water body, these other contaminants in water would be Relevant and Appropriate.*
Taste- and Odor-Producing Substances	Shall not interfere with beneficial uses.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(F)	(F) Taste- and Odor-Producing Substances Taste- and odor-producing substances shall be limited to concentrations in the streams or lakes that will not interfere with beneficial uses of the water. For those streams and lakes designated for drinking water supply use, the taste- and odor-producing substances shall be limited to concentrations that will not interfere with the production of potable water by reasonable water treatment processes.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if taste and odor producing substance are elevated in any potential discharge.*

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Turbidity and Color	Shall not cause or contribute substantial visual contrast with natural appearance or interfere with beneficial uses.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(G)	(G) Turbidity and Color. Water contaminants shall not cause or contribute to turbidity or color that will cause substantial visible contrast with the natural appearance of the stream or lake or interfere with beneficial uses.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if turbidity and color are elevated in any potential discharge.*
Solids	Shall not cause or contribute to excess of a level that will interfere with beneficial uses.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(H)	(H) Solids. Water contaminants shall not cause or contribute to solids in excess of a level that will interfere with beneficial uses. The stream or lake bottom shall be free of materials which will adversely alter the composition of the benthos, interfere with the spawning of fish or development of their eggs, or adversely change the physical or chemical nature of the bottom.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if elevated TSS is present in any potential discharge.*
Radioactive Materials	Shall conform to state and federal limits for drinking water supply.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(I); cross-reference 10 CSR 60-4.060	(I) Radioactive Materials. All streams and lakes shall conform to state and federal limits for radionuclides established for drinking water supply.	Yes	No	*Not applicable, potentially relevant and appropriate. These standards apply to public water systems and therefore are not applicable to the West Lake Landfill OU-1 Site. As these standards provide for maximum concentrations in drinking water and the alluvial aquifer could be used for drinking water outside of the West Lake Landfill boundaries; these standards are potentially relevant and appropriate for groundwater at the Site.*
Dissolved Oxygen	Shall not cause levels lower than described in Table A or Table K.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 2-7.031(5)(J)	(J) Dissolved Oxygen. Water contaminants shall not cause the dissolved oxygen to be lower than the levels described in Table A or Table K—Site-Specific Criteria.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if DO is not within the acceptable range in any potential discharge.*
Total Dissolved Gases	Operation of impoundments shall not to exceed 110% of the saturation value for gases at the existing atmospheric and hydrostatic pressures.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(K)	(K) Total Dissolved Gases. Operation of impoundments shall not cause the total dissolved gas concentrations to exceed one hundred ten percent (110%) of the saturation value for gases at the existing atmospheric and hydrostatic pressures.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if dissolved gases are present in any potential discharge.*

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Sulfates and Chlorides	Shall not cause or contribute to levels in excess of Table A from 2009 version of the Missouri Water Quality Standards.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(L), 10 CSR 20-7.031 Table A (2009)	(L) Sulfate and Chloride Limit for Protection of Aquatic Life. Water contaminants shall not cause sulfate or chloride criteria to exceed the levels described in Table A.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if sulfides and chlorides are elevated in any potential discharge.*
Carcinogenic Substances	Shall not exceed concentrations in water which correspond to the 10^{-6} cancer risk rate, at average fish and water consumption amounts. Federal limits for drinking water supply shall supersede criteria developed in this manner.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(M)	(M) Carcinogenic Substances. Carcinogenic substances shall not exceed concentration in water which correspond to the 10-6 cancer risk rate. This risk rate equates to one (1) additional cancer case in a population of one (1) million with lifetime exposure. Derivation of this concentration assumes average water and fish consumption amounts. Assumptions are two (2) liters of water and six and one-half (6.5) grams of fish consumed per day. Federally established final maximum contaminant levels for drinking water supply shall supersede drinking water supply criteria developed in this manner.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if carcinogenic substances are elevated in any potential discharge.*
All Pollutants	Sample collection shall be performed per Standard Methods, 40 CFR 136, for the examination of water and wastewater or other procedures approved by EPA and the Department.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(0)	(O) All methods of sample collection, preservation, and analysis used in applying criteria in these standards shall be in accord with those prescribed in the latest edition of Standard Methods for the Examination of Water and Wastewater or other procedures approved by the Environmental Protection Agency and the Missouri Department of Natural Resources.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if pollutants are elevated in any potential discharge.*

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Whole Effluent Toxicity (WET)	Chronic WET tests performed at the percent effluent at the edge of the missing zone shall not be toxic to the more sensitive of at least two representative, diverse species. Pollutant attenuation will be considered.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(Q)	(Q) WET Chronic Tests. Chronic WET tests performed at the percent effluent at the edge of the mixing zone shall not be toxic to the more sensitive of at least two (2) representative, diverse species. Pollutant attenuation processes such as volatilization and biodegradation which may occur within the allowable mixing zone will be considered in interpreting results.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if WET is elevated in any potential discharge.*
Biocriteria	Receiving waters shall not be significantly different than reference waters.	Water	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031 (5)(R)	(R) Biocriteria. The biological integrity of waters, as measured by lists or numeric indices of benthic invertebrates, fish, algae, or other appropriate biological indicators, shall not be significantly different from reference waters. Waters targeted for numeric biological criteria assessment must be contained within the Missouri Use Designation Dataset and shall be compared to reference waters of similar size, scale within the stream network, habitat type, and aquatic ecoregion type. Reference water locations for some aquatic habitat types are listed in Table I.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if biocriteria are met in any potential discharge.*
Water Quality	Appendix 1 Appendix 2	Water	Continue to monitor	10 CSR 80-3.010(11)B.4 10 CSR 80-3.010 Appendix 1 10 CSR 80-3.010 Appendix 2	(11) Groundwater Monitoring. (A) Requirements. The owner/operator of a sanitary landfill shall implement a groundwater monitoring program capable of determining the sanitary landfill’s impact on the quality of groundwater underlying the sanitary landfill. (B) Satisfactory Compliance-Design	No	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water is required to be monitored.*
Water Quality	TMDLs	Water	Continue to monitor	TMDL for Missouri Load	Missouris Water Quality Standards, 10 CSR 20-7.031, Table A, under Persistent, Bioaccumulative, Man-made Toxics.Satisfactory Compliance-Design	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water is required to be monitored.*

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Odor	May not cause, permit, or allow the emission of odor greater than 7:1 for two separate trials not less than 15 minutes apart within the period of one hour outside of property boundary	Air	Protect air quality	10 CSR 10-6.165	10 CSR 10-6.165 Restriction of Emission of Odors	No	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if odor is present in the air, if waste is excavated.*
Air particulates	Particulate matter (dust) seen leaving the property or observed on surfaces beyond the property of origin are a violation of Missouri regulations.	Air	Protect air quality	10 CSR 10-6.170	10 CSR 10-6.170 Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin	*Yes*	*Yes*	*Not applicable to CERCLA sites, but may be relevant and appropriate if PM is present in the air if waste is excavated or dust is generated during cover construction of soil layers under the capping scenario.*
Asbestos	Registration, Abatement, Notification, Inspection, Demolition and performance requirements	Air	Health and Safety	10 CSR 10-6.241	10 CSR 10-6.241 Asbestos Projects—Registration, Notification and Performance Requirements	No	Yes	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2." Not applicable to CERCLA sites, but may be relevant and appropriate if friable asbestos is encountered*
Asbestos	Certification, Accreditations and Business Exemption Requirements	Air	Health and Safety	10 CSR 10-6.250	10 CSR 10-6.250 Asbestos Projects—Certification, Accreditation and Business Exemption Requirements Note that in the entry for 19 CSR 20-10.099, there is a reference to another reg that is incorrectly called out as 10 CSR, should be 19 CSR	No	Yes	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2." Not applicable to CERCLA sites, but may be relevant and appropriate if friable asbestos is encountered. This also looks administrative – any substantive elements?*
Radiation	Specified in regulation	Air	Protection against ionizing radiation	19 CSR 20-10	Title 19—DEPARTMENT OF HEALTH AND SENIOR SERVICES Division 20—Division of Environmental Health and Epidemiology Chapter 10—Protection Against Ionizing Radiation	Yes	Yes	*Potentially applicable for the excavation scenarios with offsite disposal.*

Table 3-1a: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria All Proposed Scenarios

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Air pollutants	Air quality standards, definitions, sampling and reference methods and air pollution control regulations for the entire State of Missouri	Air	Protection against air pollutants	10 CSR 10-6 Related: 643.010-643.620 RSMo	Department of Natural Resources Division 10—Air Conservation Commission Chapter 6—Air Quality Standards, Definitions, Sampling and Reference Methods and Air Pollution Control Regulations for the Entire State of Missouri	Yes	Yes	*Potentially applicable during the remedy implementation.*
Water pollutants	Safe Drinking Water Law and specified regulatory contaminant limits	Water	Drinking water protection	640.100-640.140 RSMo	Drinking water regulations	Yes	Yes	*Not applicable to CERCLA sites since these pertain to drinking water, but may be relevant and appropriate if water pollutants are present in any water discharged or to groundwater.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Preliminary Identification of Potential State ARARs: Chemical Specific No Action

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Regulated quantities of hazardous waste	None	Solid or liquid	Hazardous waste excluded from landfill	10 CSR 80-3.010(3)(A)1	*(3) Solid Waste Excluded, Requirement. (A) The following are excluded from disposal: 1. Regulated quantities of hazardous waste;*	*No*	*No*	*These regulatory citations should only be proposed for inclusion as Chemical Specific ARARs for the No Action scenario if OU1 is still receiving waste. As discussed in the FFS, OU1 closed in the 1970's and is therefore no longer receiving waste. As no waste would be removed and reconsolidated or relocated under the No Action scenario this should not be included as ARAR.*
Radioactive materials	Defined in regulation		Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)2	*See below*	*No*	*No*	

Preliminary Identification of Potential State ARARs: Chemical Specific Cap in Place

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Asbestos	See standard	Air	Air quality protection	40 CFR 61 Subpart M	Management and disposal of asbestos and asbestos-containing material	*Yes*	*Y Potentially applicable if encountered during remedy implementation*	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2". Not applicable as OU1 is not one of the sources specified in §§61.142 through 61.151, 61.154, and 61.155, but potentially relevant and appropriate if friable asbestos is encountered.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Preliminary Identification of Potential State ARARs: Chemical Specific Consolidation and Excavation, then Capping

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Regulated quantities of hazardous waste	None	Any	Hazardous waste excluded from landfill	10 CSR 80-3.010(3)(A)1	*Solid waste excluded*	*No*	*N/A*	*Per discussion in Section 5.3.1.9, hazardous waste, if encountered will not be placed back in the landfill.* *These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*
Other excluded waste	none	Any	If excavated, needs to be removed	10 CSR 80-3.010(3)(A)2.H.I.3-13	*Solid waste excluded*	*No*	*N/A*	*May be Relevant and Appropriate if encountered.*
Tires		Any	If excavated, needs to be removed	10 CSR 80-8.020	*Solid waste excluded*	*No*	*N/A*	*I would recommend that "10 CSR 80-3.010(3)(A)2.H.I.3-11 be used here instead. Waste tires as provided by 10 CSR 80-8.020" be cited instead; These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially Relevant and Appropriate if encountered.*
Radioactive materials	Defined in regulation	Any	Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)2	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Asbestos	See standard	Air	Air quality protection	40 CFR 61 Subpart M	*Asbestos*	*Yes*	*Y Potentially applicable if encountered during remedy implementation*	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2". Not applicable as OU1 is not one of the sources specified in §§61.142 through 61.151, 61.154, and 61.155, but potentially relevant and appropriate if friable asbestos is encountered.*

Preliminary Identification of Potential State ARARs: Chemical Specific Partial Excavation with Off Site Disposal and Cap

Chemical	**Maximum Concentration Allowed**	**Medium**	**Reason**	**Regulatory Citation**	***Citations***	***Citation Included in Draft FFS?***	***Potentially ARAR?***	***Discussion/Analysis***
Regulated quantities of hazardous waste	None	Any	Hazardous waste excluded from landfill	10 CSR 80.3.010(3)(A)1	*Solid waste excluded*	*No*	*N/A*	*Per discussion in Section 5.3.1.9, hazardous waste, if encountered will not be placed back in the landfill.* *These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*
Other excluded waste	None	Any	If excavated, needs to be removed	10 CSR 80-3.010(3)(A)2.H.I.3-13	*Solid waste excluded*	*No*	*N/A*	*May be Relevant and Appropriate if encountered.*
Tires		Any	If excavated, needs to be removed	10 CSR 80-8.020	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially relevant and appropriate if encountered.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Radioactive materials	Defined in regulation	Any	Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)2	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*
Asbestos	See standard	Air	Air quality protection	40 CFR 61 Subpart M	*Asbestos*	*Yes*	*Y Potentially applicable if encountered during remedy implementation*	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2". Not applicable as OU1 is not one of the sources specified in §§61.142 through 61.151, 61.154, and 61.155, but potentially relevant and appropriate if friable asbestos is encountered.*

Preliminary Identification of Potential State ARARs: Chemical Specific Full Excavation with Off Site Disposal

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Regulated quantities of hazardous waste	None	Any	Hazardous waste excluded from landfill	10 CSR 80.3.010(3)(A)1	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*
Other excluded waste	None	Any	If excavated, needs to be removed	10 CSR 80-3.010(3)(A)2.H.I.3-13	*Solid waste excluded*	*No*	*N/A*	*May be Relevant and Appropriate if encountered.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Tires		Any	If excavated, needs to be removed	10 CSR 80-8.020	*Solid waste excluded*	*No*	*N/A*	*I would recommend that "10 CSR 80-3.010(3)(A)2.H.I.3-11. Waste tires as provided by 10 CSR 80-8.020" be cited instead; These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially Relevant and Appropriate if encountered.*
Radioactive materials	Defined in regulation	Any	Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)2	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*
Asbestos	See standard	Air	Air quality protection	40 CFR 61 Subpart M	*Asbestos*	*Yes*	*Y Potentially applicable if encountered during remedy implementation*	*As stated in the FFS, "no definitive information exists from the RI investigations regarding the presence of RACM in Areas 1 and 2". Not applicable as OU1 is not one of the sources specified in §§61.142 through 61.151, 61.154, and 61.155, but potentially relevant and appropriate if friable asbestos is encountered.*

Preliminary Identification of Potential State ARARs: Chemical Specific Full Excavation with On Site Disposal

Chemical	Maximum Concentration Allowed	Medium	Reason	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Regulated quantities of hazardous waste	None	Any	Hazardous waste excluded from landfill	10 CSR 80.3.010(3)(A)1	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario

Radioactive materials	Defined in regulation	Any	Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)2	*Solid waste excluded*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*
Radioactive chemicals	Defined in regulation	Any	Radioactive chemicals excluded from landfill	10 CSR 80-3.010(3)(11)(C) 4.D	*Radioactive chemicals*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*
Sulfates and chlorides	Defined in regulation	Any	Substances in water	10 CSR 20-7.031(5)(L)	*Substances in water*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*
Toxic Substances	Tables A and B	Water	Toxic chemicals in groundwater	10 CSR 20-7.031(5)(B)(1-3)	*Toxic substances in discharge*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*
Chlordane and PCBs	TMDLs, WLA=0	Water	Toxic chemicals in groundwater	2006 EPA Approved TMDL for Missouri River	*Toxic substances in discharge*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered.*

Table 3-1b: Preliminary Identification of Potential State Chemical-Specific ARARs and TBC Criteria by Scenario								
PCBs	Defined in regulation	Any	Radioactive waste excluded from landfill	10 CSR 80-3.010(3)(A)4	*PCB*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate if encountered above levels that would allow for unrestricted use.*

Table 3-2: Preliminary Identification of Potential Location-Specific ARARs and TBC Criteria

Citation	Location	Requirement	Preliminary Determination	Remarks
Archeological and Historic Preservation Act (54 USC 312508; PL 113-287; 128 Stat. 3256)	Land	Data recovery and preservation activities should be conducted if prehistoric, historical, and archaelogical data might be destroyed as a result of a federal, federally assisted, or federally licensed activity or program.	Potentially applicable	No destruction of such data is expected to result from remedial action. The Site has been considerably disturbed by past human activities and is therefore not expected to contain any such data. However, if these data were affected, *e.g.* , at any potential off-site borrow area, the requirement would be applicable.
Endangered Species Act, as amended [16 USC 1531-1544; 50 CFR Part 17]	Any	Federal agencies should ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify any critical habitat.	Potentially applicable	No critical habitat has been identified in the affected area, and no adverse impacts to threatened or endangered species are expected to result from any remedial action. However, if such species were affected, the requirement would be applicable. An assessment of the potential for occurrences of threatened or endangered species was performed during the RI. No federal listed or proposed threatened and endangered species or their habitats were identified at or in the vicinity of the Site.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.111), Endangered Species	Any	Endangered species, i.e., those designated by the U.S. Department of the Interior and the Missouri Department of Conservation as threatened or endangered (see1978 Code, RSMo. 252.040), should not be pursued, taken, possessed, or killed.	Potentially applicable	No critical habitat has been identified in the affected area, and no adverse impacts to threatened or endangered species are expected to result from any remedial action. However, if such species were affected, the requirement would be applicable.
Floodplain Management [Executive Order 11988; 40 CFR 6.302(b)]	Floodplain	Federal agencies should avoid, to the maximum extent possible, any adverse impacts associated with direct and indirect development of a floodplain.	Potentially applicable	This requirement may be applicable to any remedial action for the Buffer Zone/Crossroad Property. Mitigative measures would be taken to minimize any adverse impacts.

Table 3-2: Preliminary Identification of Potential Location-Specific ARARs and TBC Criteria

Citation	Location	Requirement	Preliminary Determination	Remarks
Governor's Executive Order 82-19	Floodplain	Potential effects of actions taken in a floodplain should be evaluated to avoid adverse impacts.	Potentially applicable	This requirement may be applicable to any remedial action for the Buffer Zone/Crossroad Property. Mitigative measures would be taken to minimize any adverse impacts.
Clean Water Act, 33 U.S.C. § 1251, et seq. and associated regulations Clean Water Act (33 USC 1344); Disposal Sites Specifications(40 CFR 230), Dredged or Fill Material Discharges (Section 404 Program); Definitions, Exempt Activities Not Requiring Permits (40 CFR 232); State Program Regulations (40 CFR 233); General Regulatory Policies (33 CFR 320); Nationwide Permits (33 CFR 330)	Wetland	Regulates the discharge of pollutants into the waters of the United States. Dredge or fill material is not to be discharged into a wetland (as defined by the U.S. Army Corps of Engineers) without a permit.	Potentially applicable	This requirement could be applicable to any off-site borrow area if the location selected contains any wetlands or if the borrow activities could indirectly impact wetlands. No wetlands have been identified on-site. Effluent limitations under 33 U.S.C. § 1311 (Subpart C) are effectively covered by the Missouri state equivalents.
Farmland Protection Policy Act (7 USC 4201 et seq.) Farmland Protection [7 CFR 658; 40 CFR 6.302(c)]	Farmland (prime, unique, or of state and local importance)	Federal agencies should take steps to ensure that federal actions do not cause U.S. farmland to be irreversibly converted to nonagricultural uses in cases in which other national interests do not override the importance of the protection of farmland or otherwise outweigh the benefits of maintaining farmland resources. Criteria developed by the U.S. Soil Conservation Service are to be used to identify and take into account the adverse effects of federal programs on farmland preservation. Federal agencies should consider alternative actions that could lessen adverse effects and should ensure that programs are compatible with state and local government and private programs and policies to protect farmland.	Potentailly applicable	This requirement would be applicable for any potential soil borrow area off-site. Mitigative measures and restoration activities would also be conducted at any off-site borrow area, as appropriate, to minimize any adverse impacts to farmland.

Table 3-2: Preliminary Identification of Potential Location-Specific ARARs and TBC Criteria

Citation	Location	Requirement	Preliminary Determination	Remarks
RCRA Subtitle D (40 CFR Part 258 Subpart B) and MDNR Solid Waste Regulations (10 CSR 80-3.010 (4)(B)(1))	Proximity of solid waste landfills to the end of runways used for turbojet aircraft	Requires new or existing municipal solid waste landfills or lateral expansions that are located within 10,000 ft of any airport runway end used by turbojet aircraft to demonstrate that the units are designed and operated so that the municipal solid waste landfill unit does not pose a bird hazard to aircraft.	Not applicable Potentially relevant and appropriate to the ROD-remedy and "complete rad removal" and partial excavation alternatives	As the OU-1 portion of the West Lake landfill closed in the 1970's, this requirement is not applicable to Areas 1 and 2. The ROD-remedy, "complete rad removal", and partial excavation alternatives include regrading of existing solid waste in Areas 1 and 2. This requirement may potentially be relevant and appropriate to these alternatives.
RCRA Subtitle D (40 CFR Part 258 Subpart B) and MDNR Solid Waste Regulations (10 CSR 80-3.010 (4)(B))	Landfill site selection	Sets forth criteria for site selection for new landfills and horizontal expansions of existing sanitary landfills and requirements for design and operation plans for sanitary landfills. Site selection criteria include (1) proximity to airport runways (see discussion above), floodplains, wetlands, seismic zones and faults, and unstable areas. Also sets out required demonstrations for liners placed near the depth of groudnwater.	Not applicable nor relevant and appropriate	No new landfills or horizontal expansion of existing landfills would be constructed under any of the remedial alternatives.
Missouri Guidance for Conducting and Reporting Detailed Geologic and Hydrogeologic Investigations at a Proposed Solid-Waste Disposal Area 10 CSR 80-2.015 Appendix 1	Landfill site selection	Provides general procedures for characterization of potential solid waste landfill sites	Not applicable nor relevant and appropriate	No new solid waste diposal areas would be proposed under any of the remedial alternatives.

Table 3-2a: Preliminary Identification of Potential State Location-Specific ARARs and TBC Criteria All Proposed Scenarios

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Landfills, land application sites, open dumps that have received hazardous or industrial wastes.	Establishes regulatory basis and substantive requirements for storm water discharges.	To ensure existing or proposed discharges are in compliance.	10 CSR 20-6.200	10 CSR 20-6.200 Storm Water Regulations	Yes	Yes	*Potentially applicable. Substantive requirements are potentially applicable for control ofstorm water runoff during and after remedy construction.*
Landfills, land application sites, open dumps that have received hazardous or industrial wastes.	Establishes regulatory basis and substantive requirements for site selectionm planning and zoning.	To ensure that new landfills are sited properly.	10 CSR 80-2.015, 10 CSR 80-2.020(2)(A)2.E, and 10 CSR 80-3.010(4)(A)	10 CSR 80 - Landfill Regulations	Yes	Yes	*Potentially applicable. Substantive requirements are potentially applicable for control ofstorm water runoff during and after remedy construction.*
Waters of the State of Missouri	Protection of designated uses.	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(2)(A)-(C)	(2) Designation of Uses. (A) Rebuttable presumption. (B) Presumed Uses. All waters described in subsection (2)(A) shall also be assigned Livestock and wildlife protection and Irrigation designated uses, as defined in this rule. (C) Other Uses	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in any water discharge.*
Waters of the State of Missouri	Waters of the state are subject to applicable Anti-Degradation Tiers 1 & 2.	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(3)	(3) Antidegradation. The antidegradation policy shall provide three (3) levels of protection.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in any water discharge.*
Waters of the State of Missouri	General criteria are applicable to all waters of the state at all times, including mixing zones.	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(4)	(4) General Criteria. The following water quality criteria shall be applicable to all waters of the state at all times including mixing zones.	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in any water discharge.*

Table 3-2a: Preliminary Identification of Potential State Location-Specific ARARs and TBC Criteria All Proposed Scenarios

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Mixing Zones	Where mixing zones are applicable, they will be based on 7Q10 low flow.	To ensure existing or proposed discharges are in compliance.	10 CSR 20-7.031(5)(A)	(5) Specific Criteria. The specific criteria shall apply to waters contained in Tables G and H of this rule and the Missouri Use Designation Dataset. Protection of drinking water supply is limited to surface waters designated for raw drinking water supply and aquifers. Protection of whole body contact recreation is limited to waters designated for that use. (A) The maximum chronic toxicity criteria in Tables A and B shall apply to waters designated for the indicated uses given in the Missouri Use Designation Dataset and Tables G and H,	Yes	Yes	*Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in any water discharge.*
Surface of Landfills	Runoff Control	Minimize infiltration and erosion	10 CSR 80-3.010(8)(B)F,(C)	10 CSR 80-3.010 Design and Operation (8) Water Quality. (B) Satisfactory Compliance-Design. F. Provisions for surface water runoff control to minimize infiltration and erosion of cover. All applicable permits and approvals necessary to comply with requirements of the Missouri Clean Water Law and corresponding rules shall be obtained from the department.	Yes	Yes	*These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal", full and partial excavation alternatives for disposal into a new cell.*
Surface of Landfills	Siting	Location specific prohibitions of landfills	10 CSR 80-3.010(4)(B)3.A,10 CSR 80-3.010(4)(B)4,6,7,8, 10 CSR 80-3.010(5)(B)1	10 CSR 80-3.010 Design and Operation - All applicable permits and approvals necessary to comply with requirements of the Missouri Solid Waste Regulations and corresponding rules shall be obtained from the department.	Yes	Yes	*These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal", full and partial excavation alternatives for disposal into a new cell.*

Table 3-2a: Preliminary Identification of Potential State Location-Specific ARARs and TBC Criteria All Proposed Scenarios

Location Subject to Requirement	**Requirement**	**Reason Why Requirement is an ARAR**	**Regulatory Citation**	**Citations**	***Citation Included in Draft FFS?***	***Potentially ARAR?***	**Discussion/Analysis**
Landfill	Vector Control	Exposed waste	10 CSR 80-3.010(15)	(15) Vectors. (A) Requirements. Conditions shall be maintained that are unfavorable for the harboring, feeding and breeding of vectors.	Yes	Yes	These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal", full and partial excavation alternatives for disposal into a new cell.
Landfill	Aesthetics	Exposed waste	10 CSR 80-3.010(16)	(16) Aesthetics. (A) Requirement. The sanitary landfill shall be designed and operated at all times in an aesthetically acceptable manner. (B) Satisfactory Compliance	Yes	Yes	*These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal", full and partial excavation alternatives for disposal into a new cell.*
All work areas	Safety	Designed, constructed to protect health and safety of personnel	10 CSR 80-3.010(4)(B) 1.A and 1.B., 10 CSR 80-3.010(19)	(4)(B) Demonstrate that the landfill does not pose a bird hazard to aircraft, (19) Safety. (A) Requirement. The sanitary landfill shall be designed, constructed and operated in a manner so as to protect the health and…	Yes	Yes	*These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal", full and partial excavation alternatives for disposal into a new cell.*

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

Preliminary Identification of Potential State ARARs: Location Specific Cap in Place

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Side slope of landfill and disturbed areas	QA/QC	Part of landfill cover	10 CSR 80-3.010(6)	*(A) Requirement. The construction, operation and closure of the sanitary landfill shall include quality assurance and quality control measures to ensure compliance with approved plans and all applicable federal, state and local requirements. The permittee shall be responsible for ensuring that the quality assurance/quality control supervision is conducted by a qualified professional. (B) Satisfactory Compliance- Design.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions as related to closure/final cover and to ensure compliance with ARARs are potentially Relevant and Appropriate under Action Specific. The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process.*
Surface of landfills	Runoff control	Minimize infiltration and erosion	10 CSR 80-3.010(8)(B)F, (C)	*The comment may refer to10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)© (B) Satisfactory Compliance - Design. 1. Plans shall include: (F). Provisions for surface water runoff control to minimize infiltration and erosion of cover. All applicable permits and approvals necessary to comply with requirements of the Missouri Clean Water Law and corresponding rules shall be obtained from the department.(C) Satisfactory Compliance - Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions of 10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)(C) are potentially Relevant and Appropriate under Action Specific. Runoff control to minimize infiltration and erosion is standard practice. Regarding (8)(C), while not operations, minimization of surface water contact with waste and surface water diversion from open waste if waste is exposed during remedy implementation should be performed.*

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

Landfill	Cover	Minimize fire hazard, infiltration, odors, blowing litter, gas venting, vectors, discourage scavenging, appearance	10 CSR 80-3.010(17)	*Note that the Reason is only 10 CSR 80-3.010(17)(A): Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging;*	*Potentially Relevant and Appropriate for design of the final cover under Action Specific.Also, Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however they are potentially relevant and appropriate under Action Specific if waste is exposed during implementation. However, placement in Location-Specific seems out of place and recommend it be retained only in the Action-Specific portion of this Scenario.*
Landfill	Compaction	If existing cap is disturbed	10 CSR 80-3.010(18)	*(A) Requirement. In order to conserve sanitary landfill site capacity, thereby preserving land resources and to minimize moisture infiltration and settlement, solid waste and cover shall be compacted to the smallest practicable volume. (B) Satisfactory Compliance Design. (C) Satisfactory Compliance Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(18)(A) and (B) substantive portions are potentially Relevant and Appropriate under Action Specific; 10 CSR 80-3.010(18)(C) only deals with operational placement of waste and is potentially Relevant and Appropriate under Action Specific if waste is exposed during remedy implementation.*

Preliminary Identification of Potential State ARARs: Location Specific Consolidation and Excavation, then Capping

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Side slope of landfill and disturbed areas	QA/QC	Part of landfill cover	10 CSR 80-3.010(6)	*(A) Requirement. The construction, operation and closure of the sanitary landfill shall include quality assurance and quality control measures to ensure compliance with approved plans and all applicable federal, state and local requirements. The permittee shall be responsible for ensuring that the quality assurance/quality control supervision is conducted by a qualified professional.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions as related to closure/final cover and to ensure compliance with ARARs are potentially Relevant and Appropriate under Action Specific. The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process.*

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

Surface of landfills	Runoff control	Minimize infiltration and erosion	10 CSR 80-3.010(8)(B)F, (C)	*The comment may refer to 10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)(C)* *(B) Satisfactory Compliance - Design. 1. Plans shall include: (F). Provisions for surface water runoff control to minimize infiltration and erosion of cover. All applicable permits and approvals necessary to comply with requirements of the Missouri Clean Water Law and corresponding rules shall be obtained from the department.* *(C) Satisfactory Compliance - Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions of 10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)(C) are potentially Relevant and Appropriate under Action Specific. Runoff control to minimize infiltration and erosion is standard practice. Regarding (8)(C), while not operations, minimization of surface water contact with waste and surface water diversion from open waste if waste is exposed during remedy implementation should be performed.*
Landfill	Cover	Minimize fire hazard, infiltration, odors, blowing litter, gas venting, vectors, discourage scavenging, appearance	10 CSR 80-3.010(17)	*(A): Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; (B) Satisfactory Compliance Design. The owner/operator shall prepare a written closure plan that describes the steps necessary to close all sanitary landfill phases at any point during the active life of the sanitary landfill in accordance with the requirements of 10 CSR 80-2.030(4)(A). In addition, the final cover requirements specified in the closure and post-closure plans shall specify…*	*Potentially Relevant and Appropriate for design of the final cover.* *Also, Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(17)(A): Potentially Relevant and Appropriate if waste is exposed during remedy implementation. 10 CSR 80-3.010(17)(B): Potentially Relevant and Appropriate for design of the final cover.*
Landfill	Compaction	If existing cap is disturbed	10 CSR 80-3.010(18)	*(A) Requirement. In order to conserve sanitary landfill site capacity, thereby preserving land resources and to minimize moisture infiltration and settlement, solid waste and cover shall be compacted to the smallest practicable volume. (B) Satisfactory Compliance Design. (C) Satisfactory Compliance Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(18)(A) and (B) substantive portions are potentially Relevant and Appropriate; 10 CSR 80-3.010(18)(C) only deals with operational placement of waste and is potentially Relevant and Appropriate under Action Specific if waste is exposed during remedy implementation.*

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

Runway	Airport	Demonstrate that the landfill does not pose a bird hazard to aircraft	10 CSR 80-3.010(4)(A)(1)	*There is no regulation 10 CSR 80-3.010(4)(A)(1).* *10 CSR 80-3.010(4)(B)(1)?*	*Yes*	*Yes as Location Specific*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate under Location Specific during exposure and consolidation of waste.*

Preliminary Identification of Potential State ARARs: Location Specific Partial Excavation with Off-Site Disposal and Cap

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Side slope of landfill and disturbed areas	QA/QC	Part of landfill cover	10 CSR 80-3.010(6)				*Potential State ARARs — Location Specific Cap in Place*
Surface of landfills	Runoff control	Minimize infiltration and erosion	10 CSR 80-3.010(8)(B)F, (C)				*Potential State ARARs — Location Specific Cap in Place*
Landfill	Cover	Minimize fire hazard, infiltration, odors, blowing litter, gas venting, vectors, discourage scavenging, appearance	10 CSR 80-3.010(17)				*Potential State ARARs — Location Specific Cap in Place*
Landfill	Compaction	If existing cap is disturbed	10 CSR 80-3.010(18)				*Potential State ARARs — Location Specific Cap in Place*
Runway	Airport	Demonstrate that the landfill does not pose a bird hazard to aircraft	10 CSR 80-3.010(4)(A)(1)	*There is no regulation 10 CSR 80-3.010(4)(A)(1).* *10 CSR 80-3.010(4)(B)(1)?*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste.*

Preliminary Identification of Potential State ARARs: Location Specific Full Excavation with Off-Site Disposal

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Side slope of landfill and disturbed areas	QA/QC	Part of landfill cover	10 CSR 80-3.010(6)	*(A) Requirement. The construction, operation and closure of the sanitary landfill shall include quality assurance and quality control measures to ensure compliance with approved plans and all applicable federal, state and local requirements. The permittee shall be responsible for ensuring that the quality assurance/quality control supervision is conducted by a qualified professional.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions as related to closure/final cover and to ensure compliance with ARARs are potentially Relevant and Appropriate under Action Specific. The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process*

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

				(B) Satisfactory Compliance- Design.			*as part of the CERCLA process.*
Surface of landfills	Runoff control	Minimize infiltration and erosion	10 CSR 80-3.010(8)(B)F, (C)	*The comment may refer to 10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)(C)* *(B) Satisfactory Compliance - Design. 1. Plans shall include: (F). Provisions for surface water runoff control to minimize infiltration and erosion of cover. All applicable permits and approvals necessary to comply with requirements of the Missouri Clean Water Law and corresponding rules shall be obtained from the department.* *(C) Satisfactory Compliance - Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions of 10 CSR 80-3.010(8)(B)(1)(F) and 10 CSR 80-3.010(8)(C) are potentially Relevant and Appropriate under Action Specific. Runoff control to minimize infiltration and erosion is standard practice. Regarding (8)(C), while not operations, minimization of surface water contact with waste and surface water diversion from open waste if waste is exposed during remedy implementation should be performed.*
Landfill	Cover	Minimize fire hazard, infiltration, odors, blowing litter, gas venting, vectors, discourage scavenging, appearance	10 CSR 80-3.010(17)	*Note that the Reason is only 10 CSR 80-3.010(17)(A): Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging;*	*Potentially Relevant and Appropriate for design of the final cover under Action Specific.* *Also, Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however Potentially Relevant and Appropriate under Action Specific if waste is exposed during implementation. However, placement in Location-Specific seems out of place and recommend it be retained only in the Action-Specific portion of this Scenario.*
Landfill	Compaction	If existing cap is disturbed	10 CSR 80-3.010(18)	*(A) Requirement. In order to conserve sanitary landfill site capacity, thereby preserving land resources and to minimize moisture infiltration and settlement, solid waste and cover shall be compacted to the smallest practicable volume. (B) Satisfactory Compliance Design. (C) Satisfactory Compliance Operations.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(18)(A) and (B) substantive portions are potentially Relevant and Appropriate under Action Specific; 10 CSR 80-3.010(18)(C) only deals with operational placement of waste and is potentially Relevant and Appropriate under Action Specific if waste is exposed during remedy implementation.*
Runway	Airport	Demonstrate that the landfill does not pose a bird hazard to aircraft	10 CSR 80-3.010(4)(A)(1)	*There is no regulation 10 CSR 80-3.010(4)(A)(1).* *10 CSR 80-3.010(4)(B)(1)?*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste.*

Preliminary Identification of Potential State ARARs: Location Specific Full Excavation with On-Site Disposal

Table 3-2b: Preliminary Identification of Potential State ARARs Location Specific by Scenario

Location Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Landfill	Local Planning and Zoning	Approval from local authorities	10 CSR 80-2.020(2)(A)2.E	*(1) General Requirements. (A) Any disposal or processing of solid waste shall comply with the permitting requirements of this rule unless specifically exempted under section (9) of this rule. (B) All solid waste disposal areas and solid waste processing facilities shall be located, designed and operated in conformity with the rules in 10 CSR 80, as authorized by section 260.225.1(3), RSMo*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste and landfilling in on-site cell.The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process.*
Landfill	Site Selection	Geologic, hydrologic and soil conditions	10 CSR 80-3.010(4)(A)	*(A) Requirement. In order to conserve sanitary landfill site capacity, thereby preserving land resources and to minimize moisture infiltration and settlement, solid waste and cover shall be compacted to the smallest practicable volume. (B) Satisfactory Compliance Design. (C) Satisfactory Compliance Operations.*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste and landfilling in on-site cell.*
Landfill	Landfill characteristics	Integrity of structural components and landfill operational characteristics	10 CSR 80-3.010(4)(B)(4, 6, 7, 8)	*4. Sanitary landfills permitted after October 9, 1993, and unfilled surfaces of existing sanitary landfills located in the seismic impact zone shall not be located within two hundred feet (200') of a fault that has had displacement in Holocene time unless that owner/operator demonstrates to the department that an alternative setback distance of less than two hundred feet (200') will prevent damage to the structural integrity of the landfill and will be protective of public health and*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste and landfilling in on-site cell.*
Landfill	Site characteristics	Design criteria for new landfills	10 CSR 80-3.010(5)(B)	*(B) Satisfactory ComplianceóDesign. 1. Plans submitted as part of an application for a construction permit after the effective date of this rule shall*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste and landfilling in on-site cell.*
Runway	Airport	Demonstrate that the landfill does not pose a bird hazard to aircraft	10 CSR 80-3.010(4)(A)(1)	*(A) Requirement. In order to conserve sanitary landfill site capacity, thereby preserving land resources and to minimize moisture infiltration and settlement, solid waste and cover shall be compacted to the smallest practicable volume. (B) Satisfactory Compliance Design. (C) Satisfactory Compliance Operations.*	*Yes*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, potentially Relevant and Appropriate during exposure and consolidation of waste and landfilling in on-site cell.*

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart A, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites	Radioactive waste disposal		Control of residual radioactive materials at designated uranium processing or depository sites should be designed to be effective for at least 200 years and up to 1,000 years, to the extent reasonably achievable. In addition, the control should be designed such that releases of radon-222 from the residual radioactive material would not exceed an average rate of 20 pCi/m2-s or increase the annual average concentration in air outside the disposal site by more than 0.5 pCi/L. Because this standard applies to design, monitoring after disposal is not required to demonstrate compliance.	Not applicable but potentially relevant and appropriate in part for ROD-remedy and partial excavation alternatives	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site; therefore, this requirement would not be applicable. These regulations are applicable to uncontrolled areas, whereas the current and future uses of Areas 1 and 2 are restricted. As OU-1 does contain radiologically-impacted materials, these requirements may potentially be relevant; however, the radiologically-impacted materials at the Site are a small fraction of an overall matrix of municipal solid waste, debris and fill materials. Although the waste materials are not similar to uranium tailings, the wastes do contain radium and thorium; therefore the longevity standard is potentially relevant and appropriate. As the radiologically-impacted materials do emit radon, the radon standard is potentially relevant and appropriate. For the ROD-remedy and partial excavation alternatives, radiologically-impacted materials will remain past the post-closure period for a solid waste landfill and longevity considerations should be factored into the cover design.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart D, Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the U.S. Atomic Energy Act of 1954, as amended; Subpart E, Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the U.S. Atomic Energy Act of 1954, as amended.	Radioactive waste disposal		Disposal areas for uranium and thorium by-product materials should be designed to be effective for at least 200 years and up to 1,000 years, to the extent reasonably achievable. In addition, the control should be designed so that releases of radon-222 and radon-220 from these materials (*i.e.* , excluding the cover) would not exceed an average of 20 pCi/m2-s. The standard applies to design, so monitoring for radon after installation of an appropriately designed cover is not required. (This requirement does not apply to any portion of the Site that contains residual surface and subsurface concentrations of radium-226 and radium-228 at or below those identified in Subparts B and E, respectively, which were described under potential chemical-specific ARARs and TBCs.)	Not applicable but potentially relevant and appropriate in part for the ROD-remedy and partial excavation alternatives	The West Lake Landfill OU-1 Site is not a designated Title I uranium mill tailings site. Therefore, this requirement would not be applicable. These regulations are applicable to uncontrolled areas whereas the current and future uses of Areas 1 and 2 are restricted. As OU-1 does contain radiologically impacted materials, these requirements may potentially be relevant; however, the radiologically-impacted materials at the Site are a small fraction of an overall matrix of municipal solid waste, debris and fill materials. Although the waste materials at West Lake Site are not similar to uranium mill tailings, the wastes do contain radium . and thorium; therefore the longevity standard is potentially relevant and appropriate. As the radiologically impacted materials will remain on-site beyond the 30-year post-closure period for a solid waste landfill, the 200/1000 year period, this standard is considered to be potentially relevant and appropriate.

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
Resource Conservation and Recovery Act (RCRA) Subtitle C (40 CFR 240 et seq.)	Hazardous waste management		Establishes standards for identification of and treatment, storage and disposal of hazardous wastes including hazardous wastes disposed in landfills. Standards for Identification of hazardous wastes (40 CFR 261) Standards for Generators of hazardous wastes (40 CFR 262) Standards for Transporters of hazardous wastes (40 CFR 263) Use and Management of Containers (40 CFR 264 Subpart I) Land Disposal Restrictions (40 CFR 264 Subpart N) Staging Piles (40 CFR 264.554)	Possibly applicable in the event that hazardous wastes or materials that potentially could be hazardous wastes are encountered during remedy implementation	The radiologically-impacted materials in Areas 1 and 2 do not meet the criteria for classification as hazardous wastes; however, other waste materials in Areas 1 or 2 may meet these criteria and as such these requirements may be applicable. The Subtitle D standards are considered to be the appropriate criteria for final cover design.
Solid Waste Disposal Act, as amended (42 USC 6901 et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart F, Closure and Post-Closure Care	Solid waste disposal		Criteria for closure of a landfill unit and post-closure care requirements are specified. Cover system design requirements at closure include (1) an infiltration layer constructed of a minimum of 18 in. of earthen material with a permeability less than or equal to the permeability of the bottom liner system or no greater than 1 x 10-5 cm/s, whichever is less, and (2) an erosion protectin layer of earthen material capable of supporting native plant growth; or equivalents approved by the director of an approved state program. Post-closure care requires maintenance of the integrity of the final cover system, the leachate collection system, ground-water monitoring, and gas monitoring for a period of 10 years or as necessary to protect human health and the envrionment. Management of the leachate may be terminated if the owner/ operator demonstrates that leachate no longer poses a threat to human health and the environment	Neither applicable nor relevant and appropriate	Neither applicable nor relevant and appropriate as solid waste landfills in Missouri are regulated by the Missouri solid waste regulations.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.090), Disposal of Radioactive Wastes	Radioactive waste disposal		Radioactive waste material should not be disposed of by dumping or burial in soil, except at sites approved by and registered with the Missouri Department of Health; a permit should be obtained for holding and preparation of such material prior to disposal; and no releases to air or water should cause exposure of any person above the limits specified in 10-CSR 20-10.040.	Potentially applicable to the "complete rad removal" and partial excavation with off-site disposal alternatives	Certain of these requirements would be potentially applicable if one of the alternatives involving off-site disposal were to be implemented
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.070), Storage of Radioactive Materials	Radioactive waste storage		Radioactive materials should be stored in a manner that will not result in the exposure of any person, during routine access to a controlled area, in excess of the limits identified in 19 CSR 20-10.040 (see related discussion for contaminant-specific requirements); a facility used to store materials that may emit radioactive gases or airborne particulate matter should be vented to ensure that the concentration of such substances in air does not constitute a radiation hazard; and provisions should be made to minimize hazards to emergency workers in the event of a fire, earthquake, flood, or windstorm.	Potentially applicable	These requirements would be applicable to the temporary storage of radiologically-impacted soils that might be generated during any remedial action.
Missouri Solid Waste Rules (10 CSR 80), Chapter 3, Sanitary Landfills, 3.010(17),	Solid waste disposal		The landfill should be covered to minimize fire hazard, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; and provide	Only applicable if Areas 1 or 2 are re-opened to	These requirements are not applicable as they only apply to landfills in operation after 10-9-91. These requirements would be applicable to regrading of Areas 1 and 2 after removal of

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
Cover			a pleasing appearance. Final slope of the top shall be a minimum of 5%. No slopes shall ever exceed 33 1/3 % and slopes shall not exceed 25% without a detailed slope stability analysis. The final cover should be at least 2 ft of compacted clay with a permeability of 1 x 10^{-5} cm/sec or less overlain by 1 ft of soil capable of supporting vegetative growth.	accept additional solid wastes. Potentially relevant and appropriate for design of the final cover	radiologically-impacted material under the "complete rad removal" and partial excavation alternatives. These regulations would also be applicable to the final slopes and cover design for Areas 1 and 2 under the ROD-selected remedy , "complete rad removal", and partial excavation alternatives except that the slopes would be a minimum of 2% (seee discussion in text).
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(17), Cover	Solid waste disposal		The landfill should be covered to minimize fire hazard, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; and provide a pleasing appearance. Final slope of the top shall be a minimum of 5%. No slopes shall ever exceed 33 1/3 % and slopes shall not exceed 25% without a detailed slope stability analysis. The final cover should be at least 1 ft of compacted clay with a permeability of 1 x 10^{-5} cm/sec or less overlain by 2 ft of soil capable of supporting vegetative growth.	Only applicable if Areas 1 or 2 are re-opened to accept additional solid wastes. Potentially relevant and appropriate for design of the final cover	These requirements are not applicable as they only apply to landfills in operation after 10-9-91. These requirements would be applicable to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal" and partial excavation alternatives. These regulations would also be applicable to the final slopes and cover design for Areas 1 and 2 under the ROD-selected remedy , "complete rad removal", and partial excavation alternatives except that the slopes would be a minimum of 2% (seee discussion in text).
Noise Control Act, as Amended; Noise Pollution and Abatement Act (42 USC 4901 et seq)	Construction activities		The public should be protected from noises that jeopardize human health or welfare.	Potentially applicable	These requirements would be applicable to any remedial action.
CERCLA Offsite Rule 40 CFR 300.440	Off-site disposal		Wastes can only be disposed at offsite facilities operating in compliance with applicable regulations as verified by EPA.	Applicable to off-site disposal	These requirements would be applicable to the "complete rad removal" and partial excavation with off-site disposal alternatives.
DOT and NRC regulations for shipment of radioactive materials 49 CFR Parts 171-180 and 10 CFR Part 71	Off-site disposal		Specifies requirements for shipment of radioactive materials including hazard communications, labeling, manifests, security, emergency response, and planning.	Applicable to off-site disposal	These requirements would be applicable to the "complete rad removal" and partial excavation with off-site disposal alternatives.
Offsite disposal Waste Acceptance Criteria	Off-site disposal		Lists the types of materials and activity levels of waste materials that can be accepted by off-site disposal facilities.	Applicable to off-site disposal	These requirements would be applicable to the "complete rad removal" and partial excavation with off-site disposal alternatives.
National Emissions Standards for Hazardous Air Pollutants - Asbestos 40 CFR Part 61 40 C.F.R. § 61.154(j)	Asbestos management	Waste	Requirements for management of regulated asbestos containing materials (RACM)	Potentially applicable if RACM are encountered during remedy implementation	Standards for demolition and renovation may be applicable in the event that RACM is encountered during remedy implementation. Notice requirements may become applicable in the event that it is determined that RACM is located within the relevant portions of the Site and that the remedy may involve the excavation or disturbance of said RACM.
National Ambient Air Quality Standards, 40 CFR 50 40 C.F.R. §§ 50.3-50.19	Radionuclides Radon and Particulates	Air	Air quality standards	Potentially applicable	Potential standards for air emissions during remedy implementation. It should be noted that these primary and secondary standards reference the following: sulfur dioxide, PM10 (particulate matter), PM2.5 (particulate matter), Carbon Monoxide, Ozone, Oxides of Nitrogen, and Lead. They do not directly address radioactive

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
					materials, but may be relevant to the extent that there may be a need to control airbone particulates during the implementation of the ultimate remedy selected for the Site.
PCB Spill Cleanup Policy 40 CFR 761 Subpart G Cleanup Site Characterization Sampling for PCB Remediation Waste 40 CFR 761 Subpart N Sampling to Verify Completion of Self-Implementing Cleanup and On-Site Disposal of Bulk PCB Remediation Waste and Porous Surfaces 40 CFR 761 Subpart O Sampling Non-Porous Surfaces for Measurement-Based Use, Reuse and On-Site or Off-Site Disposal 40 CFR 761 Subpart P Sampling Non-Liquid, Non-Metal PCB Bulk Product Waste for Purposes of Characterization for PCB Disposal and Sampling PCB Remediation Waste Destined for Off-Site Disposal 40 CFR 761 Subpart R Double Wash/Rinse Method for Decontaminating Non-Porous Surfaces 40 CFR 761 Subpart S	PCB cleanup and management	Soil or waste	Requirements for cleanup of PCB wastes	Potentially applicable if PCBs are encountered during remedy implementation	Sets out procedures for cleanup of PCB wastes.
Missouri Storm Water Regulations 10 CSR 20-6.200		Stormwater	Requirements for control of stormwater runoff	Potentially applicable	Substantive requirements are potentially applicable for control of storm water runoff during and after remedy construction.
De Minimis Emissions Levels 10 CSR 10-6.020(3)(A)	PM-10 Non-methane organic compounds (NMOC)		Air quality standards	Potentially applicable	Potential standards for air emissions during remedy implementation.
Sampling Methods for Air Pollution Sources 10 CSR 10-6.030		Air	Stack emissions sampling procedures	Potentially applicable	Potentially applicable if a landfill gas flare is constructed and operated as part of the remedy.
Controlling Emissions During Episodes of High Air Pollution Potential 10 CSR 10-6.130		Air	Requirements for controlling emissions during air pollution events	Potentially applicable	Potentially could require shut down of remedy implementation construction operations during a purple or maroon air quality event.
Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin 10 CSR-6.170	Particulate Matter	Air	Requirements for controlling emissions	Potentially applicable	Potentially applicable to the control of fugitive dust emissions during remedy construction activities.

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
Closure and Post-Closure Plan Laidlaw Waste Systems (Bridgeton), Inc. Sanitary Landfill, December 1996, Revised September 1997, Revised April 1998, Revised April 2016	Landfill cover		Sets out closure and post-closure procedures for the West Lake Landfill, in particluar, the final cover, grading and vegetation plan.	Potential TBC	Sets out the procedures to be used at the Landfill to comply with the MDNR Solid Waste Regulations. This document should be considered in the design and construction of any cover system or drainage improvements that may be constructed for Areas 1 and 2 or if aditional waste materials are placed in these areas as part of a remedial action. This docment will also need to be considered if any regrading and/or landfill cover improvements are implemented for Areas 1 or 2.
40 C.F.R. Part 122 (EPA Administered Permit Program - The National Pollutant Discharge Elimination System), Subpart C (Permit Conditions) 40 C.F.R. 122.26(b)(14)(v)	Various pollutants	Water/ Stormwater	The regulatory provisions contained in this part implement National Pollutant Discharge Elimination System (NPDES) Program under sections 318, 402, and 405 of the Clean Water Act (CWA) (Public Law 92-500, as amended, 33 U.S.C. 1251 *et seq.*) Stormwater permits are required for any landfill, land application sites and open dumps that receive or have received industrial waste, and said stormwaters impact waters of the United States. 40 C.F.R. 122.26(b)(14)(v). Certain conditions are applicable to permits and permit holders regulated pursuant to 40 C.F.R. 122.26, including compliance with the effluent standard under Section 307a of the Clean Water Act for toxic pollutants and with standard for sewage sludge.	Potentially applicable	At this time, it is uncertain whether stormwaters draining from the Site impact Waters of the United States. In any event, Missouri has an approved state program/delegated water program under 40 C.F.R. Part 123.
40 C.F.R. Part 131 (Water Quality Standards) 40 C.F.R. § 131.36	Sets forth requirements and procedures for developing, reviewing, revising and approving water quality standards by the States as authorized by the Clean Water Act	Ground-water	40 CFR Part 131 describes the requirements and procedures for developing, reviewing, revising, and approving water quality standards by the States as authorized by section 303(c) of the Clean Water Act. 40 C.F.R. Part 131 does not lay out specific standards to be applied, but rather serves as a framework by which States must develop water quality standards for water bodies, including uses that may be made of such bodies, and standards to promote the safety of water as used. It also provides for the process by which EPA reviews, revises and approves of water quality standards developed by States.	Not applicable, but potentially relevant to groundwater	It does not appear that these standards are applicable to Missouri. It should be noted that Missouri has adopted Water Quality Standards under 10 CSR 20-7.031(5), which regulate concentrations of inorganics, trace metals, organics, pesticides, man-made volatiles, PAHs, phthalates and other chemicals.
42 U.S.C. 10171, Part D (Financial Arrangement for Low-Level Radioactive Waste Site Closure)	Unclear		This statute permits the Commission to establish by rule, regulation or order, that an adequate bond, surety or other financial arrangement be provided by a licensee to permit the completion of all requirements established by the Commission for the decontamination, decommissioning, site closure, and reclamation of sites, structures or equipment used in conjunction with such low-level radioactive waste.	Not applicable nor potentially relevant and appropriate	This statute does not contain any standard, requirement, criteria, or limitation that would apply directly to the Site but instead is a mechanism for NRC to require financial assurance for cleanup of NRC permitted facilities. Financial assurance is an administrative requirement and not a substantive requirement. Any financial assurance that may be required would be established by the Order or Consent Decree governing the remedial action.

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
10 CFR 61 Subpart C (NRC Low-Level Waste Regulations - Performance Objectives) 10 CFR § 61.41 (Protection of the general population from releases of radioactivity) 10 CFR § 61.42 (Protection of individuals from inadvertent intrusion) 10 CFR § 61.43 (Protection of individuals during operations) 10 CFR § 61.44 (Stability of the disposal site after closure)	Land/Environment		These regulations establish the procedures, criteria, and terms and conditions upon which the Commission issues licenses for land disposal of radioactive waste containing byproduct, source and special nuclear material. A general requirement of the subpart C regulations is that land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44.	Not applicable, but certain provisions may be potentially relevant or appropriate.	The portions of the 10 C.F.R. Part 61 referenced here are not applicable, but may be potentially relevant to the design and operation/performance of a new on-site disposal cell. However, because these regulations were developed for waste materials that are substantially different from those present at West Lake Landfill (including wastes that would potentially be placed in an on-site disposal cell at the Site), they are not considered to be appropriate for the design, operation, or closure of an on-site disposal cell. The NRC regulations related to disposition of uranium mill tailings and the UMTRCA regulations are considered to be more appropriate to the design and operation/performance of an on-site disposal cell.
10 CFR 61 Subpart D (NRC Low-Level Waste Regulations - Technical Requirements for Land Disposal Facilities) 10 CFR 61.50 (Disposal site suitability requirements for land disposal) 10 CFR 61.51 (Disposal site design for land disposal) 10 CFR 61.52 (Land disposal facility operation and disposal site closure)	Land/Disposal Cell/ Various		These regulations establish the procedures, criteria, and terms and conditions upon which the Commission issues licenses for land disposal of radioactive waste containing byproduct, source and special nuclear material. Subpart D describes the requirements for disposal site suitability, disposal site design, disposal site operation and closure, and environmental monitoring and waste classification.	Not applicable, but certain provisions may be potentially relevant or appropriate.	The portions of the 10 C.F.R. Part 61 referenced here are not applicable, but may be potentially relevant to the design and operation/performance of a new on-site disposal cell. However, because these regulations were developed for waste materials that are substantially different from those present at West Lake Landfill (including wastes that would potentially be placed in an on-site disposal cell at the Site), they are not considered to be appropriate for the design, operation, or closure of an on-site disposal cell. The NRC regulations related to disposition of uranium mill tailings and the UMTRCA regulations are considered to be more appropriate to the design and operation/performance of an on-site disposal cell.

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
10 CFR 61.53 (Environmental Monitoring)			s		
10 CFR 40 Appendix A (Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings of Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content)	Land/Disposal Cell/Various		This appendix establishes technical, financial, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located. These regulations are applicable to uranium or thorium milling and disposition of tailings or wastes resulting from such milling activities at sites licensed by the NRC.	Not applicable, but certain technical provisions may be potentially relevant or appropriate.	The portions of the 10 C.F.R. Part 40, Appendix A referenced here are not applicable, but may be potentially relevant to the design and operation/performance of a new on-site disposal cell. However, because these regulations were developed for waste materials that are substantially different from those present at West Lake Landfill (including wastes that would potentially be placed in an on-site disposal cell at the Site), they are not considered to be appropriate for the design, operation, or closure of an on-site disposal cell. The standards established by these regulations are essentially the same as those set forth in the UMTRCA standards (40 C.F.R. 192), and therefore, compliance with the UMTRCA standards should result in compliance with these standards, and they may be more appropriate to the design and operation/performance of an on-site disposal cell.
Criterion 1 (Siting Objectives), Criterion 3 (preference for placement below grade), Criterion 4 (selected site and design criteria), Criterion 6 (waste cover design and effectiveness)					

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Statements, Acts	Unlawful acts prohibited; false statements and negligent acts prohibited, penalties, exceptions	To ensure existing or proposed discharges are in compliance.	Missouri Clean Water Law, Missouri Revised statute Chapter 644, 641.076	644.006. This subchapter shall be known and may be cited as the "Missouri Clean Water Law". Unlawful acts prohibited--false statements and negligent acts prohibited--penalties--exception. 644.076. 1	N	Y	*Substantive elements of these chapters may be Relevant and Appropriate if implementing a remedial action that includes a discharge to water.*
Disturbance of landfilled wastes	Cannot remove/disrupt/excavate from a discontinued landfill without receiving prior approval from the Department.	Disturbed existing landfill	10 CSR 80-2.030(3) and 260.210.1 (2) RSMo.	80-2.030 Solid Waste Disposal Area Closure, Post-Closure Care and Corrective Action Plans and Procedures with Associated Financial Assurance Requirements. (3) No person may excavate, disrupt or remove any deposited material from any active or discontinued solid waste disposal area without having received prior approval from the department	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Removal of waste from sanitary landfill	Screening and removal of unapproved wastes	Disturbed existing landfill	10 CSR 80-3.010(3)(B)2	Missouri Code of State Regulations > TITLE 10- DEPARTMENT OF NATURAL RESOURCES >DIVISION 80- SOLID WASTE MANAGEMENT > CHAPTER 3- SANITARY LANDFILL 80-3.010 Design and Operation (1) General Provisions	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Encountering whole waste tires	None allowed in landfill	If dug up, needs to be removed.	10 CSR 80-3.010(3)(A)11	11. Waste tires as provided by 10 CSR 80-8.020;	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Sanitary Landfill construction	One hundred foot buffer zone	Provide room for assessment of remedial actions	10 CSR 80-3.010(5)(B)1	(B) Satisfactory Compliance--Design. 1. Plans submitted as part of an application for a construction permit after the effective date of this rule shall provide for the maintenance of a one hundred foot (100')-buffer zone between the outer edge of the landfill liner and any property line(s) or any right-of-way(s) of adjoining road(s) when the property line(s) is inside the right-of-way(s) to provide room for assessment and/or remedial actions.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Water quality; Detailed Site Investigation, projected use of water resources and groundwater elevation.	Protection of the state and local waterways	10 CSR 80-3.010(8)(B)1.A -10 CSR 80-3.010(8)(B)1.C	(8) Water Quality. (A) Requirement. The location, design, construction and operation of the sanitary landfill shall minimize environmental hazards and shall conform to applicable ground and surface water quality standards and requirements. Applicable standards are federal, state or local standards and requirements that are legally enforceable.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Leachate collection system	Collect and remove leachate from landfill	10 CSR 80-3.010(9)(A)	(9) Leachate Collection System. (A) Requirement. A leachate collection system shall be designed, constructed, maintained and operated to collect and remove leachate from the sanitary landfill.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Less than one foot of leachate on liner	Prevent collapse under pressures	10 CSR 80-3.010(9)(B)1.E	E. Design and operate systems to maintain less than one foot (1') depth of leachate over the disposal area liner.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Sanitary Landfill construction	Groundwater monitoring program	Determine the impact of the landfill on the quality of groundwater	10 CSR 80-3.010(11)(A)	(11) Groundwater Monitoring. (A) Requirements. The owner/operator of a sanitary landfill shall implement a groundwater monitoring program capable of determining the sanitary landfill's impact on the quality of groundwater underlying the sanitary landfill.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Air quality control	Conform to ambient air standards	10 CSR 80-3.010(13)	(13) Air Quality. (A) Requirement. The design, construction and operation of the sanitary landfill shall minimize environmental hazards and shall conform to applicable ambient air quality and source control regulations.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Gas generated shall be controlled	Protect the public's health and environment	10 CSR 80-3.010(14)A	(14) Gas Control. (A) Requirement. Decomposition gases generated within the sanitary landfill shall be controlled on-site, as necessary, to avoid posing a hazard to the environment or to public health and the safety of occupants of adjacent property.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Decomposition of gas not allowed to migrate	Protect the public's health and environment	10 CSR 80-3.010(14) (C)1	C. The gas monitoring specified in the plans shall be performed at gas monitoring wells. The monitoring program shall specify how buildings on the landfill property are to be monitored.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Unfavorable conditions for vectors	Prevent harboring, feeding or breeding of vectors	10 CSR 80-3.010(15)A	(15) Vectors. (A) Requirements. Conditions shall be maintained that are unfavorable for the harboring, feeding and breeding of vectors.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Sanitary Landfill construction	Cover	Minimize fire hazards, vectors, infiltration of water, control gas, etc.	10 CSR 80-3.010(17)	(17) Cover. (A) Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; and provide a pleasing appearance.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Closure and post closure plans	Plans and maintenance of landfill when it closes	10 CSR 80-3.010(20)(C) 1.I	(C) Satisfactory Compliance--Operations. 1. Records shall be maintained at the landfill office. Records five (5) years old or older may be stored at an alternate site if approved by the department; such stored records must be made available at the landfill upon request of department personnel	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Sanitary Landfill construction	Financial Assurance Information	Monies to maintain the landfill after closure	10 CSR 80-3.010(20)(C) 1.J	J. Any cost estimates and financial assurance documentation required under 10 CSR 80-2.030(4)(B) and (C);	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Release of Pollutants to Waters of the State	Unlawful to pollute waters of the state, reduce quality below water quality standards, violate pretreatment and toxic material control regulations, discharge radiological, chemical or biological gen or high-level radioactive wastes into waters of the state.	To protect water quality and ensure existing or proposed discharges do not degrade water quality beyond the bounds of the law.	644.051.1	644.051. 1. It is unlawful for any person: (1) To cause pollution of any waters of the state or to place or cause or permit to be placed any water contaminant in a location where it is reasonably certain to cause pollution of any waters of the state;	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Hazardous Waste landfill construction	Hazardous waste landfills constructed after October 31, 1980, shall have a leachate collection system. The rules and regulations of the commission shall treat and protect all aquifers to the same level of protection.	Statutory requirements for construction of hazardous waste landfills	260.395(17) RSMo	17. All hazardous waste landfills constructed after October 31, 1980, shall have a leachate collection system. The rules and regulations of the commission shall treat and protect all aquifers to the same level of protection. The provisions of this subsection shall not apply to the disposal of tailings and slag resulting from mining, milling and primary smelting operations.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*
Evaluation of Alternatives prior to Hazardous waste landfill construction	1. Nothing in this section shall apply to the storage or treatment of hazardous waste by a generator on-site or to the disposal on-site of smelter slag waste from the processing of materials into reclaimed metals if the smelter was in operation prior to August 13, 1988, nor preclude the transportation of hazardous waste out of state for treatment, storage or disposal. After August 13, 1988, no person shall dispose of untreated hazardous waste in a hazardous waste disposal facility permitted in the state of Missouri.2. Before using a hazardous waste disposal facility permitted under sections 260.350 to 260.432, generators of hazardous waste must prove that they have investigated and reviewed alternatives to landfilling to an extent acceptable to the hazardous waste management commission. The generator shall use, to the maximum extent feasible, the best demonstrated available technology for source reduction, recycling, treatment, stabilization, solidification or destruction, including, but not limited to, biodegradation, detoxification, incineration and neutralization, as determined by the commission. In determining the best demonstrated	Statutory requirements for construction of hazardous waste landfills	260.394 RSMo	260.394. Disposal of untreated hazardous waste, prohibited, exceptions — alternative to landfilling, best demonstrated available technology. — 1. Nothing in this section shall apply to the storage or treatment of hazardous waste by a generator on-site or to the disposal on-site of smelter slag waste from the processing of materials into reclaimed metals if the smelter was in operation prior to August 13, 1988, nor preclude the transportation of hazardous waste out of state for treatment, storage or disposal. After August 13, 1988, no person shall dispose of untreated hazardous waste in a hazardous waste disposal facility permitted in the state of Missouri.	Y	Y	*Substantive elements of these chapters may be Applicable if implementing a remedial action to include a on-site cell option.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
	available technology, the commission shall give consideration to the relative economic feasibility of the technology, including potential future costs of cleanup and environmental damage. Such technology shall render the hazardous waste sufficiently low in toxicity, reactivity and corrosivity as to present the least possible risk to human health and safety and to the environment in the event of a release from a hazardous waste disposal facility.3. The commission shall determine that the best demonstrated available technology is used at hazardous waste disposal facilities in the state of Missouri in accordance with the provisions of sections 260.350 to 260.432, and the federal Resource Conservation and Recovery Act (P.L. 94-580), as amended.4. Any hazardous waste diluted below the listed concentration threshold shall remain a listed hazardous waste unless the dilution occurs as a normal part of the manufacturing process.5. The provisions of this section shall not apply to abandoned or uncontrolled sites as listed under section 260.440, or sites listed in the national priority list pursuant to the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (P.L. 96-510), as amended, unless otherwise determined by the department or required by the commission by rule.						
Construction of Earthen Basin	Ensure all engineering reports, plans, and specifications in accordance with state law for construction of earthen basins	To ensure existing or proposed discharges are in compliance.	10 CSR 20-8.110	10 CSR 20-8.110 Engineering—Reports, Plans, and Specifications	N	N	*Administrative, but design elements will be included in CERCLA documents*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Groundwater monitoring	Groundwater quality	Landfill location	10 CSR 80-3.010(12)(C)	(12) Corrective Action. (C) Implementation of the Corrective Action Program. 1. Based on the schedule established under paragraph (12)(B)4. of this rule for initiation and completion of remedial activities the owner/operator shall….	Y	Y	*Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in groundwater or any water discharge.*
Structures on landfill	Not allowed without controls	Stability and gas	10 CSR 80-3.010(4)(B)7.C(I) (14)	WRONG CITATION (4) Site Selection. (B) Satisfactory Compliance-Design. 7. Plans shall include: (14) Gas Control. (A) Requirement. Decomposition gases generated within the sanitary landfill shall be controlled on-site, as necessary, to avoid posing a hazard to the environment or to public health and the safety of occupants of adjacent property.	Y	Y	*Not applicable to CERCLA sites, but may be relevant and appropriate If structures are present or gas is generated at Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal" and partial excavation.*
Gas monitoring and control	Control gas migration	Safety	10 CSR 80-3.010(14)	(14) Gas Control. (A) Requirement. Decomposition gases generated within the sanitary landfill shall be controlled on-site, as necessary, to avoid posing a hazard to the environment or to public health and the safety of occupants of adjacent property.	Y	Y	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91. These requirements would be relevant and appropriate to regrading of Areas 1 and 2 after removal of radiologically-impacted material under the "complete rad removal" and partial excavation.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Installation of observation or monitoring wells	Regulates drilling, construction, registration, and abandonment of monitoring wells in Missouri	Groundwater protection	10 CSR 23-4	Title 10 DNR Division 23 Division of Geology and Land Survey Chapter 4 Monitoring Well Construction Code	N	Y	*Substantive portions of Division 23 may be relevant and appropriate if wells are constructed and/or abandoned as part of the remedy, but will mostly be administrative.*
Practice of geology	Regulates practice	Health and safety	4 CSR 145-1.010	4 CSR 145-1.010 Board of Geologist Registration—General Organization	N	Y	*Substantive portions of 4 CDR 145-1.010 may be relevant and appropriate if a PG stamp and seal on drawings are necessary as part of the remedy. but will mostly be administrative.*
Abandonment of unused domestic supply wells	Regulates activity	Groundwater protection	10 CSR 23-3.110	10 CSR 23-3.010 Location of Wells	N	Y	*Although abandonment of unused domestic supply wells are not envisioned in the ROD-selected remedy, could be Relevant and Appropriate if monitoring wells are required to be abandoned.*
Pollution and vandalism	Relates to protection of caves (including sinkholes) and cave life	Groundwater protection	L. 1981 H.S.H.B. 1192, an Act		N	Y	*State law providing for protection of caves (including sinkholes) and cave life from vandalism and pollution. The law may be applicable if site contains the presence of solution enlarged fractures during excavation. This act is an ARAR for all excavation scenarios.*

Table 3-3a: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria All Proposed Scenarios

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	Citations	*Citation Included in Draft FFS?*	*Potentially ARAR?*	Discussion/Analysis
Groundwater tracing	Registration and reporting of results to Missouri Geological Survey	Groundwater protection	L.1991 S.B.221, an Act RSMo 256.621	Surface water tracing, registration required--renewal—documentation required. 256.621. All persons engaged in groundwater or surface water tracing, for any purpose, shall register with the division. This registration shall be renewed annually. The registrant shall report in writing all proposed injections of tracers to the division prior to actual injection. Written and graphical documentation of traces shall be provided to the division within thirty days of completion of each trace. The division shall maintain records of all injections and traces reported and will provide this information to interested parties upon request at the cost of	N	Y	*If groundwater tracing is required, this might be considered and ARAR, but note that this activity is not envisioned in the ROD-selected or other remedy.*
Open burning	Only untreated wood and lumber may be burned and a permit must be obtained	Air quality protection	10 CSR 10-6.045	10 CSR 10-6.045 Open Burning Requirements	Y	Y	*If open burning is required, this might be considered and ARAR, but note that this activity is not envisioned in the ROD-selected or other remedy.*
Hazardous Waste Generation, storage, treatment, transportation and disposal	Follow all applicable state and federal hazardous waste laws and regulations	Health and safety,env pro	Hazardous Waste Management Law 260.350-260.1039 Hazardous Waste Regulations 10 CSR 25-1 through 19	Division 25—Hazardous Waste Management Commission, Chapter 1—Organization- 10 CSR 25-19.010 Electronics Scrap Management	N	Y	*A citation of Division 25, but substantive portions of Division 25 may be Relevant and Appropriate if hazardous waste is required to be managed under the selected remedial options.*
Closure and Post-closure	Care and O&M	Long term protection	10 CSR 80-2.030	10 CSR 80-2.030 Solid Waste Disposal Area Closure, Post-Closure Care and Corrective Action Plans and procedures with Associated Financial Assurance Requirement	Y	Y	*Section 6.2.2.2.1 discusses that the "substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate.*

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Preliminary Identification of Potential State ARARs: Action Specific Cap in Place

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Recapping disturbed areas	Final cover, grading of existing cap	Damage or adding to current cover	10 CSR 80-3.010(17)	*(A): Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; (B) Satisfactory Compliance Design. The owner/operator shall prepare a written closure plan that describes the steps necessary to close all sanitary landfill phases at any point during the active life of the sanitary landfill in accordance with the requirements of 10 CSR 80-2.030(4)(A). In addition, the final cover requirements specified in the closure and post-closure plans shall specify…*	*Potentially Relevant and Appropriate for design of the final cover.Also, Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(17)(A): Potentially Relevant and Appropriate if waste is exposed during remedy implementation. 10 CSR 80-3.010(17)(B): Potentially Relevant and Appropriate for design of the final cover.*
Slope construction	Runoff without excessive erosion, stability	Cap protection	10 CSR 80-3.010(17)(B)3, 7, (C)3	*(B)3. Surface grades and side slopes needed to promote maximum runoff, without excessive erosion, to minimize infiltration. Final side slopes shall not exceed twenty-five percent (25%) unless it has been demonstrated in a detailed slope stability analysis approved by the department that the slopes can be constructed and maintained throughout the entire operational life and post-closure period of the landfill. (C)3. No active, intermediate or final slope shall exceed thirty-three and one-third percent (33 1/3%).*	*Potentially Relevant and Appropriate for design of the final cover*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially Relevant and Appropriate for design of the final cover.*
QA/QC of cover	Thickness and testing of each lifts of soil	Prevent infiltration and promote vegetative growth	10 CSR 80-3.010 (6)	*(A) Requirement. The construction, operation and closure of the sanitary landfill shall include quality assurance and quality control measures to ensure compliance with approved plans and all applicable federal, state and local requirements. The permittee shall be responsible for ensuring that the quality assurance/quality control supervision is conducted by a qualified professional.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions as related to closure/final cover and to ensure compliance with ARARs are potentially Relevant and Appropriate. The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process.*

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Cover requirements	2 feet of clay, 1 foot vegetative, $1x10^{-5}$ permeability, if disturbed	Thickness	10 CSR 80-3.010(17)(C)4	*4. As each phase of the sanitary landfill is completed, a final cover system shall be installed at portions of A. Existing sanitary landfills without composite liners. This final cover shall consist of at least two feet (2') of compacted clay with a coefficient of permeability of 1 × 10-5 cm/sec or less and overlaid by at least one foot (1') of soil capable of sustaining vegetative growth; B. Sanitary landfills with composite liners. This final cover shall consist of component layers, in order from top to bottom, as follows: (I) Two feet (2') of soil capable of sustaining vegetative growth; (II) A drainage layer; (III) A geomembrane liner at least as thick as the geomembrane liner described in subparagraph (10)(B)1.G; (IV) One foot (1') of compacted clay with a coefficient of permeability of 1 × 10-5 cm/sec or less; and C. The geomembrane liner shall be in intimate contact with the underlying compacted clay. 5. The installation of the final cover systems.*	*Potentially Relevant and Appropriate for design of the final cover.*	*Yes*	*Note that only 10 CSR 80-3.010(17)(C)4(A) is relevant to thickness.These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however they are potentially relevant and appropriate for design of the final cover, if waste is moved and re-landfilled.*
Modification of Landfill	Standards for performance of solid waste landfills — prior approvals and plan may be necessary	Air quality protection	40 CFR 60 Subpart WWW	*Applicability: (c) Activities required by or conducted pursuant to a CERCLA, RCRA, or State remedial action are not considered construction, reconstruction, or modification for purposes of this subpart.*	*No*	*No*	*Approvals and plans are generally administrative; approvals will be through the CERCLA process. May be relevant and appropriate if landfill is excavated as part of the selected remedial option,*
Modification of Landfill	National Emissions standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills	Air quality protection	40 CFR 63 Subpart AAAA	*(a) You must fulfill one of the requirements in paragraph (a)(1) or (2) of this section, whichever is applicable:(1) Comply with the requirements of 40 CFR part 60, subpart WWW.(2) Comply with the requirements of the Federal plan or EPA approved and effective State plan or tribal plan that implements 40 CFR part 60, subpart Cc.*	*No*	*No*	*Only applicable to landfills that accepted waste after 11-8-87.*

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Preliminary Identification of Potential State ARARs: Action Specific Consolidation and Excavation, then Capping

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Removing waste from landfill	May not excavate, disrupt or remove material from landfill without obtaining approval	Disturbed existing landfill	10 CSR 80-2.030(3)	*(3) No person may excavate, disrupt or remove any deposited material from any active or discontinued solid waste disposal area without having received prior approval from the department. Requests for approval shall include…*	*Section 6.2.2.2.1 discusses that the "substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate."*	*Yes*	*The Requirement refers to approval, which is an administrative action; approval will be through the ROD. However substantive portions are potentially Relevant and Appropriate.*
Closing sides of disturbed landfill	Obtain approval	Disturbed existing landfill	10 CSR 80-2.030(1)	*(1) To prevent a solid waste disposal area from being a blight on the land, a hazard to health and safety and air pollution problem or a source of pollution to any water course, the owner/operator of any solid waste disposal area shall obtain approval of the method of closure from the department prior to closure.*	*Section 6.2.2.2.1 discusses that the "substantive MDNR landfill requirements for post-closure care and corrective action found in 10 CSR 80-2.030 are also considered relevant and appropriate."*	*Yes*	*The Requirement refers to approval, which is an administrative action; approval will be through the ROD. However substantive portions (namely prevent a solid waste disposal area from being a blight on the land, a hazard to health and safety and air pollution problem or a source of pollution to any water course) are potentially Relevant and Appropriate.*
Recapping disturbed areas	Final Cover	Damage or adding to current cover	10 CSR 80-3.010(17)	*(A): Requirement. Cover shall be applied to minimize fire hazards, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; (B) Satisfactory Compliance Design. The owner/operator shall prepare a written closure plan that describes the steps necessary to close all sanitary landfill phases at any point during the active life of the sanitary landfill in accordance with the requirements of 10 CSR 80-2.030(4)(A). In addition, the final cover requirements specified in the closure and post-closure plans shall specify…*	*Potentially Relevant and Appropriate for design of the final cover. Also, Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however 10 CSR 80-3.010(17)(A): Potentially Relevant and Appropriate if waste is exposed during remedy implementation. 10 CSR 80-3.010(17)(B): Potentially Relevant and Appropriate for design of the final cover.*

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Slope construction	Runoff without excessive erosion, stability	Cap protection	10 CSR 80-3.010(17)(B)3,7,(C)3	*(B)3. Surface grades and side slopes needed to promote maximum runoff, without excessive erosion, to minimize infiltration. Final side slopes shall not exceed twenty-five percent (25%) unless it has been demonstrated in a detailed slope stability analysis approved by the department that the slopes can be constructed and maintained throughout the entire operational life and post-closure period of the landfill. (C)3. No active, intermediate or final slope shall exceed thirty-three and one-third percent (33 1/3%).*	*Potentially Relevant and Appropriate for design of the final cover*	*Yes*	*Not certain why the main citation is included above and then this specific citation is included here.* *These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially Relevant and Appropriate for design of the final cover.*
Disturbing a landfill	Certified technician	Moving waste	10 CSR 80-2.060(2)	*(2) Facility Requirement. (A) All operations at each solid waste disposal area shall be conducted under the direct control or performed by a certified solid waste technician by January 1, 1989. The certified solid waste technician shall be a supervisor, manager or equipment operator who has primary responsibility for compliance with sections 260.200–260.245, RSMo, corresponding rules and the approved plans and permit conditions for the solid waste disposal area. (B) A solid waste disposal area or a solid waste processing facility which is required to be operated under the direction of a certified solid waste technician shall operate for no more than six (6) months in the event that the services of a certified solid waste technician are not available.*	*No*	*N/A*	*Not an ARAR. This is administrative (involves certification and timelines for operation).*
Precipitation on open side slopes	Treat as leachate	Contact with waste	10 CSR 80-3.010(8)(B)F.V	*This may be 10 CSR 80-3.010(8)(B)(1)F(V) Contingency plans for on-site management of surface water which comes in contact with solid waste shall be specified .*	*From Section 6.2.2.2.1, the substantive elements of contingency plans may be Relevant and Appropriate during construction .*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however substantive elements of contingency plans may be relevant and appropriate during construction .*
QA/QC of cover	Thickness and testing of each lift of soil	Prevent infiltration and promote vegetative growth	10 CSR 80-3.010(6)	*(A) Requirement. The construction, operation and closure of the sanitary landfill shall include quality assurance and quality control measures to ensure compliance with approved plans and all applicable federal, state and local requirements. The permittee shall be responsible for ensuring that the quality assurance/quality control supervision is conducted by a qualified professional.*	*Section 6.2.2.2.1 discusses that other portions of 10 CSR 80-3.010 are considered Relevant and Appropriate.*	*Yes*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however, substantive portions as related to closure/final cover and to ensure compliance with ARARs are potentially relevant and appropriate. The design and associated QA/QC requirements will be detailed in CERCLA documents and approved as part of the CERCLA process.*

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Cover requirements	2 feet of clay, 1 foot vegetative soil, $1x10^{-5}$ permeability, if disturbed	Thickness	10 CSR 80-3.010(17)(C)4	*4. As each phase of the sanitary landfill is completed, a final cover system shall be installed at portions of A. Existing sanitary landfills without composite liners. This final cover shall consist of at least two feet (2') of compacted clay with a coefficient of permeability of 1 × 10-5 cm/sec or less and overlaid by at least one foot (1') of soil capable of sustaining vegetative growth; B. Sanitary landfills with composite liners. This final cover shall consist of component layers, in order from top to bottom, as follows: (I) Two feet (2') of soil capable of sustaining vegetative growth; (II) A drainage layer; (III) A geomembrane liner at least as thick as the geomembrane liner described in subparagraph (10)(B)1.G; (IV) One foot (1') of compacted clay with a coefficient of permeability of 1 × 10-5 cm/sec or less; and C. The geomembrane liner shall be in intimate contact with the underlying compacted clay. 5. The installation of the final cover systems.*	*Potentially Relevant and Appropriate for design of the final cover.*	*Yes*	*Not certain why the main citation is included above and then this specific citation is included here.These requirements are not applicable as they only apply to landfills in operation after 10-9-91; however potentially Relevant and Appropriate for design of the final cover.*
Excavation, generation, interim storage, transport, and disposal of hazardous waste	Follow requirements for characterizing, handling, storage, transportation and disposal of hazardous waste	Safe management of hazardous waste materials	10 CSR 25 Related: 40 CFR Part 261; 40 CFR Part 262	*Hazardous Waste Identification and Standards Applicable to Generators*	*By reference: 40 CFR Part 261; 40 CFR Part 262*	*Yes*	*Per discussion in Section 5.3.1.9, hazardous waste, if encountered will not be placed back in the landfill. Substantive portions of 10 CSR 25 may be applicable if hazardous waste is encountered and disposed of off-site.*

Preliminary Identification of Potential State ARARs: Action Specific Partial Excavation with Off Site Disposal and Cap

Action Subject to Requirement	Requirement	Reason Why Requirement is an	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Removing waste from landfill	May not excavate, disrupt or remove material from landfill without obtaining approval	Disturbed existing landfill	10 CSR 80-2.030(3)	*See:*			
Closing sides of disturbed landfill	Obtain approval	Disturbed existing landfill	10 CSR 80-2.030(1)	Potential State ARARs —Action-Specific			
Recapping disturbed areas	Final Cover	Damage or adding to current cover	10 CSR 80-3.010(17)	Consolidation and Excavation, then Capping			
Slope construction	Runoff without excessive erosion, stability	Cap protection	10CSR 80-3.010(17)(B)3,7,(C)3				
Disturbing a landfill	Certified technician	Moving waste	10 CSR 80-2.060(2)				
Precipitation on open side slopes	Treat as leachate	Contact with waste	10 CSR 80-3.010(8)(B)F.V				
QA/QC of cover	Thickness and testing of each lift of soil	Prevent infiltration and promote vegetative growth	10 CSR 80-3.010(6)				

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Cover requirements	2 feet of clay, 1 foot vegetative soil, 1x10^{5} permeability, if disturbed	Thickness	10 CSR 80-3.010(17)(C)4	
Daily cover	Cover applied at end of working day	Minimize vectors, odors, litter, scavenging	10 CSR 80-3.010(17)(C)1,2	
Excavation, generation, interim storage, transport, and disposal of hazardous waste	Follow requirements for characterizing, handling, storage, transportation and disposal of hazardous waste	Safe management of hazardous waste materials	10 CSR 25 Related: 40 CFR Part 261; 40 CFR Part 262	

Preliminary Identification of Potential State ARARs: Action Specific Full Excavation with Off Site Disposal

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Removing waste from landfill	May not excavate, disrupt or remove material from landfill without obtaining approval	Disturbed existing landfill	10 CSR 80-2.030(3)	*See:* *Potential State ARARs —Action-Specific Consolidation and Excavation, then Capping*			
Closing sides of disturbed landfill	Obtain approval	Disturbed existing landfill	10 CSR 80-2.030(1)				
Recapping disturbed areas	Final Cover	Damage or adding to current cover	10 CSR 80-3.010(17)				
Slope construction	Runoff without excessive erosion, stability	Cap protection	10CSR 80-3.010(17)(B)3,7,(C)3				
Disturbing a landfill	Certified technician	Moving waste	10 CSR 80-2.060(2)				
Precipitation on open side slopes	Treat as leachate	Contact with waste	10 CSR 80-3.010(8)(B)F.V				
QA/QC of cover	Thickness and testing of each lift of soil	Prevent infiltration and promote vegetative growth	10 CSR 80-3.010(6)				
Cover requirements	2 feet of clay, 1 foot vegetative soil, 1x10^{-5} permeability, if disturbed	Thickness	10 CSR 80-3.010(17)(C)4				
Daily cover	Cover applied at end of working day	Minimize vectors, odors, litter, scavenging	10 CSR 80-3.010(17)(C)1,2				
Corrective Action	Address contamination	Known contaminants	10 CSR 80-3.010(12)	*(12) Corrective Action. (C) Implementation of the Corrective Action Program. 1. Based on the schedule established under paragraph (12)(B)4. of this rule for initiation and completion of remedial activities the owner/operator shall…*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91. Substantive elements are potentially Relevant and Appropriate.*
Excavation, generation, interim storage, transport, and disposal of hazardous waste	Follow requirements for characterizing, handling, storage, transportation and disposal of hazardous waste	Safe management of hazardous waste materials	10 CSR 25Related: 40 CFR Part 261; 40 CFR Part 262	*See:* *Potential State ARARs —Action-Specific Consolidation and Excavation, then Capping*			

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Preliminary Identification of Potential State ARARs: Action Specific Full Excavation with On Site Disposal

Action Subject to Requirement	Requirement	Reason Why Requirement is an ARAR	Regulatory Citation	*Citations*	*Citation Included in Draft FFS?*	*Potentially ARAR?*	*Discussion/Analysis*
Sanitary Waste landfill disturbance	Cannot remove/disrupt/excavate from a discontinued landfill without receiving prior approval from the Department.	Disturbed existing landfill	10 CSR 80-2.030(3) and 260.210.1 (2) RSMo.	*See:*			
Removal of waste from sanitary landfill	Screening and removal of unapproved wastes	Disturbed existing landfill	10 CSR 80-3.010(3)(B)2				
Encountering whole waste tires	None allowed in landfill	If dug up, needs to be removed.	10 CSR 80-3.010(3)(A)11	*Potential State ARARs —Action-Specific Consolidation and Excavation, then Capping*			
Sanitary Landfill construction	One hundred foot buffer zone	Provide room for assessment of remedial actions	10 CSR 80-3.010(5)(B)1				
Sanitary Landfill construction	Water quality; Detailed Site Investigation, projected use of water resources and groundwater elevation.	Protection of the state and local waterways	10 CSR 80-3.010(8)(B)1.A -10 CSR 80-3.010(8)(B)1.C				
Sanitary Landfill construction	Leachate collection system	Collect and remove leachate from landfill	10 CSR 80-3.010(9)(A)				
Sanitary Landfill construction	Less than one foot of leachate on liner	Prevent collapse under pressures	10 CSR 80-3.010(9)(B)1.E				
Sanitary Landfill construction	Groundwater monitoring program	Determine the impact of the landfill on the quality of groundwater	10 CSR 80-3.010(11)(A)				
Sanitary Landfill construction	Air quality control	Conform to ambient air standards	10 CSR 80-3.010(13)				
Sanitary Landfill construction	Gas generated shall be controlled	Protect the public's health and environment	10 CSR 80-3.010(14)A				
Sanitary Landfill construction	Decomposition of gas not allowed to migrate	Protect the public's health and environment	10 CSR 80-3.010(14)(C)1				
Sanitary Landfill construction	Unfavorable conditions for vectors	Prevent harboring, feeding or breeding of vectors	10 CSR 80-3.010(15)A				
Sanitary Landfill construction	Cover	Minimize fire hazards, vectors, infiltration of water, control gas, etc.	10 CSR 80-3.010(17)				
Sanitary Landfill construction	Closure and post closure plans	Plans and maintenance of landfill when it closes	10 CSR 80-3.010(20)(C)1.I				
Sanitary Landfill construction	Financial Assurance Information	Monies to maintain the landfill after closure	10 CSR 80-3.010(20)(C)1.J				
Release of Pollutants to Waters of the State	Unlawful to pollute waters of the state, reduce quality below water quality standards, violate pretreatment and toxic material control regulations, discharge radiological, chemical or biological gen or high-level radioactive wastes into waters of the state.	To protect water quality and ensure existing or proposed discharges do not degrade water quality beyond the bounds of the law.	644.051.1				
Hazardous Waste landfill construction	Hazardous waste landfills constructed after October 31, 1980, shall have a leachate collection system. The rules and regulations of the commission shall treat and protect all aquifers to the same level of protection.	Statutory requirements for construction of hazardous waste landfills	260.395(17) RSMo				

Table 3-3b: Preliminary Identification of Potential State Action-Specific ARARs and TBC Criteria by Scenario

Evaluation of Alternatives prior to Hazardous waste landfill construction	1. Nothing in this section shall apply to the storage or treatment of hazardous waste by a generator on-site or to the disposal on-site of smelter slag waste from the processing of materials into reclaimed metals if the smelter was in operation prior to August 13, 1988, nor preclude the transportation of hazardous waste out of state for treatment, storage or disposal. After August 13, 1988, no person shall dispose of untreated hazardous waste in a hazardous waste disposal facility permitted in the state of Missouri.2. Before using a hazardous waste disposal facility permitted under sections 260.350 to 260.432, generators of hazardous waste must prove that they have investigated and reviewed alternatives to landfilling to an extent acceptable to the hazardous waste management commission. The generator shall use, to the maximum extent feasible, the best demonstrated available technology for source reduction, recycling, treatment, stabilization, solidification or destruction, including, but not limited to, biodegradation, detoxification, incineration and neutralization, as determined by the commission. In determining the best demonstrated available technology, the commission shall give consideration to the relative economic feasibility of the technology, including potential future costs of cleanup and environmental damage. Such technology shall render the hazardous waste sufficiently low in toxicity, reactivity and corrosivity as to present the least possible risk to human health and safety and to the environment in the event of a release from a hazardous waste disposal facility.3. The commission shall determine that the best demonstrated available technology is used at hazardous waste disposal facilities in the state of Missouri in accordance with the provisions of sections 260.350 to 260.432, and the federal Resource Conservation and Recovery Act (P.L. 94-580), as amended.4. Any hazardous waste diluted below the listed concentration threshold shall remain a listed hazardous waste unless the dilution occurs as a normal part of the manufacturing process.5. The provisions of this section shall not apply to abandoned or uncontrolled sites as listed under section 260.440, or sites listed in the national priority list pursuant to the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (P.L. 96-510), as amended, unless otherwise determined by the department or required by the commission by rule.	Statutory requirements for construction of hazardous waste landfills	260.394 RSMo				
Recapping disturbed areas	Final Cover	Damage or adding to current cover	10 CSR 80-3.010(17)				
Slope construction	Runoff without excessive erosion, stability	Cap protection	10CSR 80-3.010(17)(B)3,7,(C)3				
Disturbing a landfill	Certified technician	Moving waste	10 CSR 80-2.060(2)				
Precipitation on open side slopes	Treat as leachate	Contact with waste	10 CSR 80-3.010(8)(B)F.V				
QA/QC of cover	Thickness and testing of each lift of soil	Prevent infiltration and promote vegetative growth	10 CSR 80-3.010(6)				
Cover requirements	2 feet of clay, 1 foot vegetative soil, $1x10^{-5}$ permeability, if disturbed	Thickness	10 CSR 80-3.010(17)(C)4				
Daily cover	Cover applied at end of working day	Minimize vectors, odors, litter, scavenging	10 CSR 80-3.010(17)(C)1,2				
Corrective Action	Address contamination	Known contaminants	10 CSR 80-3.010(12)	*(12) Corrective Action. (C) Implementation of the Corrective Action Program. 1. Based on the schedule established under paragraph (12)(B)4. of this rule for initiation and completion of remedial activities the owner/operator shall…*	*No*	*N/A*	*These requirements are not applicable as they only apply to landfills in operation after 10-9-91. Substantive elements are potentially Relevant and Appropriate.*
Excavation, generation, interim storage, transport, and disposal of hazardous waste	Follow requirements for characterizing, handling, storage, transportation and disposal of hazardous waste	Safe management of hazardous waste materials	10 CSR 25 Related: 40 CFR Part 261; 40 CFR Part 262	*See:* *Potential State ARARs —Action-Specific Consolidation and Excavation, then Capping*			

Table 6-1: Summary of Estimated Costs

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Estimated Cost	No Action Alternative		ROD-Selected Remedy		UMTRCA Cap Alternative		Full Excavation w/ Off-Site Disposal Alternative		Full Excavation w/ On-Site Disposal Alternative		Partial Excavation Alternatives: 52.9 pCi/g		Partial Excavation Alternatives: 1,000 pCi/g		Partial Excavation Alternatives: Risk-Based	
	i = 7%	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*	*i = 7%*	*i = 0.7%*
Capital ($M)	0		75		96		695		591		274		379		187	
Operation, Maintenance, and Monitoring ($1,000/yr)	36 every 5 years		176 - 389		176 - 389		176 - 340		182 - 444		176 - 389		176 - 389		176 - 389	
30 year:																
Present Worth ($M)	0.1	0.2	71	79	90	100	455	667	391	568	236	275	287	372	165	189
Non-discounted Total ($M)	0.2		80		102		699		596		280		384		192	
200 year:																
Present Worth ($M)	0.1	0.8	71	95	90	116	*N/A*	*N/A*	392	585	237	290	288	388	165	205
Non-discounted Total ($M)	1		113		134		*N/A*		631		312		417		225	
1,000 year:																
Present Worth ($M)	0.1	1	71	101	90	123	*N/A*	*N/A*	392	592	237	297	288	394	165	211
Non-discounted Total ($M)	7		265		287		*N/A*		788		464		569		377	

Note: These cost estimates are feasibility level cost estimates; that is they were developed to a level of accuracy such that the actual costs incurred to implement the alternatives should fall within a range bounded by 50% above and 30% below these estimates.

Table 6-2: Comparison of USEI Waste Acceptance Criteria (WAC) to Projected OU-1 RIM Concentrations for Full Excavation Alternatives

USEI Category Radionuclide	WAC Criteria: Maximum Concentration of Insitu Material	WAC Criteria: Sum of Concentrations of Parents and all Progeny	Activity Concentration (pCi/g) Area 1	Activity Concentration (pCi/g) Area 2	Mass Concentration (ppm) Area 1	Mass Concentration (ppm) Area 2	Series Activity, Assuming Equilibrium with Parent (pCi/g) Area 1	Series Activity, Assuming Equilibrium with Parent (pCi/g) Area 2	
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media									
Natural uranium in equilibrium with progeny	<500 ppm Unat or 167 pCi ^{238}U/g	≤3,000 pCi/g	99.2	208.2	138.6	275.6	397 (3 dtrs)	833 (3 dtrs)	
^{230}Th	0.1 ppm or ≤2,000 pCi/g	NC [c]	8507	4,663	0.421	0.231	8507 (0 dtrs)	4663 (0 dtrs)	
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤2,000 pCi/g	68.2	159.9	309.9	727.0	682 (9 dtrs)	1599 (9 dtrs)	
Mixture of Thorium and Uranium	Sum of ratios ≤1	≤2,000 pCi/g	4.59	3.07	NA [d]	NA [d]	4.8	3.5	e
Naturally Occurring Radioactive Material Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media									
^{226}Ra w/progeny in bulk form	500 pCi/g	≤4,500 pCi/g	535.2	329	0.00054	0.00033	3211 (5 dtrs)	1975 (5 dtrs)	
^{210}Pb with ^{210}Bi & ^{210}Po	1,500 pCi/g	≤1,500 pCi/g	205.4	144.3	0.0000027	0.0000019	616 (2 dtrs)	433 (2 dtrs)	

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotpe.

b ^{238}U used as surrogate for U nat. Assumes natural isotopic abundance of ^{238}U, ^{235}U and ^{234}U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable. See activity

e Insitu Activity in Area 2 may exceed WAC at times. Must control excavation & handling while monitoring outbound loads.

Table 6-3: Comparison of USEI Waste Acceptance Criteria (WAC) to Projected RIM Concentrations - 52.9 pCi/g Partial Excavation Alternative

USEI Category Radionuclide	WAC Criteria: Maximum Concentration of Insitu Material	WAC Criteria: Sum of Concentrations of Parents and all Progeny	OU-1 RIM Concentrations per Conveyance or Container: Activity Concentration (pCi/g) Area 1	Activity Concentration (pCi/g) Area 2	Mass Concentration (ppm) Area 1	Mass Concentration (ppm) Area 2	Series Activity, Assuming Equilibrium with Parent (pCi/g) Area 1	Series Activity, Assuming Equilibrium with Parent (pCi/g) Area 2
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media								
Natural uranium in equilibrium with progeny	<500 ppm Unat or 167 pCi ^{238}U/g	≤3,000 pCi/g	245	833	314	1117	981 (3 dtrs)	3332 (3 dtrs)
^{230}Th	0.1 ppm or ≤2,000 pCi/g	NC [c]	25773	17,881	1.28	0.89	25773 (0 dtrs)	17881 (0 dtrs)
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤2,000 pCi/g	411.8	135.6	1872	616	4118 (9 dtrs)	1356 (9 dtrs)
Mixture of Thorium and Uranium	Sum of ratios ≤1	≤2,000 pCi/g	14.20	10.88	NA [d]	NA [d]	15.4	11.3 [e]
Naturally Occurring Radioactive Material Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media								
^{226}Ra w/progeny in bulk form	500 pCi/g	≤4,500 pCi/g	2021	1260	0.00202	0.00126	12126 (5 dtrs)	7560 (5 dtrs)
^{210}Pb with ^{210}Bi & ^{210}Po	1,500 pCi/g	≤1,500 pCi/g	417	559	0.0000055	0.0000073	1251 (2 dtrs)	1677 (2 dtrs)

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotpe.

b ^{238}U used as surrogate for U nat. Assumes natural isotopic abundance of ^{238}U, ^{235}U and ^{234}U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable. See activity

e Insitu Activity in Area 2 may exceed WAC at times. Must control excavation & handling while monitoring outbound loads.

Table 6-4: Comparison of USEI Waste Acceptance Criteria (WAC) to Projected OU-1 RIM Concentrations

USEI Category Radionuclide	WAC Criteria		OU-1 RIM Concentrations per Conveyance or Container					
	Maximum Concentration of Insitu Material	Sum of Concentrations of Parents and all Progeny	Activity Concentration (pCi/g)		Mass Concentration (ppm)		Series Activity, Assuming Equilibrium with Parent (pCi/g)	
			Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media								
Natural uranium in equilibrium with progeny	<500 ppm Unat or 167 pCi ^{238}U/g	≤3,000 pCi/g	590.8	1427.8	772.3	1498.5	2363 (3 dtrs)	5711 (3 dtrs)
^{230}Th	0.1 ppm or ≤2,000 pCi/g	NC [c]	47707	20,933	2.3615	1.036	47707 (0 dtrs)	20933 (0 dtrs)
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤2,000 pCi/g	622.6	161.5	2830.0	734.0	6226 (9 dtrs)	1615 (9 dtrs)
Mixture of Thorium and Uranium	Sum of ratios ≤1	≤2,000 pCi/g	26.28	13.65	NA [d]	NA [d]	28.1	14.1 [e]
Naturally Occurring Radioactive Material Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media								
^{226}Ra w/progeny in bulk form	500 pCi/g	≤4,500 pCi/g	4039.0	1788	0.00404	0.00179	24234 (5 dtrs)	10728 (5 dtrs)
^{210}Pb with ^{210}Bi & ^{210}Po	1,500 pCi/g	≤1,500 pCi/g	1319.00	708	0.0000173	0.0000093	3957 (2 dtrs)	2123 (2 dtrs)

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotpe.

b ^{238}U used as surrogate for U nat. Assumes natural isotopic abundance of ^{238}U, ^{235}U and ^{234}U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable. See activity

e Insitu Activity in Area 2 may exceed WAC at times. Must control excavation & handling while monitoring outbound loads.

Table 6-5: Comparison of USEI Waste Acceptance Criteria (WAC) to Projected OU-1 RIM Concentrations

USEI Category Radionuclide	WAC Criteria		OU-1 RIM Concentrations per Conveyance or Container						
	Maximum Concentration of Insitu Material	Sum of Concentrations of Parents and all Progeny	Activity Concentration (pCi/g)		Mass Concentration (ppm)		Series Activity, Assuming Equilibrium with Parent (pCi/g)		
			Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media									
Natural uranium in equilibrium with progeny	<500 ppm Unat or 167 pCi ^{238}U/g	≤3,000 pCi/g	152.6	2.5	217.3	3.5	611 (3 dtrs)	10 (3 dtrs)	
^{230}Th	0.1 ppm or ≤2,000 pCi/g	NC [c]	3843	25	0.1902	0.001	3843 (0 dtrs)	25 (0 dtrs)	
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤2,000 pCi/g	18.7	2.0	84.8	8.9	187 (9 dtrs)	20 (9 dtrs)	
Mixture of Thorium and Uranium	Sum of ratios ≤1	≤2,000 pCi/g	2.26	0.02	NA [d]	NA [d]	2.3	0.0	e
Naturally Occurring Radioactive Material Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media									
^{226}Ra w/progeny in bulk form	500 pCi/g	≤4,500 pCi/g	54.0	2	0.00005	0.00000	324 (5 dtrs)	11 (5 dtrs)	
^{210}Pb with ^{210}Bi & ^{210}Po	1,500 pCi/g	≤1,500 pCi/g	106.70	3	0.0000014	0.0000000	320 (2 dtrs)	9 (2 dtrs)	

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotpe.

b ^{238}U used as surrogate for U nat. Assumes natural isotopic abundance of ^{238}U, ^{235}U and ^{234}U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable. See activity

e Insitu Activity in Area 2 may exceed WAC at times. Must control excavation & handling while monitoring outbound loads.

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
THRESHOLD CRITERIA								
Overall Protection of Human Health and the Environment								
Overall Protection of Human Health and the Environment	Per the BRA, OU-1 does not currently pose unacceptable risks. Potential risks to a future outdoor storage yard worker, future farmer north or west of the Site, or future commercial building user on Lot 2A2 or north of the Site exceed EPA's acceptable risk range. Therefore, the No Action alternative is not protective.	All of the active remedial alternatives would be protective of human health and the environment. All remedial alternatives would use engineering measures to isolate the waste from the environment and thereby would eliminate or reduce potential exposures to (1) external gamma radiation, (2) radon gas emissions, (3) inhalation or ingestion of contaminated waste/soil or contaminated media, (4) dermal contact with contaminated waste/soil or contaminated media, and (5) wind dispersal of contaminants in gases or fugitive dust. All of the remedial alternatives would reduce potential infiltration of precipitation into the waste and thereby reduce the potential for leaching of contaminants to groundwater. All remedial alternatives include institutional controls to ensure that only land and resource uses that are consistent with the remedy and protective of human health and the environment are allowed in the future.						
Compliance with ARARs								
Compliance with Chemical-Specific ARARs	Chemical-specific ARARs are currently being met, however, continued compliance with these standards cannot be ensured without additional engineering controls and enforcement of institutional controls.	All of the remedial alternatives would comply with chemical-specific ARARs, including (1) UMTRCA standards for radon emissions, maximum concentrations for groundwater protection, and cleanup of contaminated land, as modified by the EPA OSWER Directives regarding use of these standards at Superfund sites; (2) radon NESHAP standards; (3) NRC radiation protection standards; and (4) Missouri maximum contaminant levels (MCLs).						
Compliance with Location Specific ARARs	Conditions associated with OU-1 comply with the location-specific ARARs	All of the remedial alternatives would meet the location-specific ARARs found in the Missouri solid waste regulations for landfills located within the 100-year floodplain or within 10,000 feet of an airport runway. Waste excavation under the complete and partial excavation alternatives and waste regrading activities under all of the alternatives would need to be performed in a manner that minimizes attractions for birds. Specifically, an avian management plan that incorporates the various techniques described in Section 4.3.6.2 of this FFS would need to be developed and approved by EPA and MDNR.						Depending upon location of on-site cell, may not meet Solid Waste regulation or TBC requirements for separation from runway.

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Compliance with ARARs (cont.)								
Compliance with Action-Specific ARARs	No actions would be taken under this alternative and therefore, there are no action-specific ARARs.	Would meet action-specific ARARs, including the UMTRCA standards for longevity of disposal facilities; the Missouri solid waste regulations closure and post-closure standards; the NRC radiation protection standards; Missouri stormwater regulations, and the Missouri noise protection standards during implementation of a remedial action and closure of Areas 1 and 2.		Would meet action-specific ARARs including the UMTRCA standards for longevity and radon control (except for the full excavation with off-site disposal of RIM alternative as these would no longer be relevant); Missouri solid waste regulations closure and post-closure standards; the NRC radiation protection standards; Missouri stormwater regulations; the Missouri noise protection standards during implementation of a remedial action and closure of Areas 1 and 2; DOT and NRC standards for shipment of radioactive wastes; offsite disposal facility waste acceptance criteria; and CERCLA Off-Site Rule requirements.				Would meet action-specific ARARs including UMTRCA standards for longevity, radon barrier and groundwater protection; Missouri SWR for design, operation, closure, post-closure and monitoring of solid waste units; NRC radiation protection standards; stormwater regulations; and noise protection during implementation.
PRIMARY BALANCING CRITERIA								
Long-Term Effectiveness and Permanence								
Magnitude of Residual Risks								
One year	1.9×10^{-5}	7.1×10^{-7}	8.5×10^{-7}	3.3×10^{-7}	8.6×10^{-8}	4.3×10^{-7}	3.6×10^{-8}	2.4×10^{-7}
1,000 years	2.2×10^{-2}	1.2×10^{-6}	7.3×10^{-6}	2.3×10^{-6}	2.7×10^{-7}	9.3×10^{-9}	5.4×10^{-8}	2.3×10^{-6}
9,000 years	5.2×10^{-2}	2.9×10^{-6}	1.7×10^{-5}	5.4×10^{-6}	4.9×10^{-7}	2.2×10^{-8}	8.9×10^{-8}	5.4×10^{-6}

Note: Values are for the maximally exposed individual the receptor for which may vary between alternatives and time frames. Values also reflect different cover thickness for the various alternatives.

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Long-Term Effectiveness and Permanence (cont.)								
Adequacy and Reliability of Controls	Not applicable as no controls would be implemented.	Use of engineered containment has been demonstrated to be effective and reliable at numerous solid waste and NCP sites.		Removal of a portion of the RIM would increase the overall adequacy and reliability of the alternative. Use of engineered containment has been demonstrated to be effective and reliable at numerous solid waste and NCP sites.			All RIM would be removed and disposed off site so both adequate and reliable.	RIM would be placed in a new engineered cell that met UMTRCA and Subtitle C requirements. Has been utilized successfully at other sites (e.g. Weldon Springs)
Climate Change Impacts								
Potential Impacts of Climate Change on Remedy	Not applicable as no engineered controls would be implemented.	- Increased temperatures or decreased precipitation could damage the vegetative cover or dry out the low-permeability layer included in the landfill cover included as part of all of the alternatives; however, such impacts would be easily identified and are not expected to result in exposure to or release of waste materials. - Increased heavy precipitation could erode the vegetation layer and potentially underlying layers; however, the overall thickness of the cover systems and inclusion of a biointrusion layer in all alternatives except full excavation are expected to prevent exposure of the underlying waste materials. - Flooding is not expected to impact any of the alternatives because the waste materials in Areas 1 and 2 are not located in the floodplain, the area is protected by the Earth City levee and flood control systems, and regrading would include a thick starter berm of soil/rock material along the landfill toe that would isolate the waste materials from flooding.						
Potential Impacts of Extreme Weather Events on Remedy	Not applicable as no engineered controls would be implemented.	Severe weather could result in erosion of the engineered landfill cover over Areas 1 and 2 or the new on-site cell; however, the overall thickness of the cover systems (e.g., 5 ft thick for all of the alternatives except off-site disposal which would be 3 feet thick) should prevent exposure of the waste. Design of UMTRCA cover (all alternatives execpt ROD and off-site disposal) includes upper erosion barrier to protect underlying low permeability layer. UMTRCA cover may include uppermost rock mulch layer to limit erosion. Any damage to landfill cover should be easily identified and repaired using standard landfill operation measures.						
Potential Impacts of a Tornado on Remedy	Not applicable as no engineered controls would be implemented.	Not anticipated to cause any significant impact. Review of impacts of tornados indicated that primary damage is to structures and trees but that grasses were generally unaffected by tornados. May damage above-grade components such as fencing, signage, envionmental and monitoring stations; however, any damage to these would be easily identified and repaired.						

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Long-Term Effectiveness and Permanence (cont.)								
Impacts from a Subsurface Heating Event	Potential for waste consolidation resulting in subsidence and potential damage to the cover which could result in a temporary, localized increase in radon emissions; however, the total emissions from the Site during such an event are projected to remain below the UMTRCA standard and radon NESHAP. If elevated temperatures were to occur in OU-1, specific engineering controls, if implemented appropriately, are predicted to manage potential effects such that unacceptable risks are expected to be avoided. Also potential for such an event will decline over time lessening the potential for impacts.						All RIM would be removed and disposed off-site so no impacts are expected from a reaction in the landfill.	RIM would be placed in a new engineered cell separate from the rest of the landfill but could still be subject to a reaction.
Thermal Isolation Barrier (IB) Interaction	Not applicable as no engineered controls would be implemented.	Installation of an IB is not expected to impact the performance of any of the alternatives; however, implementation of any of the excavation alternatives could impact the integrity of or potentially destroy an existing IB or installation of an IB after remedy implementation could damage or destroy portions of the engineered cover.					No impact as an isolation barrier would not be needed if one of these alternatives were implemented.	
		The engineering controls needed and associated with the installation of an IB system put in place subsequent to construction of any of the remedial alternatives are not expected to impact the over-all performance of the remedy.						
						Increased separation between RIM and ground surface would reduce radon emissions.		
Environmental Justice	A screening level analysis did not identify any environmental justice concerns relative to the Site. EPA identified a need for more traditional communication methods to inform residents of the Terrisan Reste mobile home park, which is addressed in the Community Involvement Plan.							
Reduction of Toxicity, Mobility or Volume through Treatment								
Reduction of Toxicity, Mobility or Volume through Treatment	Not applicable as no actions would be implemented.	None of the alternatives include treatment technologies that would reduce the toxicity, mobility or volume of waste material through treatment as a primary component. Treatment technologies are generally not applicable to the Site wastes due to the nature and overall large volume of wastes, and the fact that radionuclides are naturally occurring elements that cannot be modified, neutralized, or destroyed by treatment.						
		All of the alternatives include off-site treatment and disposal of hazardous wastes in accordance with the RCRA regulations if any such wastes are encountered during implementation of the remedy.						

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Reduction of Toxicity, Mobility or Volume through Treatment (cont.)								
				Physical separation using screens and/or radiological segregation using gamma emissions potentially may be effective for reducing the volume of waste to be disposed off-site for the 1,000 pCi/g partial excavation alternative due to the expected higher gamma levels associated with this criteria but is not expected to be effective for the other alternatives due to the lower excavation criteria and the expected resultant lower gamma levels associated with such material.				
Short-Term Effectiveness								
Protection of the Community During Remedial Actions								
Potential radiological or chemical exposures	Not applicable as no engineered controls would be implemented.	None of the alternatives are expected to pose unacceptable risks to the general public during remedy implementation. As projected incremental additional cancer risks are within or below EPA's accepted risk range and hazard indices are less than 1.						
Carcinogenic risk		1.9×10^{-7}	1.9×10^{-7}	9.7×10^{-7}	2.5×10^{-6}	3.8×10^{-7}	5.5×10^{-6}	8.1×10^{-5}
Hazard indices		0.0003	0.0003	0.0006	0.0006	0.0006	0.0006	0.028
Waste excavation volumes (yards)								
Total (RIM+MSW)	Not applicable as no waste would be moved.	112,000	112,000	274,000	684,000	105,000	1,821,000	1,821,000
RIM only		15,750	15,750	83,900	38,700	15,580	309,600	309,600
Projected incidence of transportation accidents	Not applicable as no actions would be taken.	0.6	0.6	7.5	16.1	2.4	41.4	1.4
Greenhouse gas emissions (tons)	Not applicable as no actions would be taken.	19,000	19,000	36,000	48,000	38,000	90,000	80,000
Environmental Justice	A screening level analysis did not identify any environmental justice concerns relative to the Site. EPA identified a need for more traditional communication methods to inform residents of the Terrisan Reste mobile home park which is addressed in the Community Involvement Plan.							
Protection of Workers during Remedial Actions								
Protection of workers during remedial actions	Not applicable as no actions would be taken	Remediation workers not expected to be exposed to gamma radiation resulting in potential cancer risks above EPA accepted risk range but could be exposed to non-carcinogenic risks with a hazard index greater than 1. Not expected to result in radiation doses (TEDEs) greater than the 5,000 mrem/yr limit established by OSHA and NRC. (Values shown in red below exceed acceptable levels/standards.)		Remediation workers potentially could be exposed to gamma radiation resulting in potential cancer risks above the upper bound of EPA's target risk range of 10^{-4} to 10^{-6}, to non-carcinogenic risks with a hazard index greater than 1, and to radiation doses (TEDEs) greater than the 5,000 mrem/yr limit established by OSHA and NRC. (Values shown in red below exceed acceptable levels/standards.)		Remediation workers not expected to be exposed to cancer risks above EPA accepted risk range or TEDEs above standards but could be exposed to non-carcinogenic risks.	Remediation workers potentially could be exposed to gamma radiation resulting in potential cancer risks above the upper bound of EPA's target risk range of 10^{-4} to 10^{-6}, to non-carcinogenic risks with a hazard index greater than 1. Not expected to result in TEDEs greater than the 5,000 mrem/yr. (Values shown in red below exceed acceptable levels/standards.)	

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Short-Term Effectiveness (cont.)								
Protection of Workers during Remedial Actions (cont.)								
Carcinogenic Risks	Not applicable	2.8×10^{-5}	2.8×10^{-5}	2.2×10^{-3}	1.1×10^{-2}	5.0×10^{-5}	3.7×10^{-3}	3.7×10^{-3}
TEDEs (mrem/yr)	Not applicable	60.2	60.2	6,940	13,400	108	1,820	1,820
Hazard indices	Not applicable	27.0	27.0	27.0	27.2	27.1	27.0	26.9
Industrial accident incidence	Not applicable	5.1	5.6	11.1	15.5	8.7	25.5	25.7
Time until RAOs are Achieved								
Time until RAOs are achieved	No Action will not achieve RAOs.	RAOs would be achieved upon completion of construction. No potential threats would remain after implementation of any of the alternatives.						
Construction completion (years) including design	Not applicable as no action would be taken.	2.8	2.8	5	8.3	4.1	14.6	14.8
Environmental Impacts								
Environmental impacts	Not applicable as no action would be taken.	No measurable long-term impacts to plants or animals in surrounding ecosystems are expected to occur from any of the alternatives.						
Implementability								
Technical feasibility	Not applicable as no actions would be taken	All of the alternatives are constructible.						
Reliability of the technologies	Not applicable as no engineered controls would be implemented.	Engineered landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable.						
				Excavation and offsite disposal is a common and reliable technology.				Construction of an on-site cell is a standard landfill technology and has been done at other sites (e.g. Weldon Springs)
		Stormwater controls and environmental monitoring are commonly used and demonstrated reliable techniques.						
				Per the FAA, the reliability of most bird mitigation technologies are questionable. There is uncertainty regarding the actual volumes of RIM that would need to be removed and the volume of daily cover that would be added, resulting in uncertainty in the actual disposal				

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Implementability (cont.)								
Reliability of technologies (cont.)	Not applicable as no engineered controls would be implemented.	Engineered landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable.						
				The ability to remove deeper occurrences of RIM adjacent to other (OU-2) solid waste units is a technical difficulty with this alternative and might result in schedule delays.				
				Reductions in the number of IM containers or rail cars or the frequency of exchange of full and empty containers or rail cars could impact the schedule for these alternatives.				
				Excavation of RIM would also present significant implementability concerns associated with the excavation and handling of contaminated materials; management of fugitive dust and potential odors; mitigation of bird hazards; management and treatment of stormwater exposed to RIM during excavation; management of RIM that fails the paint filter liquids test; and the identification, segregation, and disposal offsite of any hazardous wastes or regulated asbestos containing materials that may be encountered during RIM excavation.				
Ease of undertaking additional remedial actions	Not applicable as no actions would be taken under this alternative.	The only future actions anticipated to be required for Areas 1 and 2 for all of the alternatives are ongoing inspections, monitoring, maintenance and, if needed, repair of the final landfill covers. Each of these future actions can be easily implemented.						
								Long-term inspection, maintenace and repairs may be required for an on-site cell but should not pose a problem as these are standard actions for landfills.
		All of the alternatives include a provision for the construction of a contingent landfill gas control system in the event that the monitoring of subsurface occurrences of landfill gas or radon indicates a need for such a system. Implementation of such a system is expected to be simple and straightforward and should not pose any difficulties in implementation.						
Monitoring considerations	No monitoring would be performed.	Performance of all the alternatives can be monitored and potential risk of exposure in the event of failure of any of the alternatives would be low.						

Table 7-1: Summary of Comparative Analysis of Alternatives

<table>
<tr><th>Evaluation Criteria</th><th>No Action Alternative</th><th>ROD-Selected Remedy</th><th>UMTRCA Cover Alternative</th><th>Partial Excavation to 52.9 pCi/g</th><th>Partial Excavation to 1,000 pCi/g</th><th>Risk-Based Partial Excavation</th><th>Full Excavation of RIM with Off-Site Disposal</th><th>Full Excavation of RIM with On-Site Disposal</th></tr>
<tr><td colspan="9">Implementability (cont.)</td></tr>
<tr><td rowspan="2">Administrative feasibility</td><td rowspan="2">Not applicable as no engineered controls or additional institutional controls would be implemented.</td><td colspan="7">All of the alternatives could require:
- coordination and permitting with MSD for disposal of leachate during construction;
- access to Crossroads Property for investigation/removal of soil;
- coordination with Earth City Flood Control District for design and operation of stormwater systems; and
- preparation and approval of a traffic control plan for St. Charles Rock Road.</td></tr>
<tr><td colspan="2"></td><td colspan="4">Alternatives that include off-site disposal would also require
- Routine approval and verification of current acceptability for off-site disposal from EPA.
- Use of the Clean Harbors facility for disposal would require approval by the Rocky Mountain Low Level Radioactive Waste Compact.</td><td></td></tr>
<tr><td>Availability of Specialized Services and Materials</td><td>Not applicable as no engineered controls would be implemented.</td><td colspan="7">Specialized personnel, equipment, and materials are readily available to implement the cover systems, institutional controls, and monitoring components of the remedial alternatives. The implementability and potential costs for all of the remedial alternatives will be influenced by the availability and location of clean fill materials and/or offsite soil borrow sources at the time a remedy is implemented.</td></tr>
<tr><td rowspan="2">Availability of Materials, Equipment, and Personnel</td><td rowspan="2">Not applicable as no engineered controls would be implemented.</td><td colspan="7">Preliminary discussions with MSD indicate that it is willing and has sufficient capacity to accept leachate or stormwater that may be generated during construction. Alternatively, off-site disposal facilities are available to accept these materials if necessary</td></tr>
<tr><td colspan="2"></td><td colspan="4">- Materials, equipment and personnel required for excavation of the RIM and transport of RIM to an offsite disposal facility are readily available.
- Only a limited number of offsite disposal facilities exist that can accept excavated RIM from the West Lake Landfill. It is difficult to evaluate which disposal facilities that can currently accept wastes from the West Lake Landfill may be available in the future, or what their respective future capacities or waste acceptance criteria may be.
- The volumetric rate of acceptance for all offsite disposal facilities would also be a function of the availability of IM containers and the number of railcars that could be loaded at or near the Site, as well as the number of railcars that could be unloaded at or near the disposal facility.</td><td></td></tr>
<tr><td>Availability of Technologies</td><td>Not applicable as no engineered controls would be implemented.</td><td colspan="2">Technologies for this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.</td><td colspan="5">Technologies included as part of these alternatives are generally available and sufficiently demonstrated. No prospective technologies are anticipated. Use of physical separation techniques could, if effective, reduce the overall cost of these alternatives; however, the potential effectiveness, implementability, risks and cost of such techniques cannot be determined from available information. An on-site pilot-scale test would be needed make such determinations.</td></tr>
</table>

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action Alternative	ROD-Selected Remedy	UMTRCA Cover Alternative	Partial Excavation to 52.9 pCi/g	Partial Excavation to 1,000 pCi/g	Risk-Based Partial Excavation	Full Excavation of RIM with Off-Site Disposal	Full Excavation of RIM with On-Site Disposal
Cost								
Capital cost	$0	$75,000,000	$96,000,000	$274,000,000	$379,000,000	$187,000,000	$695,000,000	$591,000,000
O&M costs	$36,000 every 5 years	$176,000 - $389,000	$176,000 - $389,000	$176,000 - $389,000	$176,000 - $389,000	$176,000 - $389,000	$176,000 - $340,000	$182,100 - $444,100
Present Worth Costs								
30 years								
(i=7%)		$71,000,000	$90,000,000	$236,000,000	$287,000,000	$165,000,000	$455,000,000	$391,000,000
(i=0.7%)		$79,000,000	$100,000,000	$275,000,000	$372,000,000	$189,000,000	$667,000,000	$568,000,000
Total (non-discounted)		$80,000,000	$102,000,000	$280,000,000	$384,000,000	$192,000,000	$699,000,000	$596,000,000
200 years								
(i=7%)		$71,000,000	$90,000,000	$237,000,000	$288,000,000	$165,000,000	Not applicable	$392,000,000
(i=0.7%)		$95,000,000	$116,000,000	$290,000,000	$388,000,000	$205,000,000	Not applicable	$585,000,000
Total (non-discounted)		$113,000,000	$134,000,000	$312,000,000	$417,000,000	$225,000,000	Not applicable	$631,000,000
1,000 years								
(i=7%)		$71,000,000	$90,000,000	$237,000,000	$288,000,000	$165,000,000	Not applicable	$392,000,000
(i=0.7%)		$101,000,000	$123,000,000	$297,000,000	$394,000,000	$211,000,000	Not applicable	$592,000,000
Total (non-discounted)		$265,000,000	$287,000,000	$464,000,000	$569,000,000	$377,000,000	Not applicable	$788,000,000

Table 7-2: Summary of Short-Term and Long-Term Risks for Each Remedial Alternative

	Category of Hazard or Risk	ROD-Selected Remedy	UMTRCA Remedy[f]	Full Excavation w/ Off-Site Disposal	Full Excavation w/ On-Site Cell	Partial Excavation to 52.9 pCi/g Alternative	Partial Excavation to 1,000 pCi/g Alternative	Risk-Based Partial Excavation Alternative
Short-term	Projected Incidence of Transportation Accidents [a]	6.02E-01	6.05E-01	4.14E+01	1.38E+00	7.51E+00	1.61E+01	2.39E+00
	Projected Incidence of Industrial Accidents [b]	5.12E+00	5.64E+00	2.55E+01	2.57E+01	1.11E+01	1.55E+01	8.72E+00
	Carcinogenic Risk to Reasonably Maximally-Exposed Remediation Tech during Construction [c]	2.84E-05	2.84E-05	3.67E-03	3.67E-03	2.20E-03	1.06E-02	4.98E-05
	Hazard Index for Reasonably Maximally-Exposed Remediation Tech during Construction	2.70E+01	2.70E+01	2.70E+01	2.69E+01	2.71E+01	2.72E+01	2.71E+01
	Carcinogenic Risk to Reasonably Maximally-Exposed Off-property Resident during Construction	1.86E-07	1.86E-07	5.49E-06	8.10E-05	9.66E-07	2.47E-06	3.75E-07
	Hazard Index for Reasonably Maximally-Exposed Off-property Resident during Construction	3.10E-04	3.10E-04	6.21E-04	2.78E-02	6.21E-04	6.21E-04	6.21E-04
	Dose (TEDE) to Remediation Tech (mrem/y)	6.02E+01	6.02E+01	1.82E+03	1.82E+03	6.94E+03	1.34E+04	1.08E+02
Long-term	Carcinogenic Risk to Reasonably Maximally-Exposed Individual after 1 Year Post-Construction	7.06E-07	8.53E-07	3.63E-08	2.45E-07	3.29E-07	8.60E-08	4.30E-07
	Maximally-Exposed Individual after 1 year Post-Construction (mrem/y)	3.22E-03	3.22E-03	2.97E-03	1.11E-03	1.68E-03	4.28E-04	2.87E-03
	Carcinogenic Risk to Reasonably Maximally-Exposed Individual after 1,000 Years Post-	1.25E-06	7.28E-06	5.38E-08	2.27E-06	2.34E-06	2.72E-07	9.33E-09
	Dose (TEDE) to Reasonably Maximally-Exposed Individual after 1,000 years Post-Construction (mrem/y)	9.51E-03	9.51E-03	3.37E-03	4.07E-03	5.80E-03	7.34E-04	1.05E-02
	Peak Risk at 9000 Years	2.92E-06	1.70E-05	8.90E-08	5.35E-06	5.43E-06	4.91E-07	2.17E-08

FIGURES

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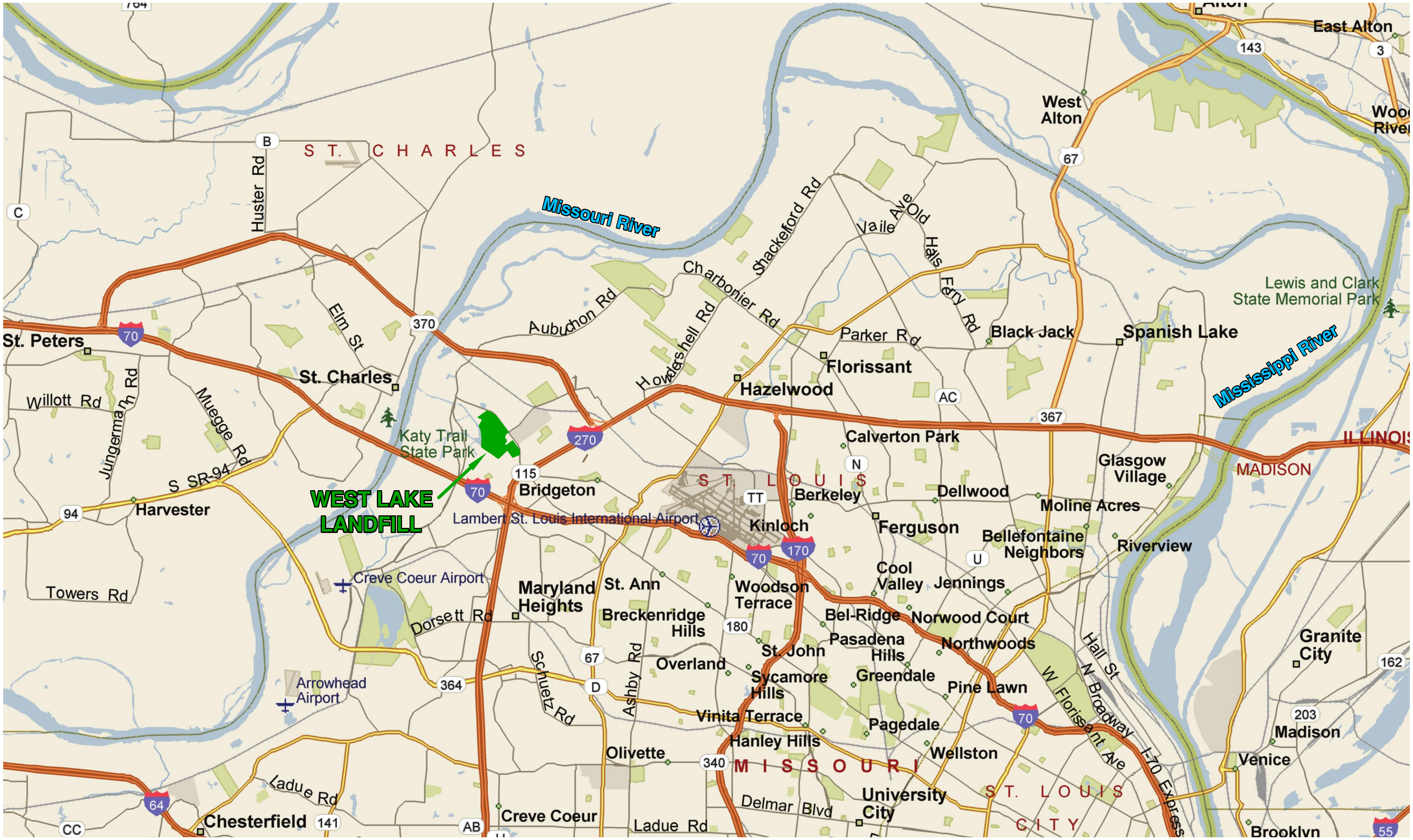

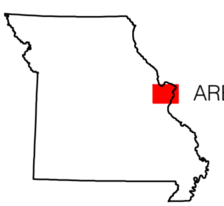

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Figure 2-1

Site Vicinity Map

West Lake Landfill OU-1 RI Addendum

EMSI Engineering Management Support, Inc.

Source: USGS Aerial Photography

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SCALE IN FEET

Figure 2-2

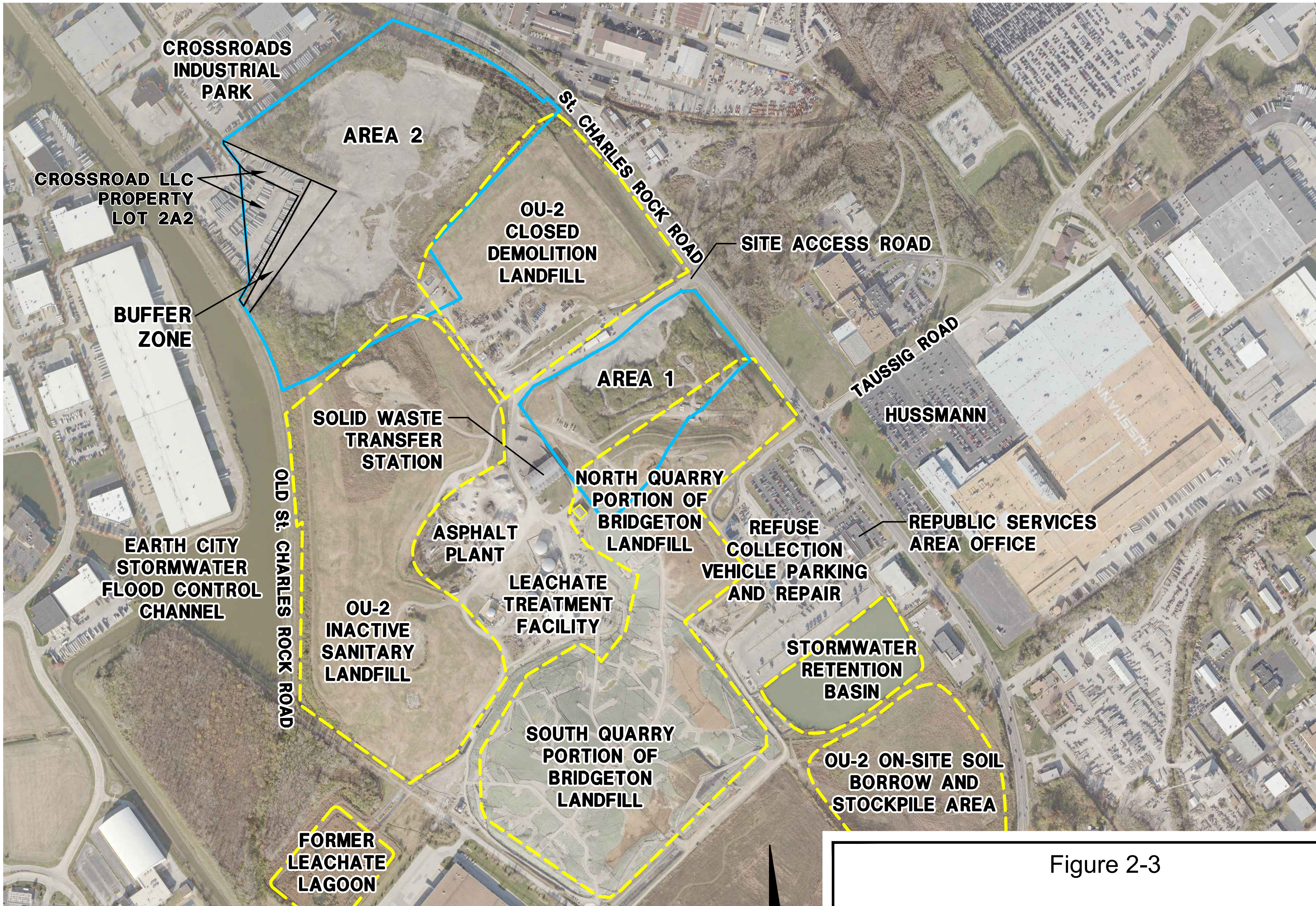
Site Location Map

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-2-Site Location Map.dwg 12/27/17

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-3-Landfill Operations.dwg 8/7/2017



Source: Cooper Aerial Surveys Company (December 2, 2016)

Legend

Operable Unit-1 Areas

Operable Unit-2 Areas

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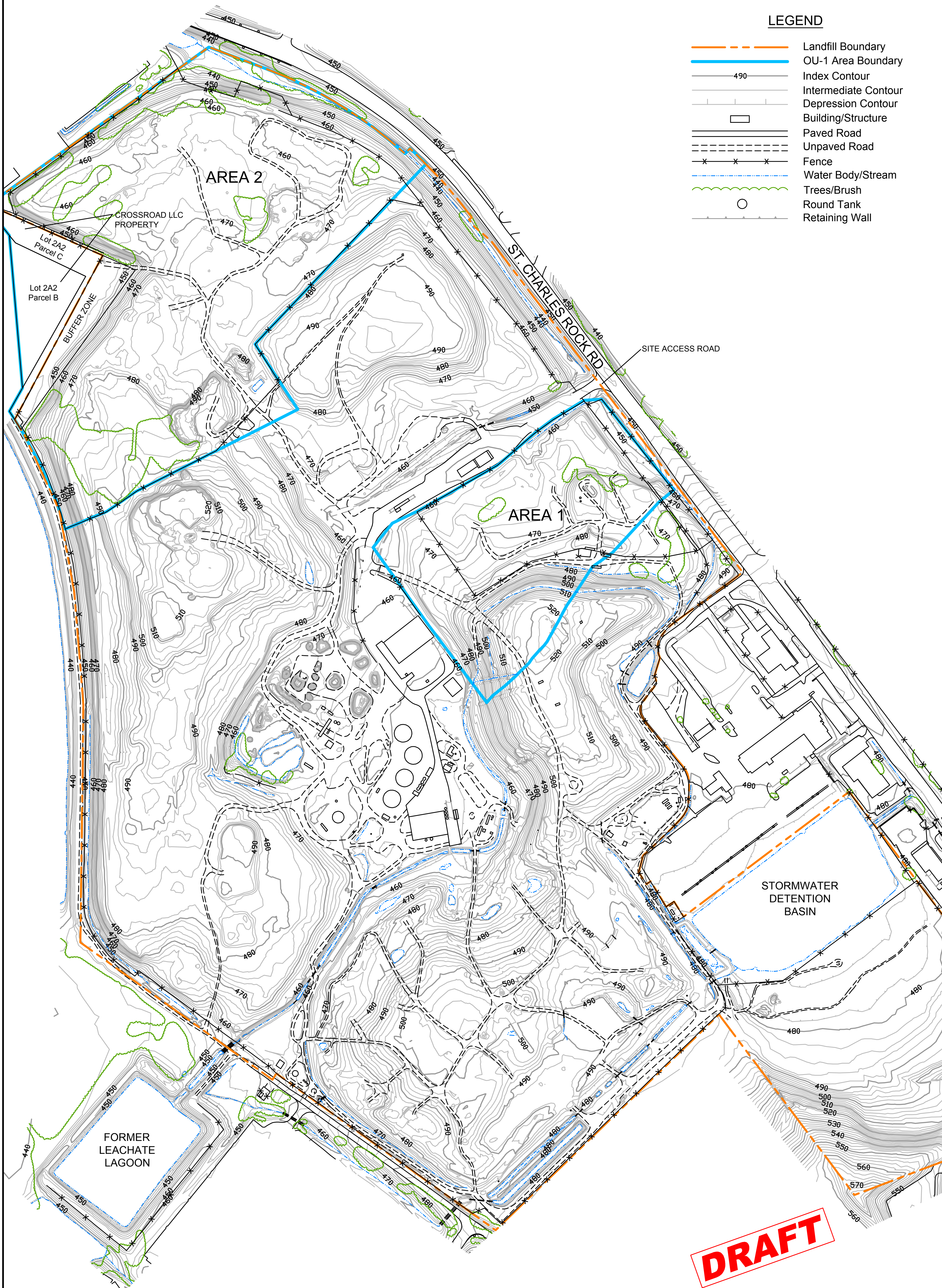
Figure 2-3

Areas of Landfill Operations

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-4-Site-Topo.dwg 7/7/17



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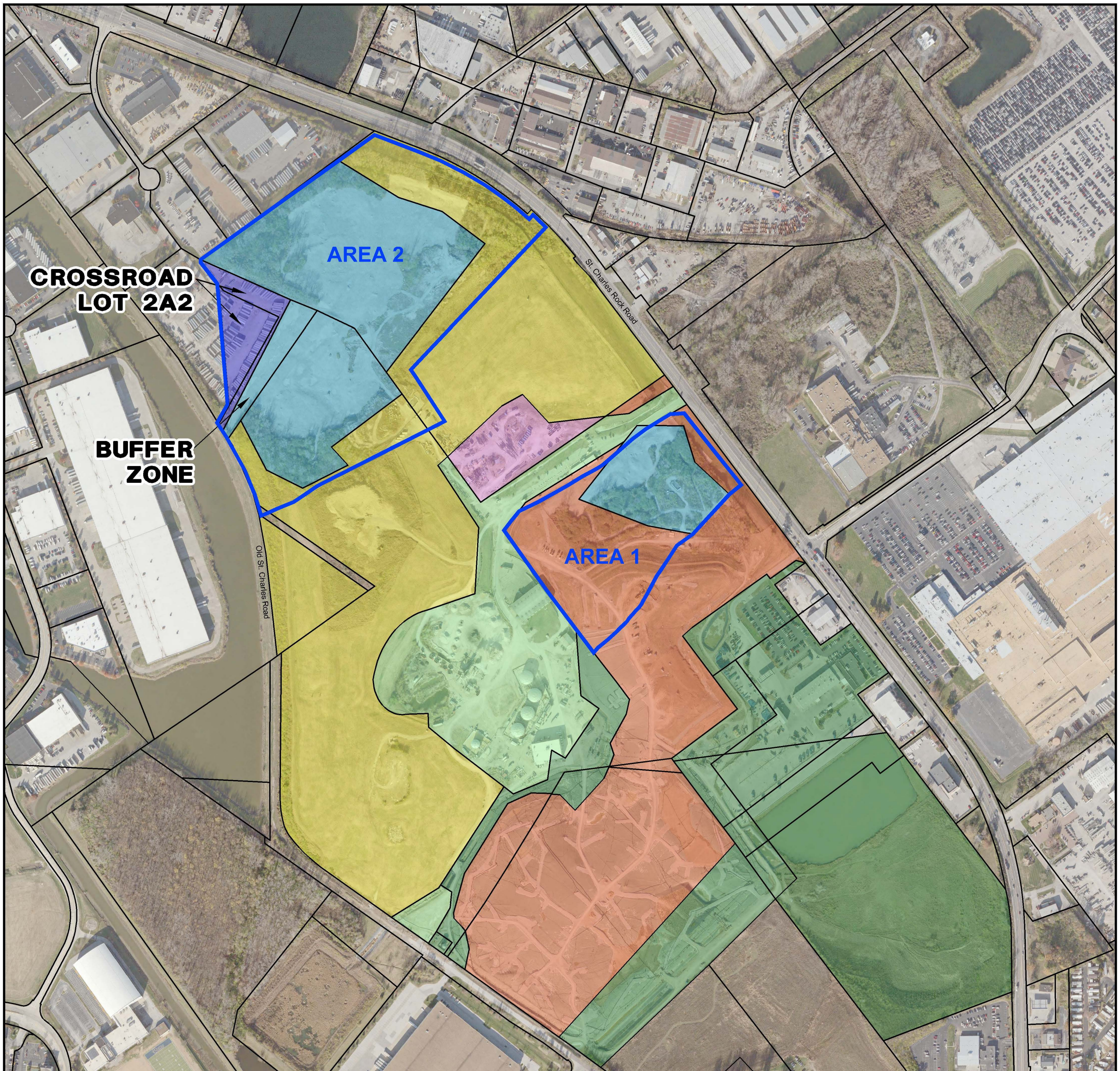
SCALE IN FEET

Notes:
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 2-4
Site Topography

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Laidlaw Waste Systems (Bridgeton) Incorporated
- West Lake Quarry and Material Company
- Rock Road Industries, Inc.
- West Lake Landfill, Inc.
- West Lake Landfill, Inc. et al.
- Bridgeton Transfer Station LLC
- Crossroad Properties LLC
- OU-1 Area Boundary

DRAFT

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SCALE IN FEET

Notes:
- Parcels from Saint Louis County Missouri, GIS Department
- Aerial provided by Cooper Aerial Surveys Company (December 2, 2016)

Figure 2-5

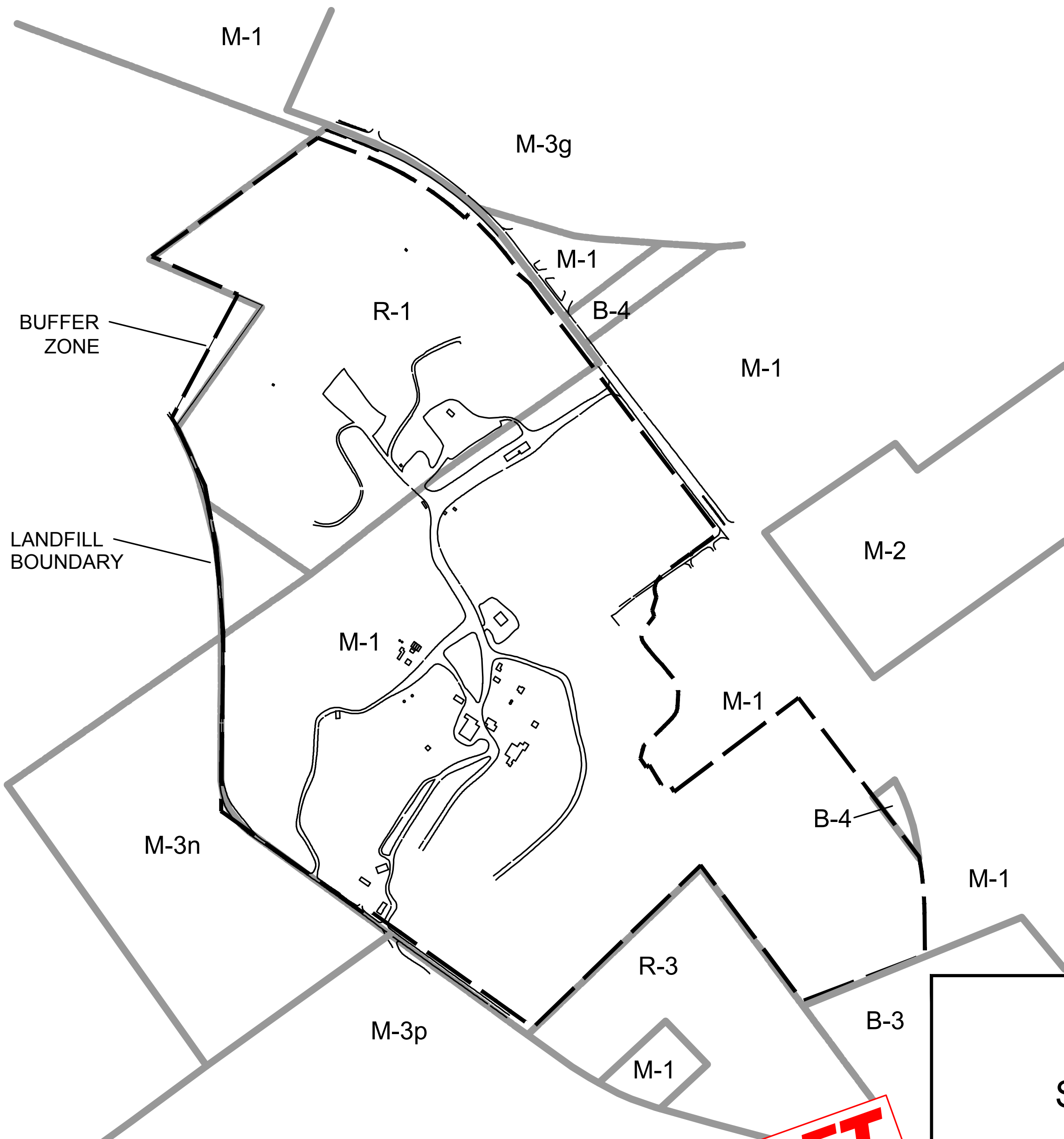
Landfill Property Ownership

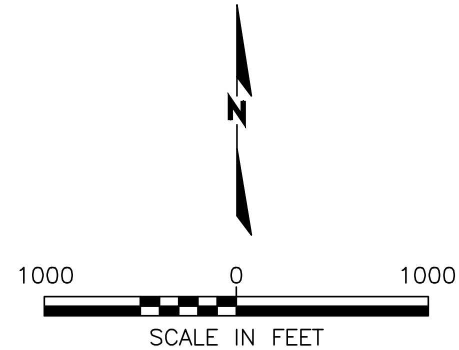
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\Fig-2-5-Site-Ownership.dwg 8/2/17

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-6-Zoning.dwg 8/23/17





LEGEND

B-3	Travel / Entertainment services district
B-4	General commercial district
M-1	Manufacturing district, limited
M-2	Manufacturing district
M-3	Planned manufacturing district
M-3g	Planned manufacturing district Northwest Industrial Park
M-3n	Planned manufacturing district Property west of Foerster Road
M-3p	Planned manufacturing district Westlake quarry tract
R-1	Single family dwelling district
R-3	Single family dwelling district

Source: City of Bridgeton Zoning Map (amended August, 2017)

NOTE:

Deed restrictions were recorded in June, 1997 against the entire landfill area prohibiting residential use and groundwater use. A supplemental deed restriction was recorded in January, 1998 against Areas 1 and 2 prohibiting the placement of buildings and restricting the installation of underground utilities, pipes, and/or excavation.

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Figure 2-6

Landfill and Surrounding Area Zoning

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

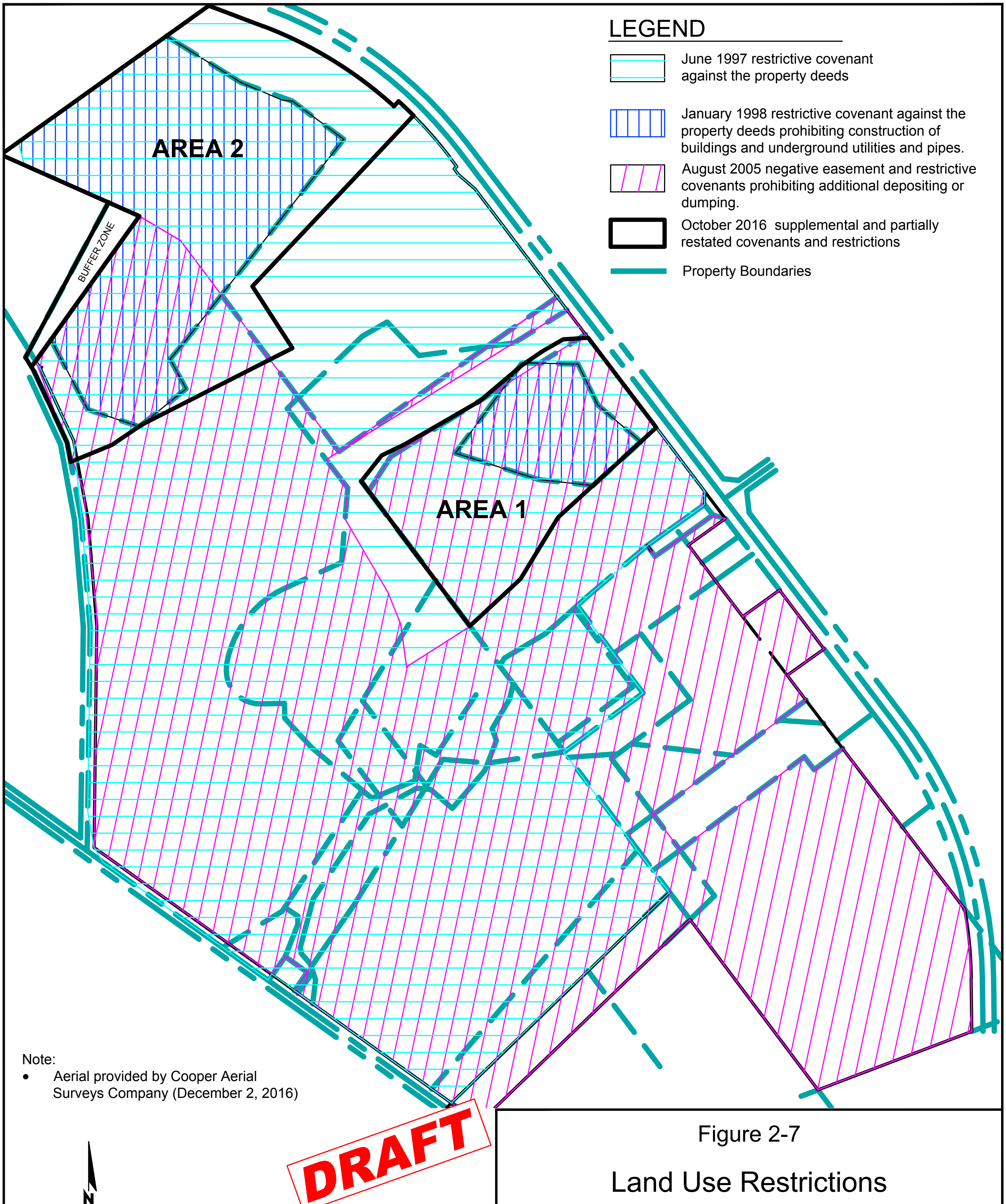

Figure 2-7

Land Use Restrictions

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG2-8-Airport-Setbacks.dwg 7/7/17

Source: Bing Maps

Legend

West Flow Radar Tracks (From Lambert-St Louis International Airport 14 CFR Part 150 Study)

East Flow Radar Tracks (To Lambert-St Louis International Airport 14 CFR Part 150 Study)

Operable Unit-1 Areas

Landfill boundary

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SCALE IN FEET

Figure 2-8

Setback From Airport Runway

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAS)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary

0.2% annual chance floodplain boundary

Floodway boundary

Zone D boundary

Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.

CBRS and OPA boundary

International, State, or County boundary

Corporate, Extraterritorial Jurisdiction, or Urban Growth boundary

Area Not Included boundary

Military Reservation, Native American Lands boundary

513 — Base Flood Elevation line and value; elevation in feet*

(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

(A)—(A) Cross section line

(23)—(23) Transect line

87°07'45", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)

4276000mE — 1000-meter Universal Transverse Mercator grid values, zone 15

600000 FT — 5000-foot grid ticks: Missouri State Plane coordinate system, east zone (FIPSZONE 2401), Transverse Mercator projection

DX5510 × — Bench mark (see explanation in Notes to Users section of this FIRM panel)

• M1.5 — River Mile

Aqueduct, Culvert, Flume, Penstock, or Storm Sewer

Road or Railroad Bridge

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
AUGUST 2, 1995

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

February 4, 2015 – to update corporate limits, to change Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to change zone designations, to add roads and road names, to incorporate previously issued Letters of Map Revision, to reflect updated topographic information.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

NFIP — NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0039K

FIRM
FLOOD INSURANCE RATE MAP

ST. LOUIS COUNTY, MISSOURI AND INCORPORATED AREAS

PANEL 39 OF 445
(SEE LOCATOR DIAGRAM OR MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

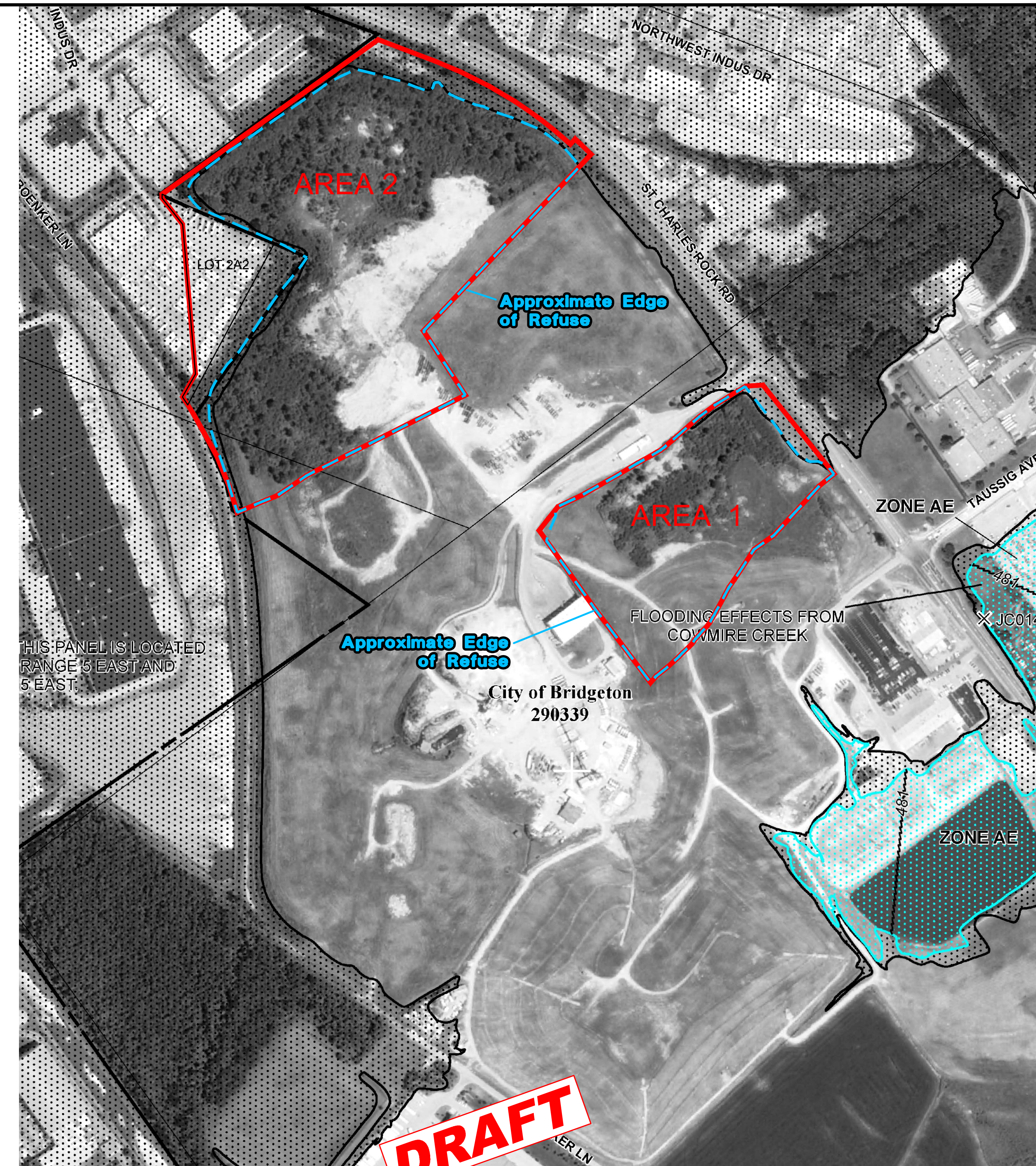
COMMUNITY	NUMBER	PANEL	SUFFIX
BRIDGETON, CITY OF	290339	0039	K
CHAMP, VILLAGE OF	290909	0039	K
MARYLAND HEIGHTS, CITY OF	290889	0039	K
ST. LOUIS COUNTY	290327	0039	K

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 29189C0039K

MAP REVISED FEBRUARY 4, 2015

Federal Emergency Management Agency



Source: FIRM Map 29189C0039K

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SCALE IN FEET

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Figure 2-9
FEMA FIRM Map
City of Bridgeton Area

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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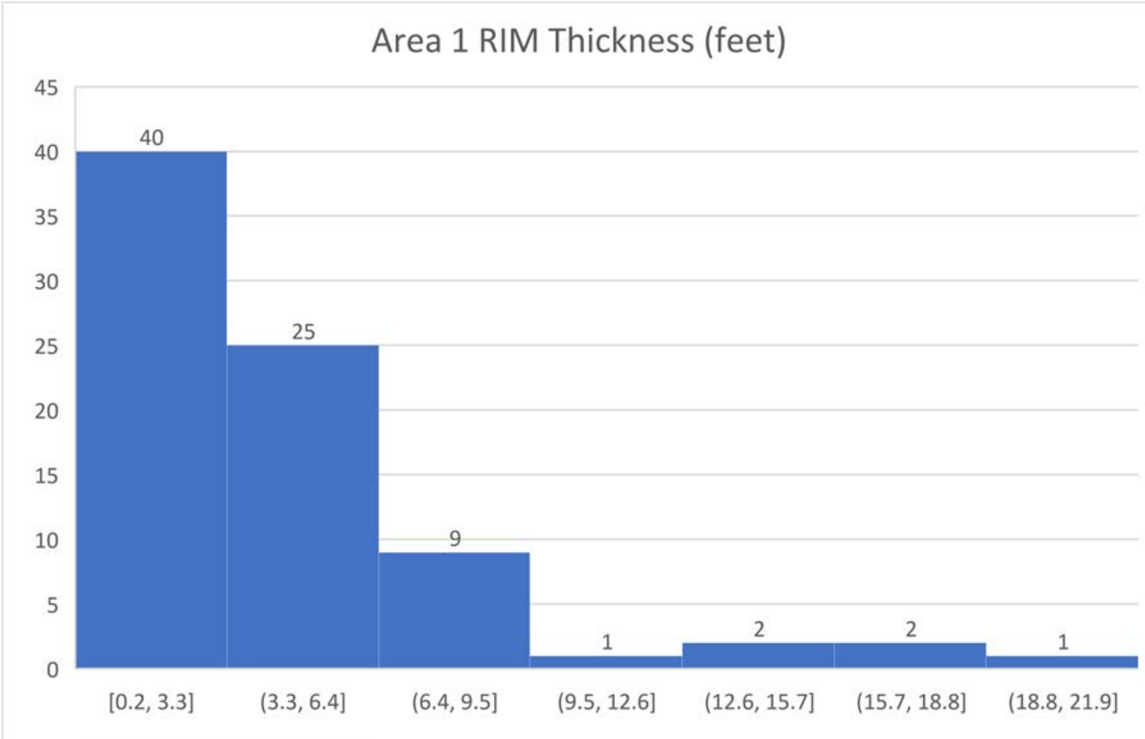


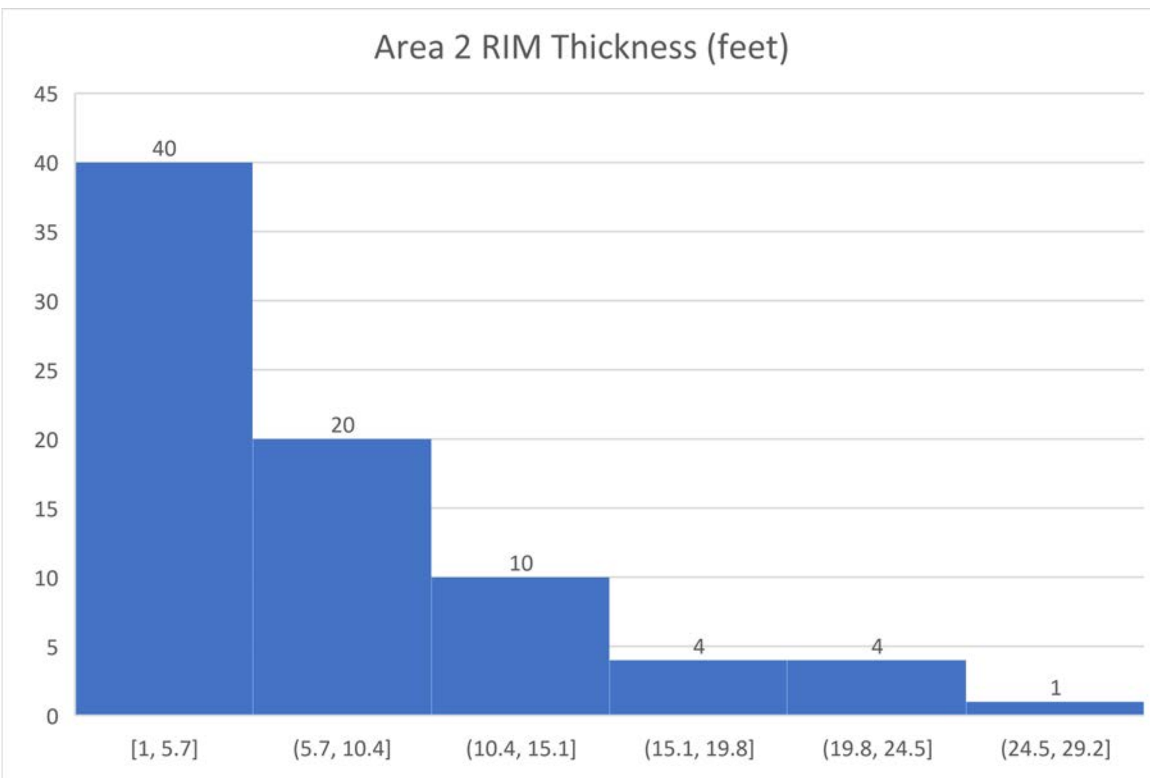
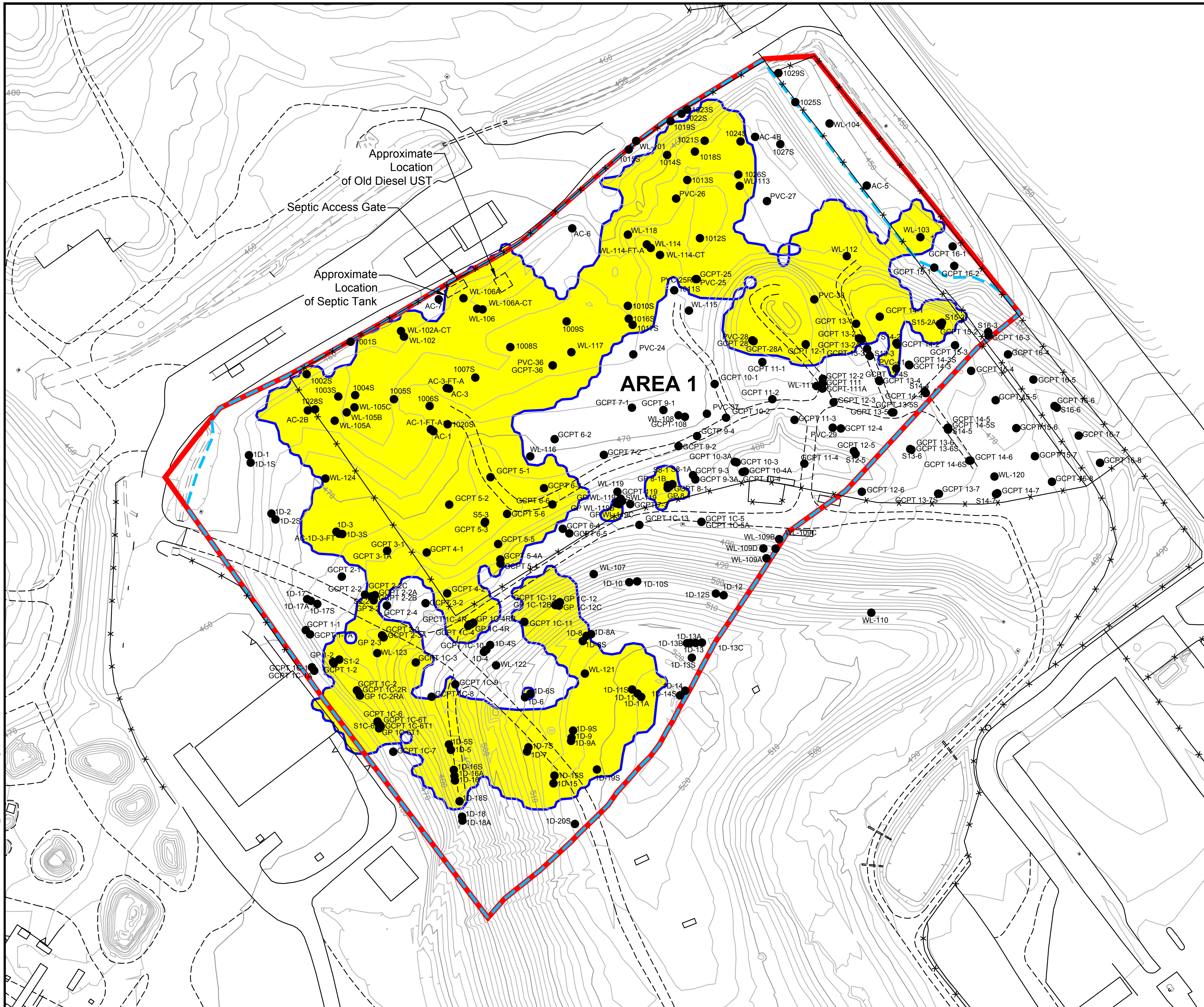


Figure 2-10

Historgrams of RIM Thickness
Areas 1 and 2

West Lake Landfill Superfund Site

EMSI Engineering Management Support, Inc.



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LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- Geostatistical-Based Estimate of RIM Extent
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

Notes:
- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

N

150 0 150

SCALE IN FEET

Figure 2-11
Approximate Extent of RIM
Area 1

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-11_2-12-Extent-RIM.dwg 12/11/17

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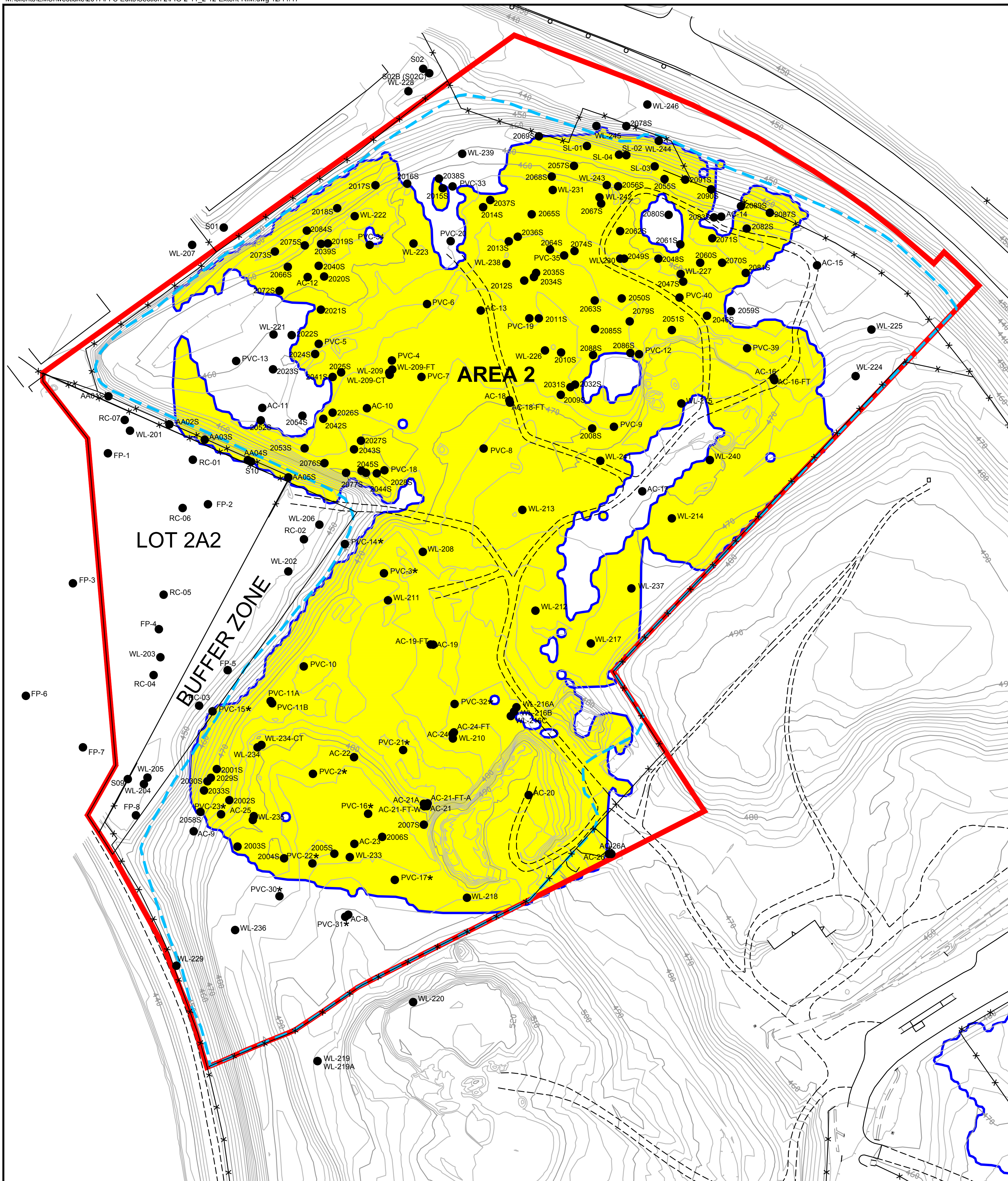


LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- * Location Approximate-No Survey Data Available
- Geostatistical-Based Estimate of RIM Extent
- 490 Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

DRAFT

200 0 200
SCALE IN FEET

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 2-12

Approximate Extent of RIM Area 2

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

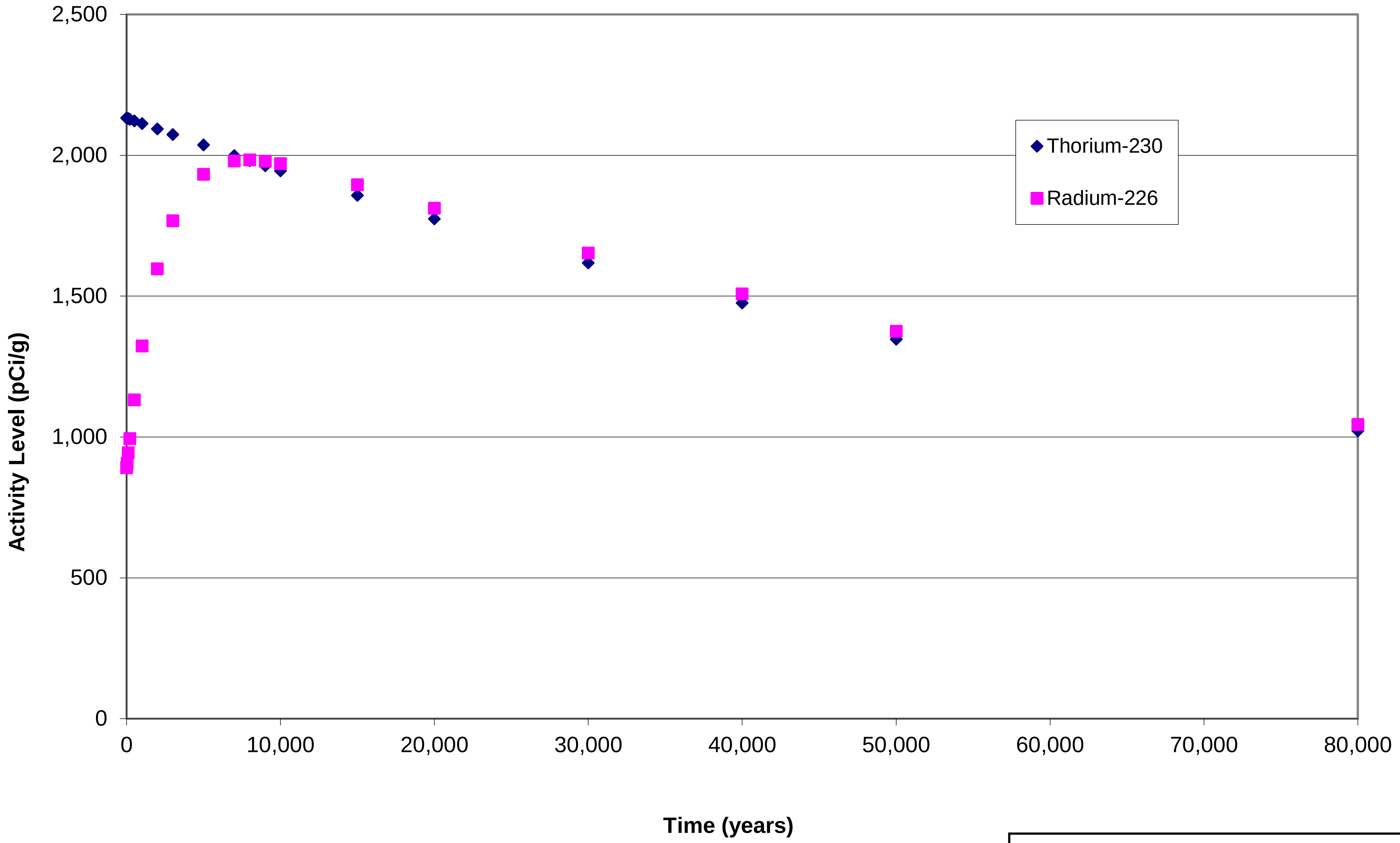


Figure 2-13
Thorium-230 Decay and Radium-226 Ingrowth Over Time
Area 1

Final Feasibility Study

EMSI Engineering Management Support, Inc.

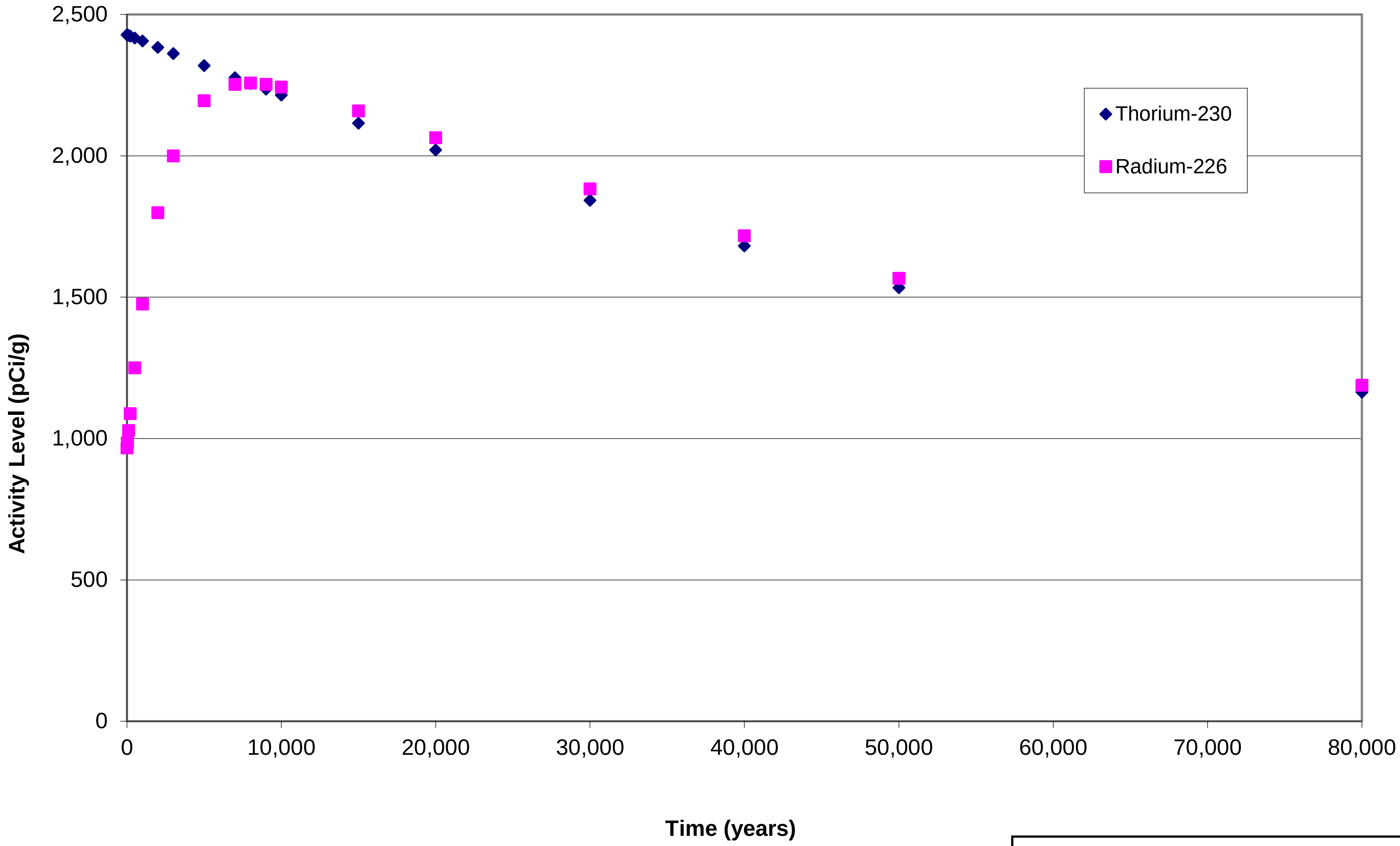


Figure 2-14
Thorium-230 Decay and Radium-226 Ingrowth Over Time
Area 2

Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-15-Buffer-Zone_Crossroad.dwg 12/27/17

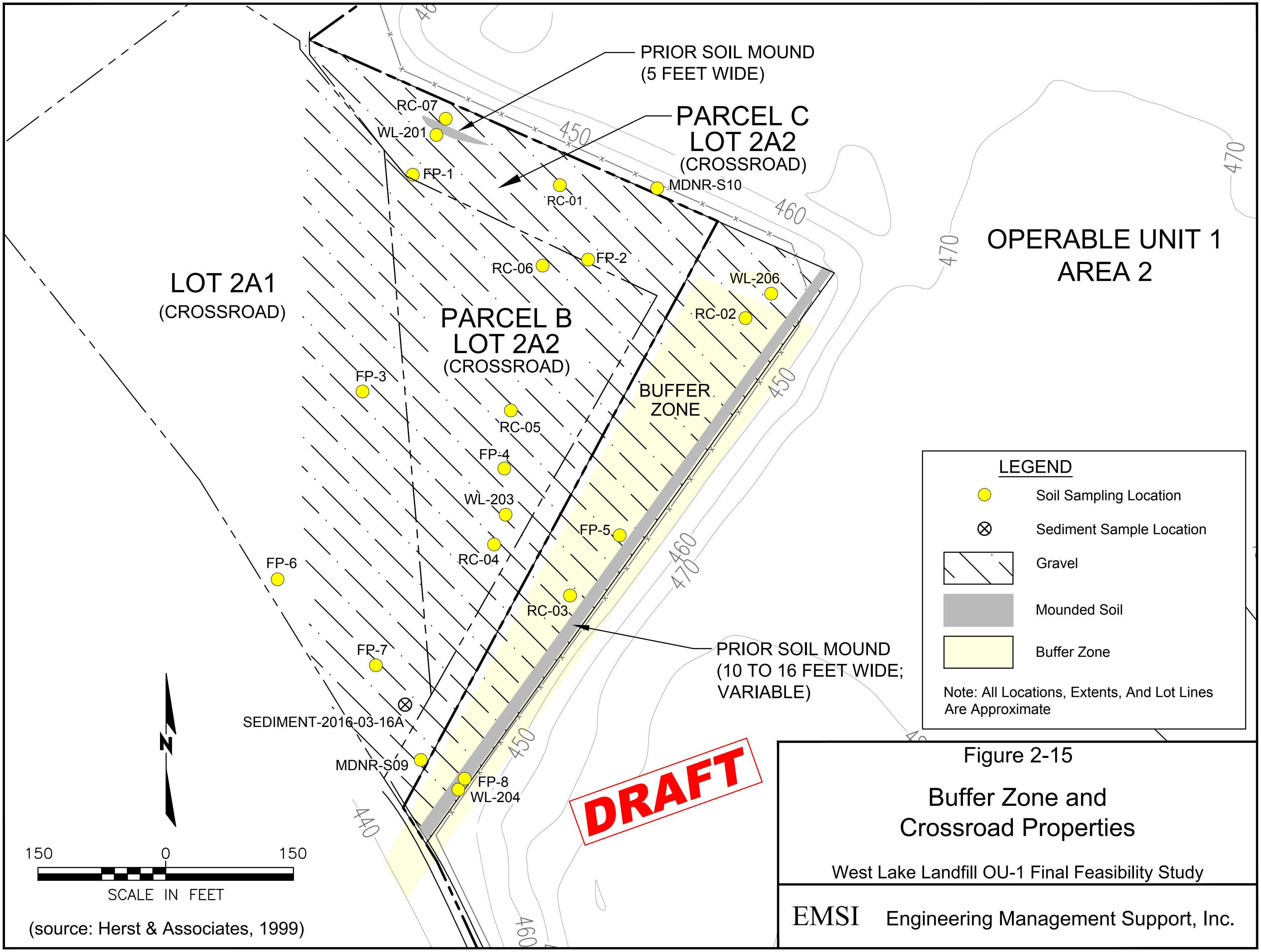


Figure 2-15

Buffer Zone and Crossroad Properties

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-16-Air-Mon.dwg 8/7/17

Source: Cooper Aerial Surveys Company (December 2, 2016)

Legend

OU-1 Area Boundary

A-1 Environmental Monitoring Station

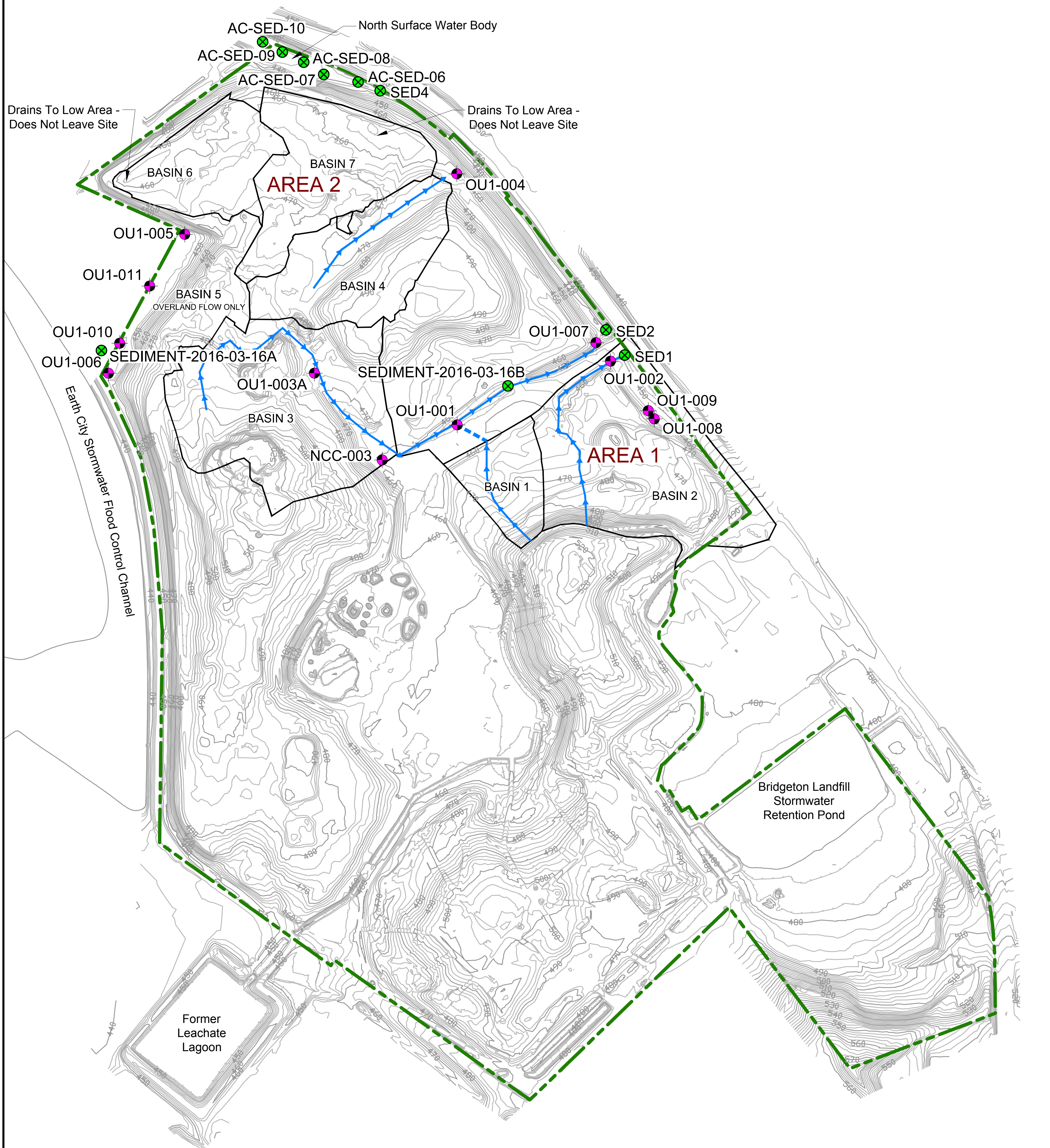
MET Meteorological Station

Figure 2-16

Air Quality Monitoring Stations for Post ROD Baseline Monitoring

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- Watershed Catchment Area
- Flow Path
- Culvert
- Stormwater Sampling Point
- Sediment Sample Location
- 490 Index Contour
- Intermediate Contour

DRAFT

Notes:

- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

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SCALE IN FEET

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Figure 2-17
Stormwater and Sediment Sampling Locations

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-18-Surf-Drainage.dwg 8/25/17

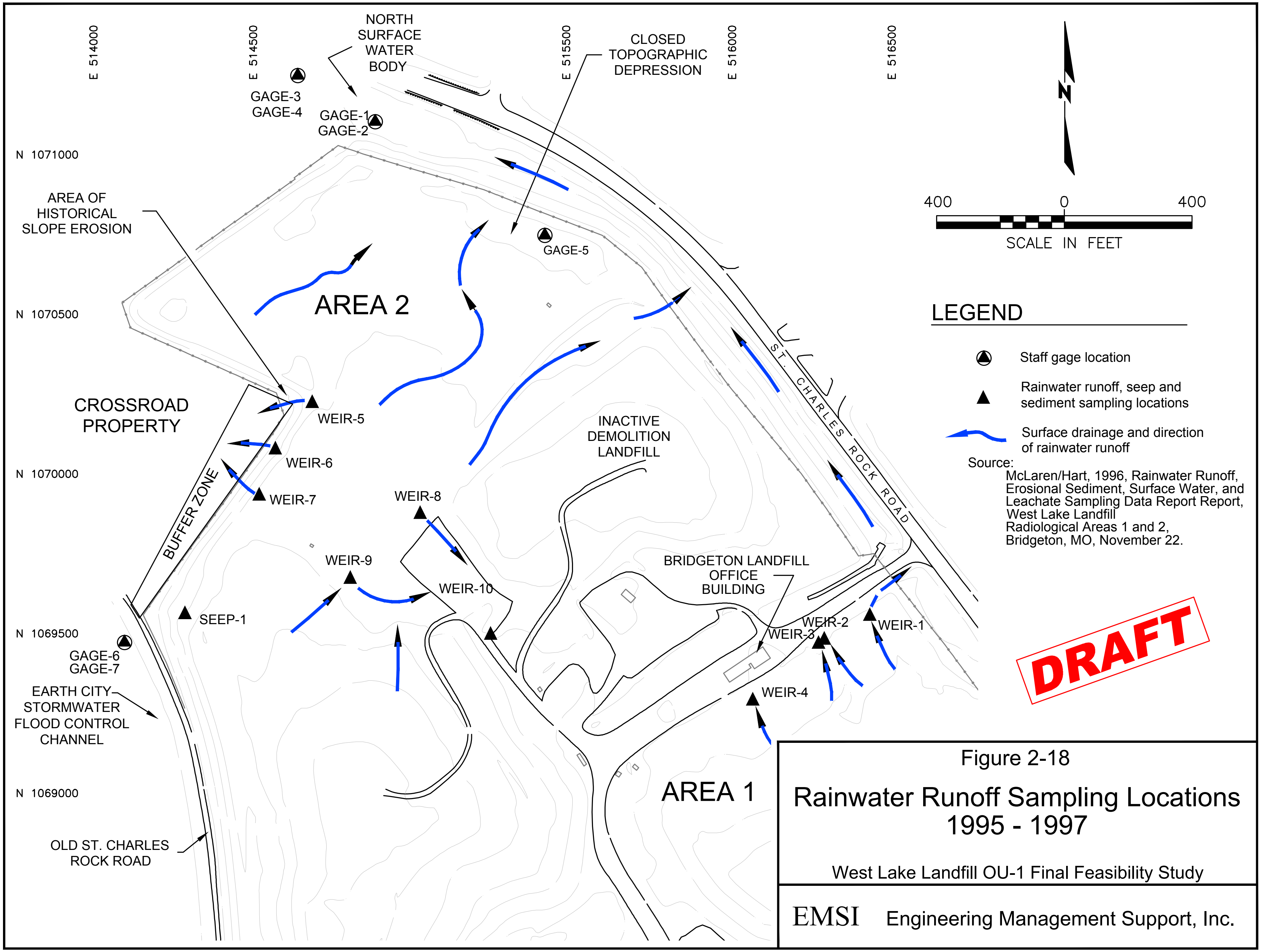


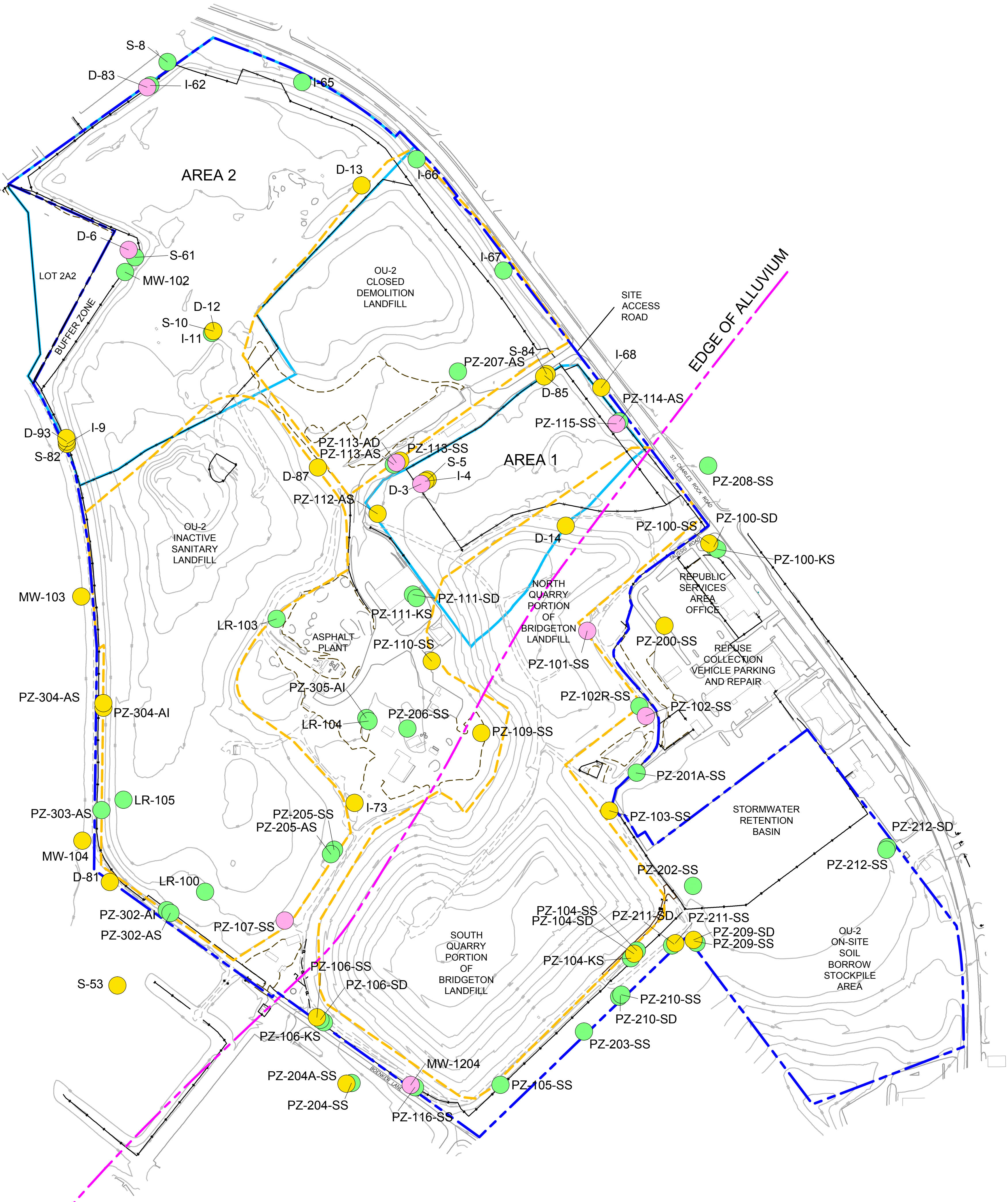
Figure 2-18

Rainwater Runoff Sampling Locations 1995 - 1997

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-19-Com-Tot-RAD-226-228-PYG.dwg 8/25/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

RADIUM EXPLANATION

- Total Radium greater than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (all sampling dates)
- Total Radium greater than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (at least one sampling date but not all sampling dates)
- Total Radium less than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (all sampling dates)

DRAFT

NORTH

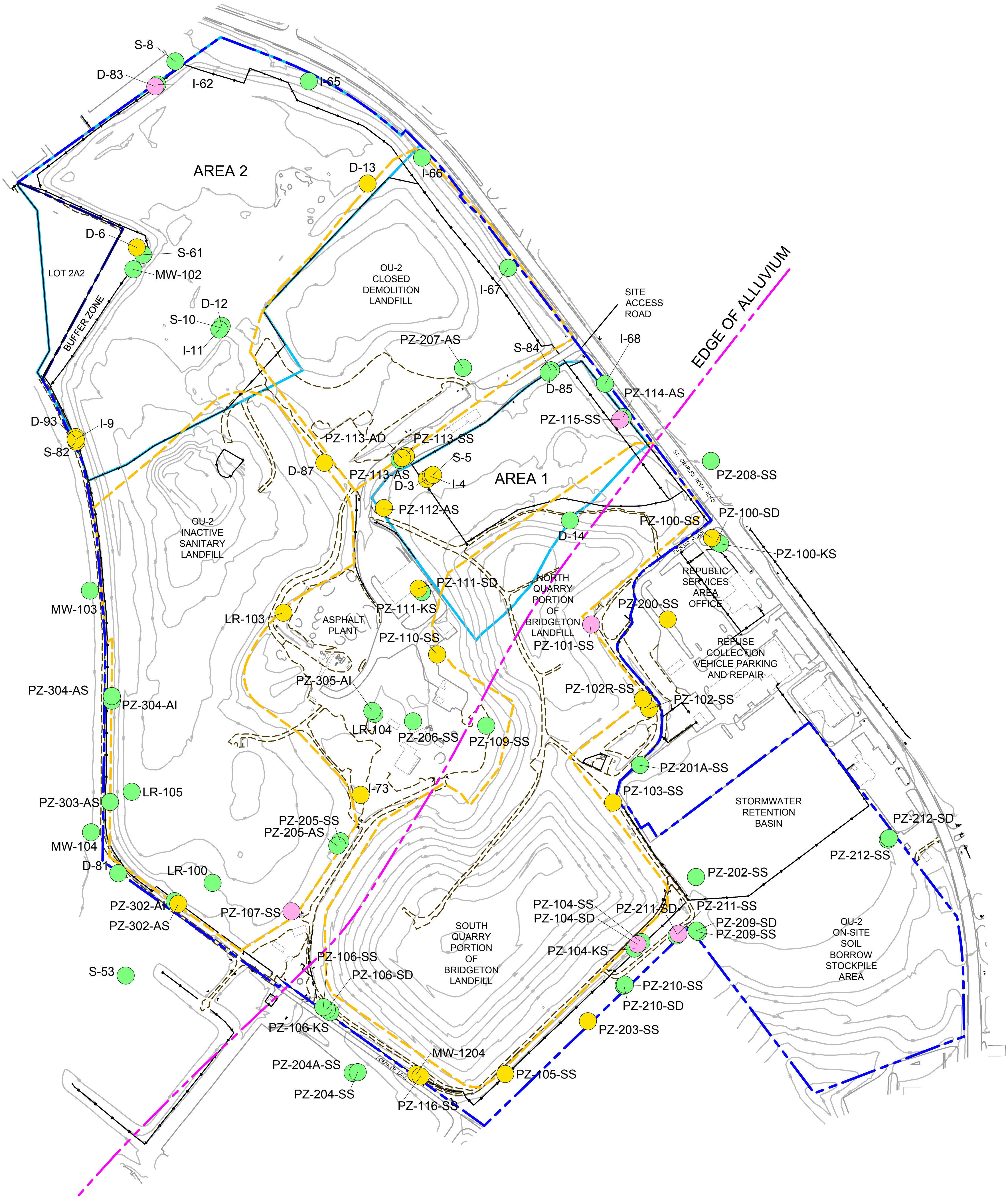
0 250 500
SCALE IN FEET

Figure 2-19
Combined Total Radium-226 + 228 in Groundwater, August 2012 Through February 2014

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-20-Com-Dis-RAD-226-228-PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

DRAFT

RADIUM EXPLANATION

- Dissolved Radium greater than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (all sampling dates)
- Dissolved Radium greater than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (at least one sampling date but not all sampling dates)
- Dissolved Radium less than the Maximum Contaminant Level of 5 pCi/L for combined Radium-226 and Radium-228 (all sampling dates)

NORTH

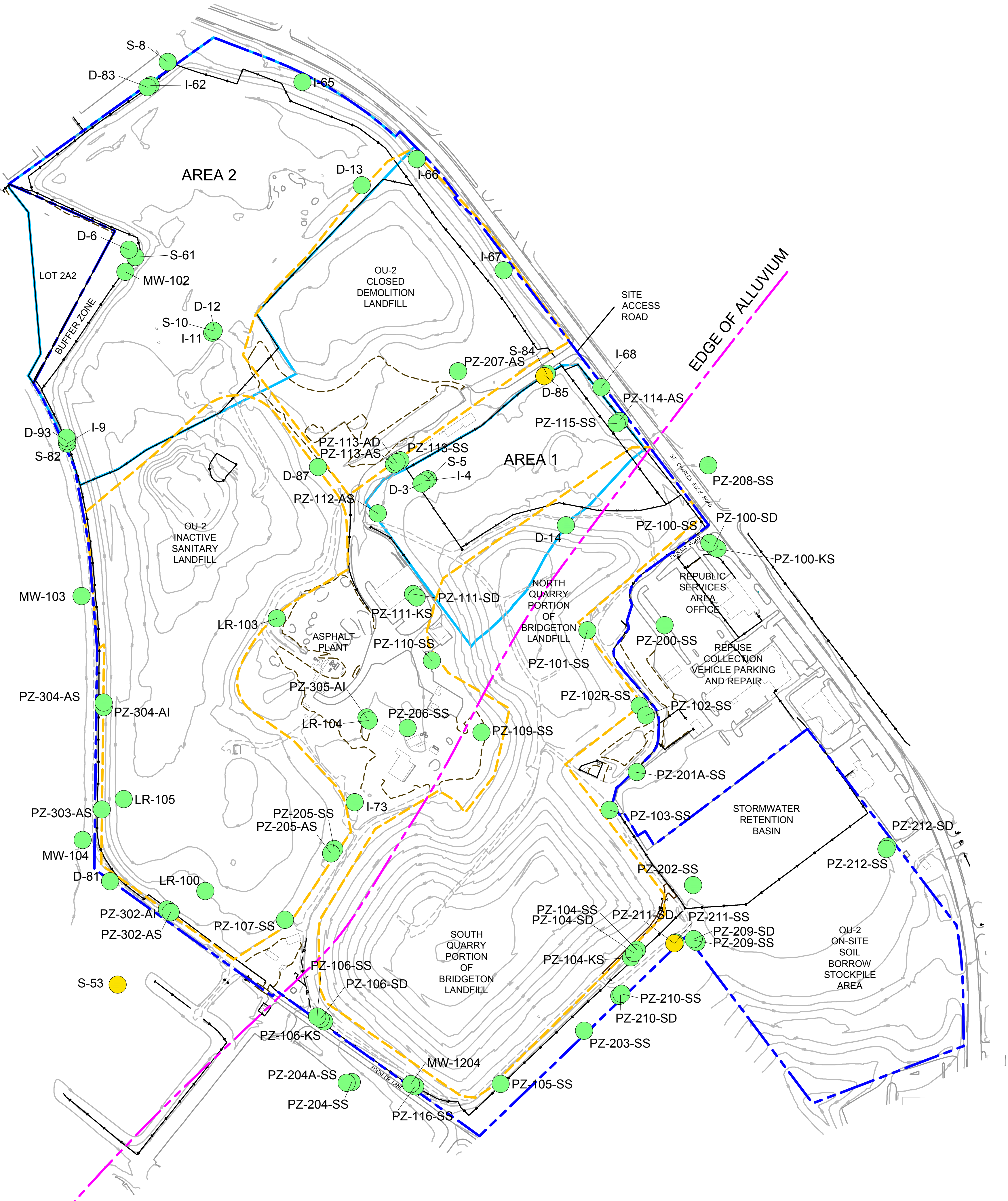
0 250 500
SCALE IN FEET

Figure 2-20
Combined Dissolved Radium-226 + 228 in Groundwater, August 2012 Through February 2014

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-21-Com-Tot-Thorium-PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

URANIUM EXPLANATION

- Total Thorium-230 + 232 less than15 pCi/L [the Gross Alpha Maximum Contaminant Level] (all sampling dates)
- Total Thorium-230 + 232 less than15 pCi/L [the Gross Alpha Maximum Contaminant Level] (at least one sampling date but not all sampling dates)
- Total Thorium-230 + 232 less than15 pCi/L [Less than the Gross Alpha Maximum Contaminant Level] (all sampling dates)

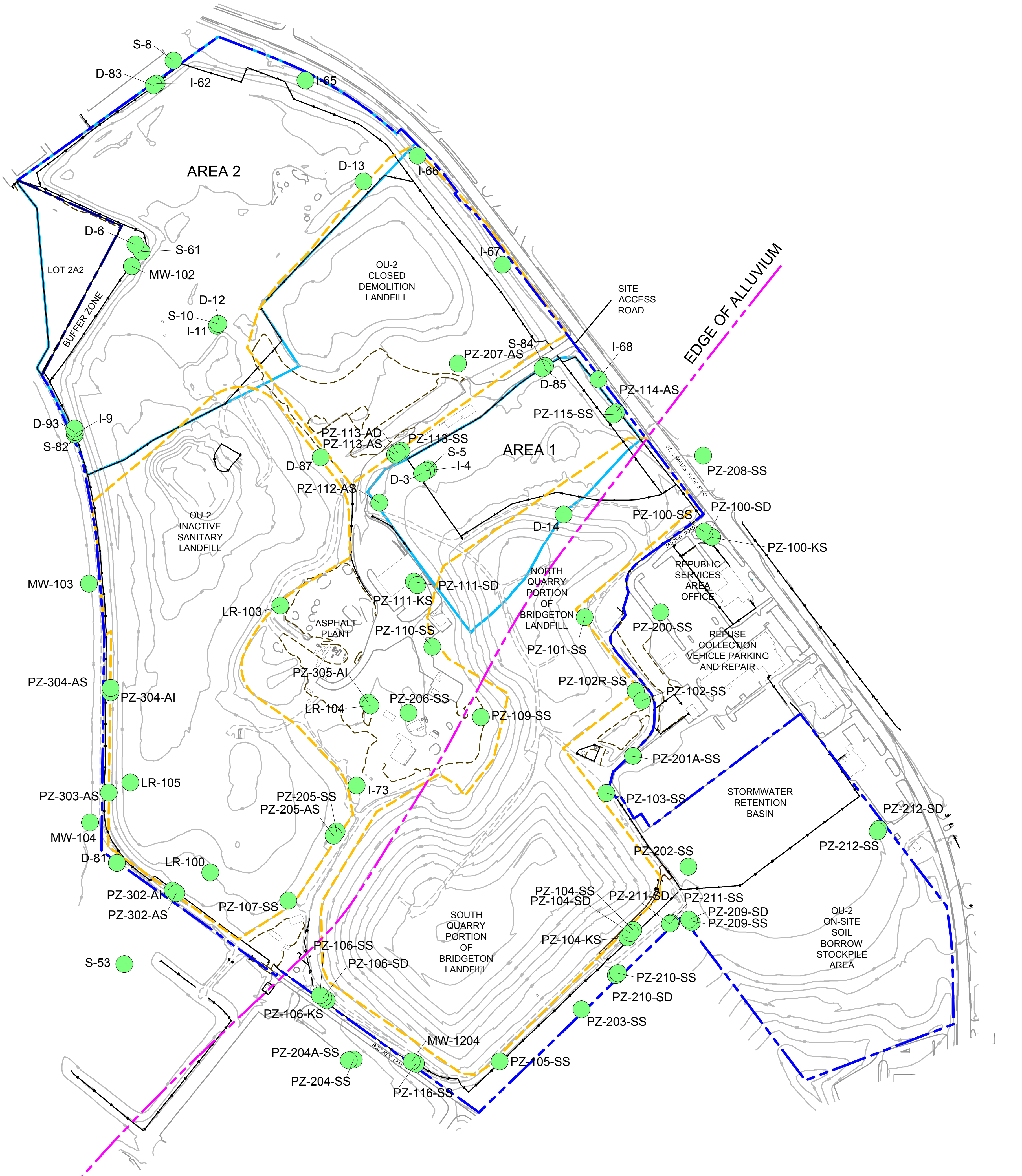
DRAFT

NORTH

0 250 500
SCALE IN FEET

Figure 2-21
Combined Total Thorium-230 + 232 in Groundwater, August 2012 Through February 2014
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

URANIUM EXPLANATION

- Dissolved Thorium-230 + 232 less than15 pCi/L [the Gross Alpha Maximum Contaminant Level] (all sampling dates)
- Dissolved Thorium-230 + 232 less than15 pCi/L [the Gross Alpha Maximum Contaminant Level] (at least one sampling date but not all sampling dates)
- Dissolved Thorium-230 + 232 less than15 pCi/L [Less than the Gross Alpha Maximum Contaminant Level] (all sampling dates)

DRAFT

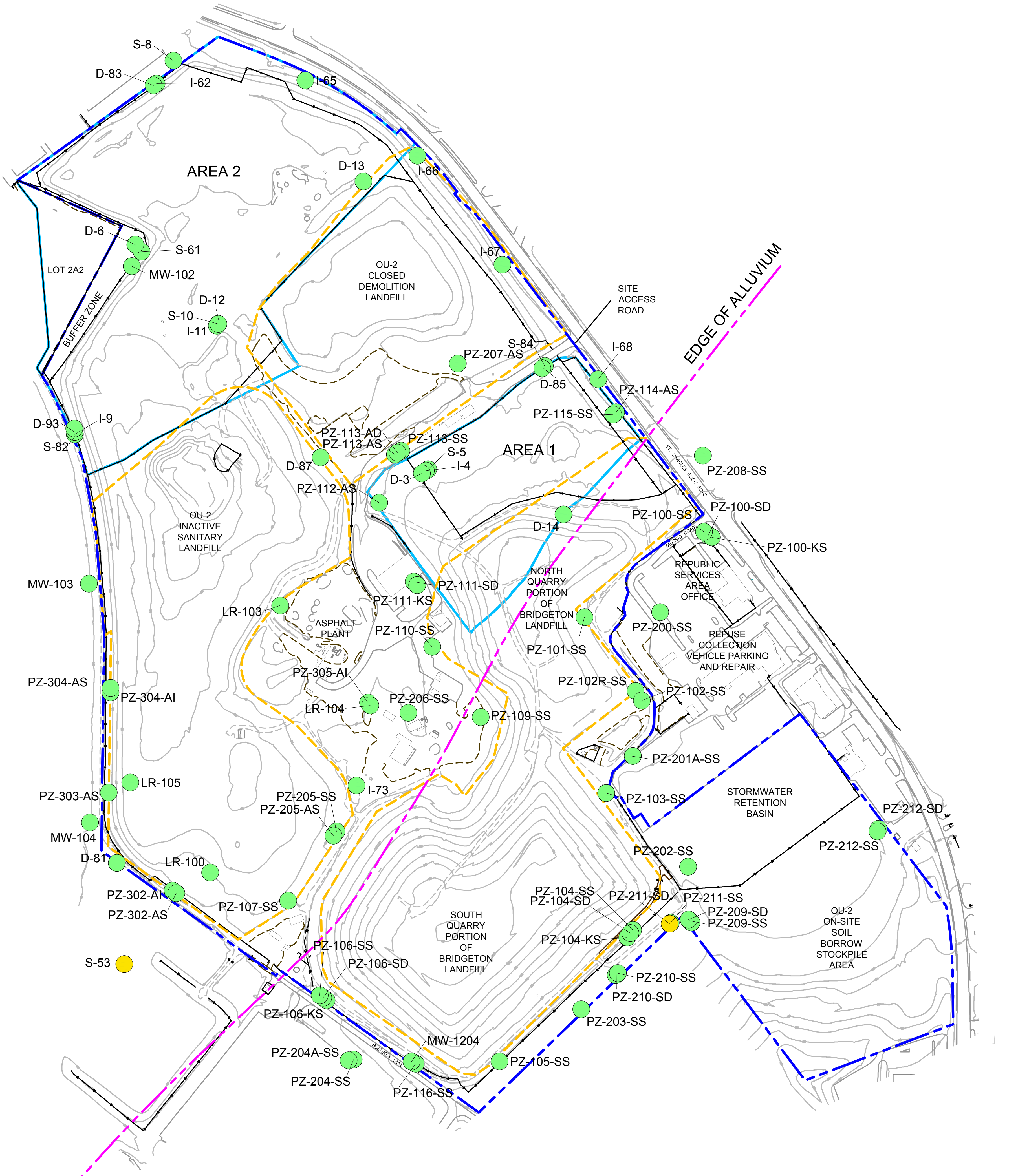
NORTH

0 250 500
SCALE IN FEET

Figure 2-22
Combined Dissolved Thorium-230 + 232
in Groundwater,
August 2012 Through February 2014
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-23-Com-Tot-Uranium-PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

URANIUM EXPLANATION

- (pink) Total Uranium greater than the Maximum Contaminant Level of 30 μg/L [converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (all sampling dates)
- (yellow) Total Uranium greater than the Maximum Contaminant Level of 30 μg/L [converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (at least one sampling date but not all sampling dates)
- (green) Total Uranium greater than the Maximum Contaminant Level of 30 μg/L [Less than converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (all sampling dates)

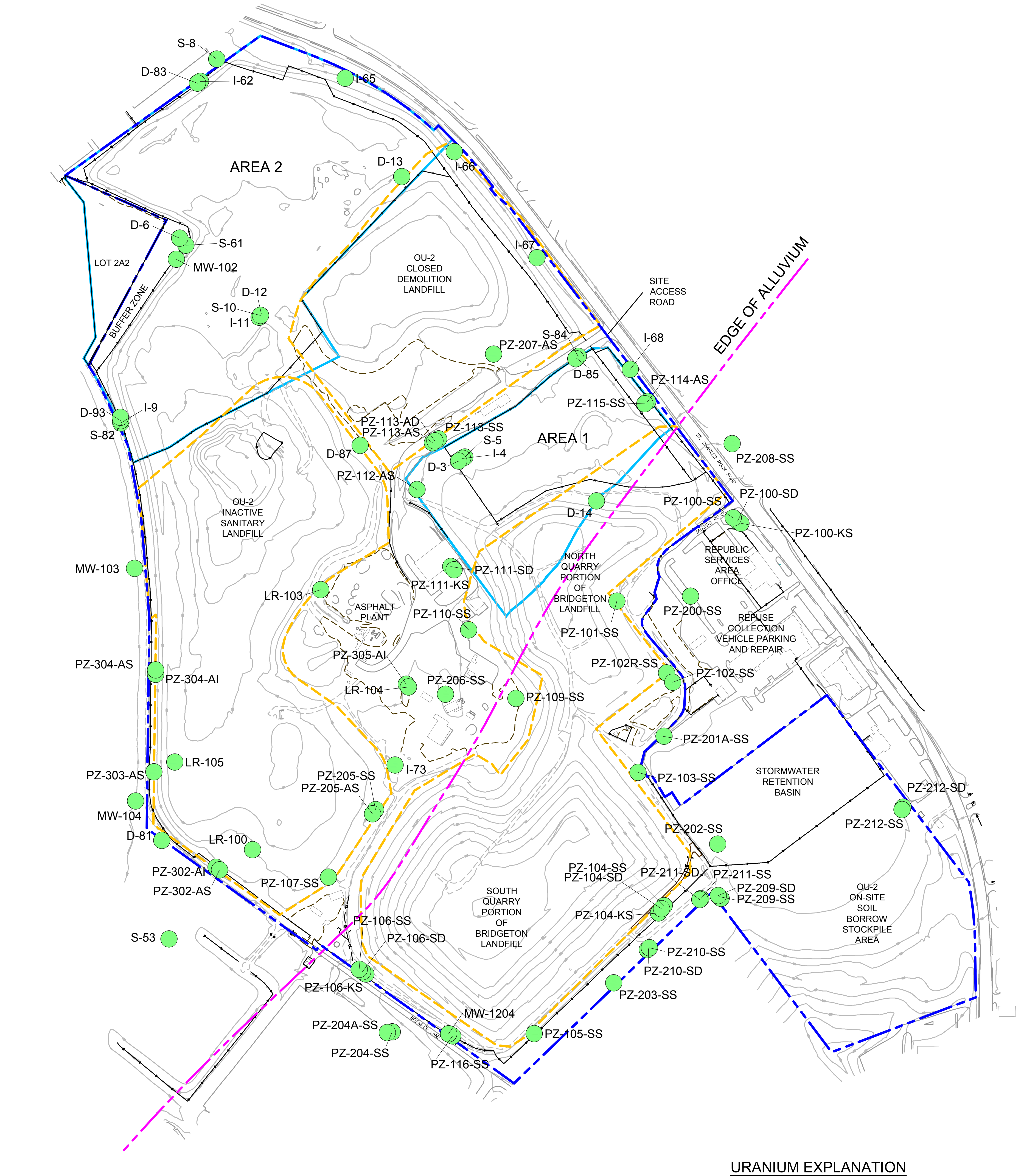
DRAFT

NORTH

0 250 500
SCALE IN FEET

Figure 2-23
Combined Total Uranium-234+235+238 in Groundwater, August 2012 Through February 2014
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
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NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

URANIUM EXPLANATION

- (pink) Dissolved Uranium greater than the Maximum Contaminant Level of 30 μg/L [converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (all sampling dates)
- (yellow) Dissolved Uranium greater than the Maximum Contaminant Level of 30 μg/L [converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (at least one sampling date but not all sampling dates)
- (green) Dissolved Uranium greater than the Maximum Contaminant Level of 30 μg/L [Less than converted to mass from Uranium-234, Uranium-235 and Uranium-238 activities] (all sampling dates)

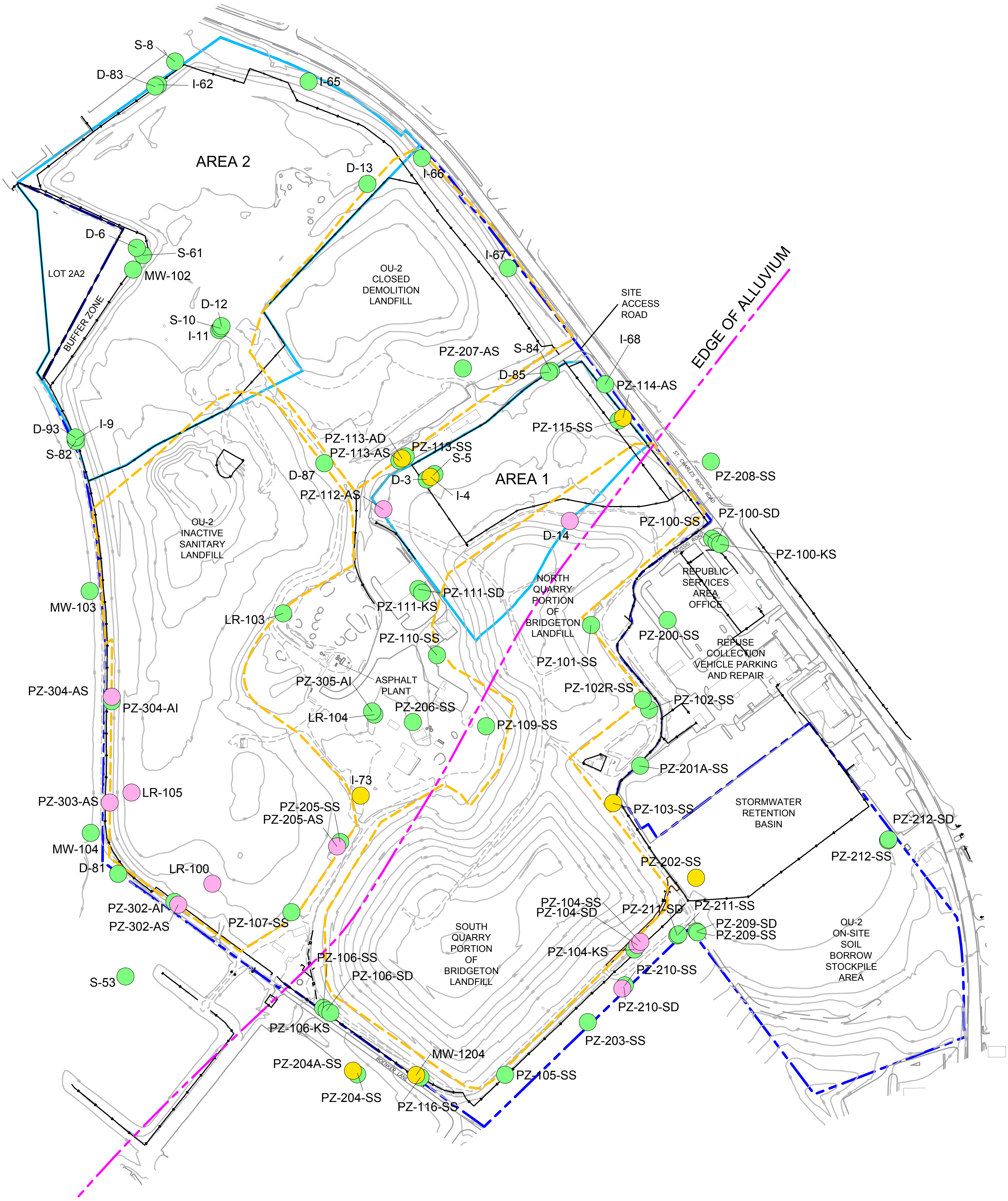
Figure 2-24

Combined Dissolved Uranium 234 + 235 + 238 in Groundwater, August 2012 Through February 2014

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-25-Hist-Benz-PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

BENZENE EXPLANATION

- Benzene greater than the Maximum Contaminant Level of 5 $\mu g/L$ for Benzene (all sampling dates)
- Benzene greater than the Maximum Contaminant Level of 5 $\mu g/L$ for Benzene (at least one sampling date but not all sampling dates)
- Benzene less than the Maximum Contaminant Level of 5 $\mu g/L$ for Benzene (all sampling dates)

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NORTH

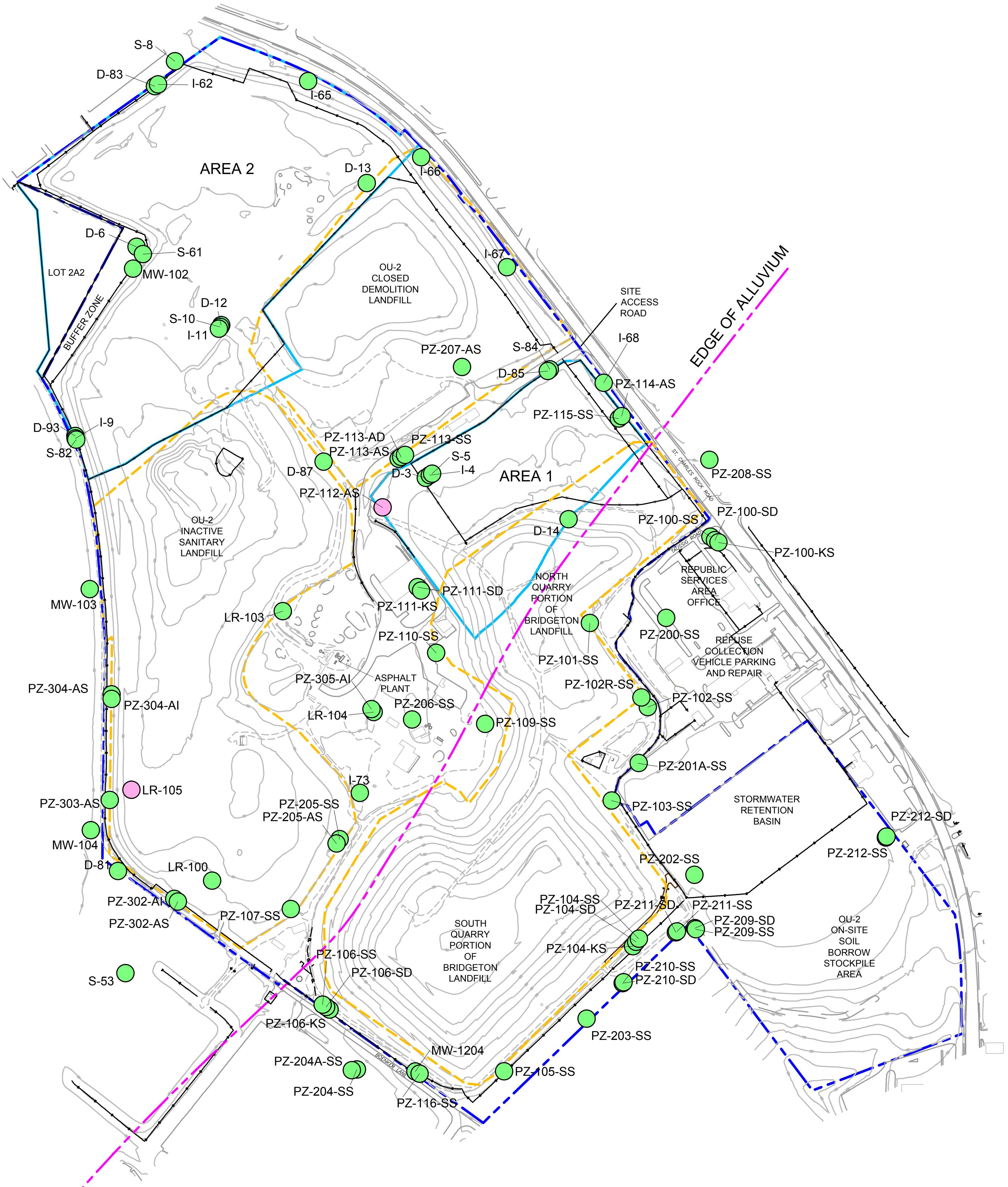
0 250 500
SCALE IN FEET

Figure 2-25

Benzene in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

CHLOROBENZENE EXPLANATION

- (pink) Total Chlorobenzene greater than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (all sampling dates)
- (yellow) Total Chlorobenzene greater than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (at least one sampling date but not all sampling dates)
- (green) Total Chlorobenzene less than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (all sampling dates)

DRAFT

NORTH

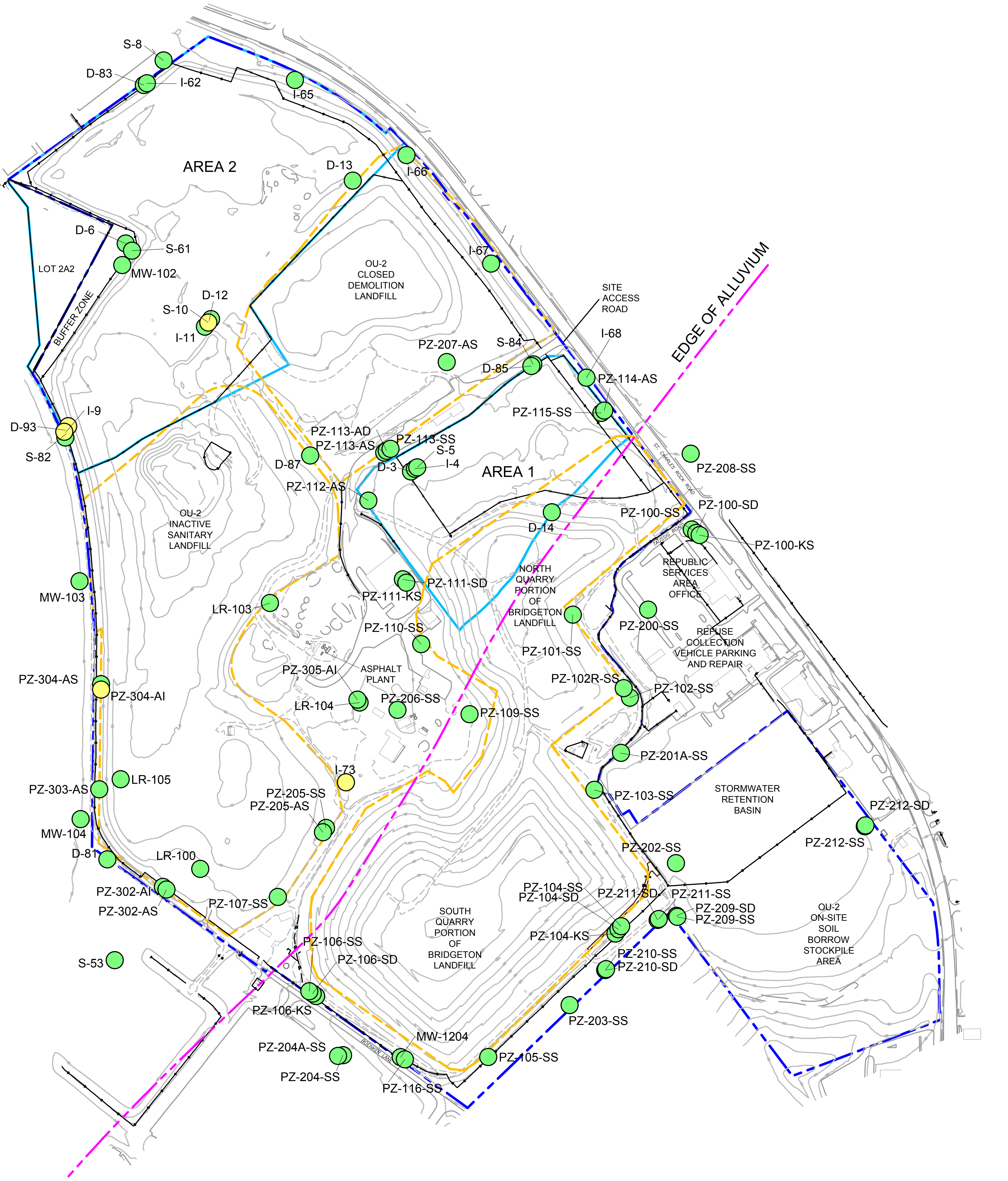
0 250 500
SCALE IN FEET

Figure 2-26

Chlorobenzene in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
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D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

1. Horizontal Coordinates Based on State Plane Missouri East Zone NAD 27
2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

VINYL CHLORIDE EXPLANATION

- Total Vinyl Chloride greater than the Maximum Contaminant Level of 2 $\mu g/L$ for Vinyl Chloride (all sampling dates)
- Total Vinyl Chloride greater than the Maximum Contaminant Level of 2 $\mu g/L$ for Vinyl Chloride (at least one sampling date but not all sampling dates)
- Total Vinyl Chloride less than the Maximum Contaminant Level of 2 $\mu g/L$ for Vinyl Chloride (all sampling dates)

DRAFT

NORTH

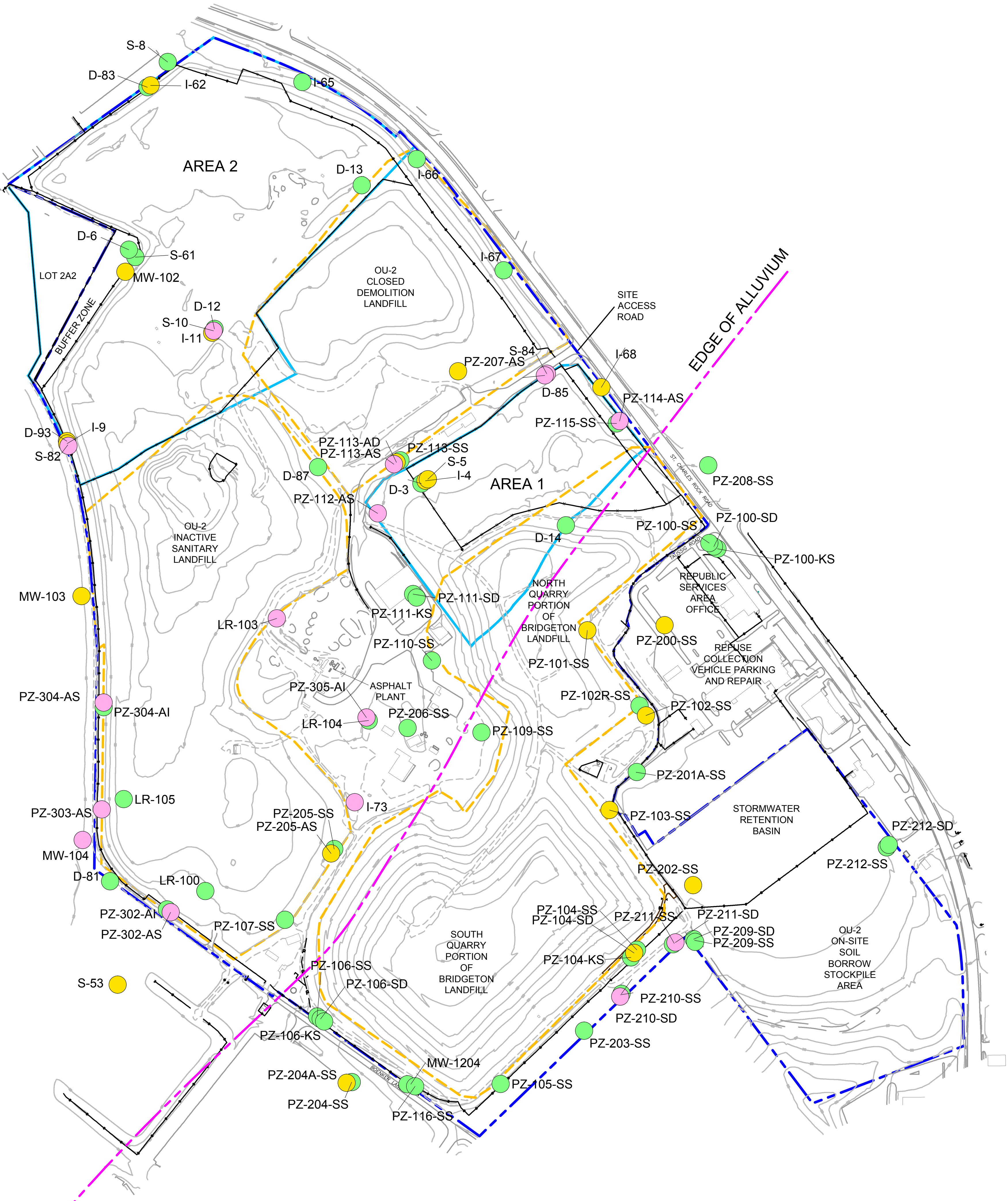
0 250 500
SCALE IN FEET

Figure 2-27

Vinyl Chloride in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
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SS: St. Louis Formation Well
SD: Salem Formation Well
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NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

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ARSENIC EXPLANATION

- Total Arsenic greater than the Maximum Contaminant Level of 10 μg/L for Arsenic (all sampling dates)
- Total Arsenic greater than the Maximum Contaminant Level of 10 μg/L for Arsenic (at least one sampling date but not all sampling dates)
- Total Arsenic less than the Maximum Contaminant Level of 10 μg/L for Arsenic (all sampling dates)

NORTH

0 250 500
SCALE IN FEET

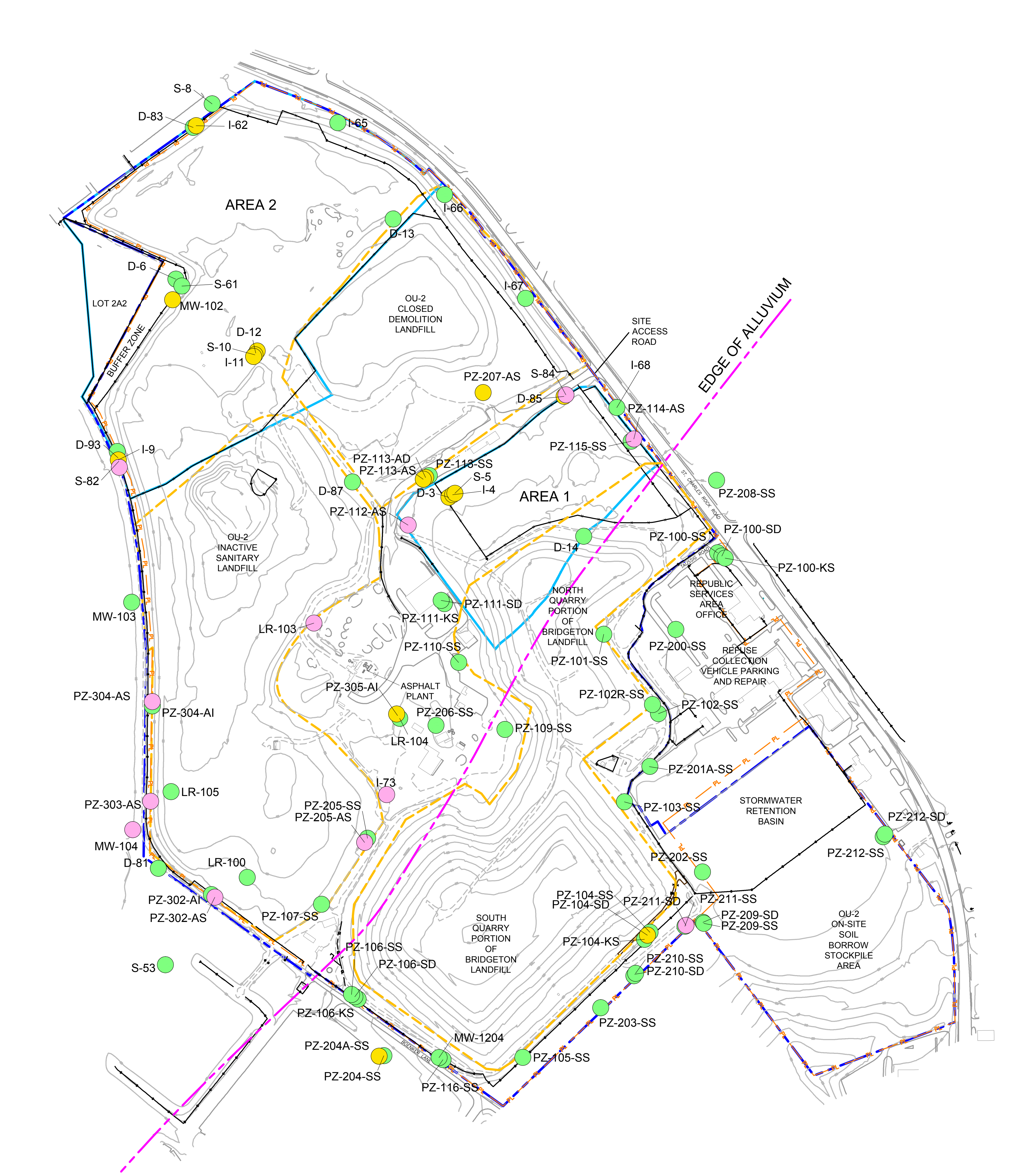
Figure 2-28

Total Arsenic in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-29-Hist-Diss-Arsenic_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
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D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
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NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

ARSENIC EXPLANATION

- Dissolved Arsenic greater than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (all sampling dates)
- Dissolved Arsenic greater than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (at least one sampling date but not all sampling dates)
- Dissolved Arsenic less than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (all sampling dates)

DRAFT

NORTH

0 250 500
SCALE IN FEET

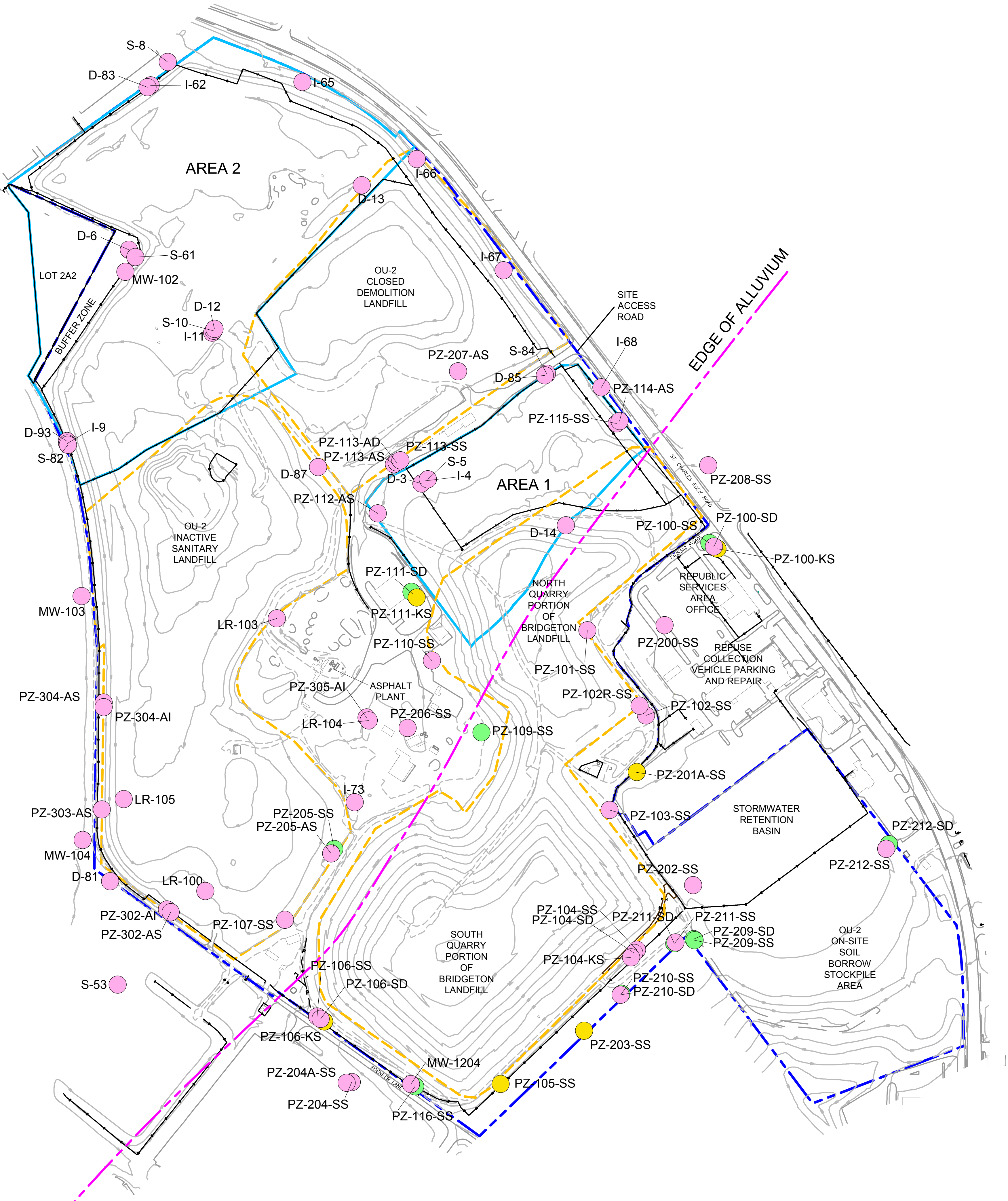
Figure 2-29

Dissolved Arsenic in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-30-Hist-Fe_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
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D or AD: Alluvial Deep Well
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

IRON EXPLANATION

- (pink) Total Iron greater than the Secondary Maximum Contaminant Level of 300 μg/L for Iron (all sampling dates)
- (yellow) Total Iron greater than the Secondary Maximum Contaminant Level of 300 μg/L for Iron (at least one sampling date but not all sampling dates)
- (green) Total Iron less than the Secondary Maximum Contaminant Level of 300 μg/L for Iron (all sampling dates)

DRAFT

NORTH

0 250 500
SCALE IN FEET

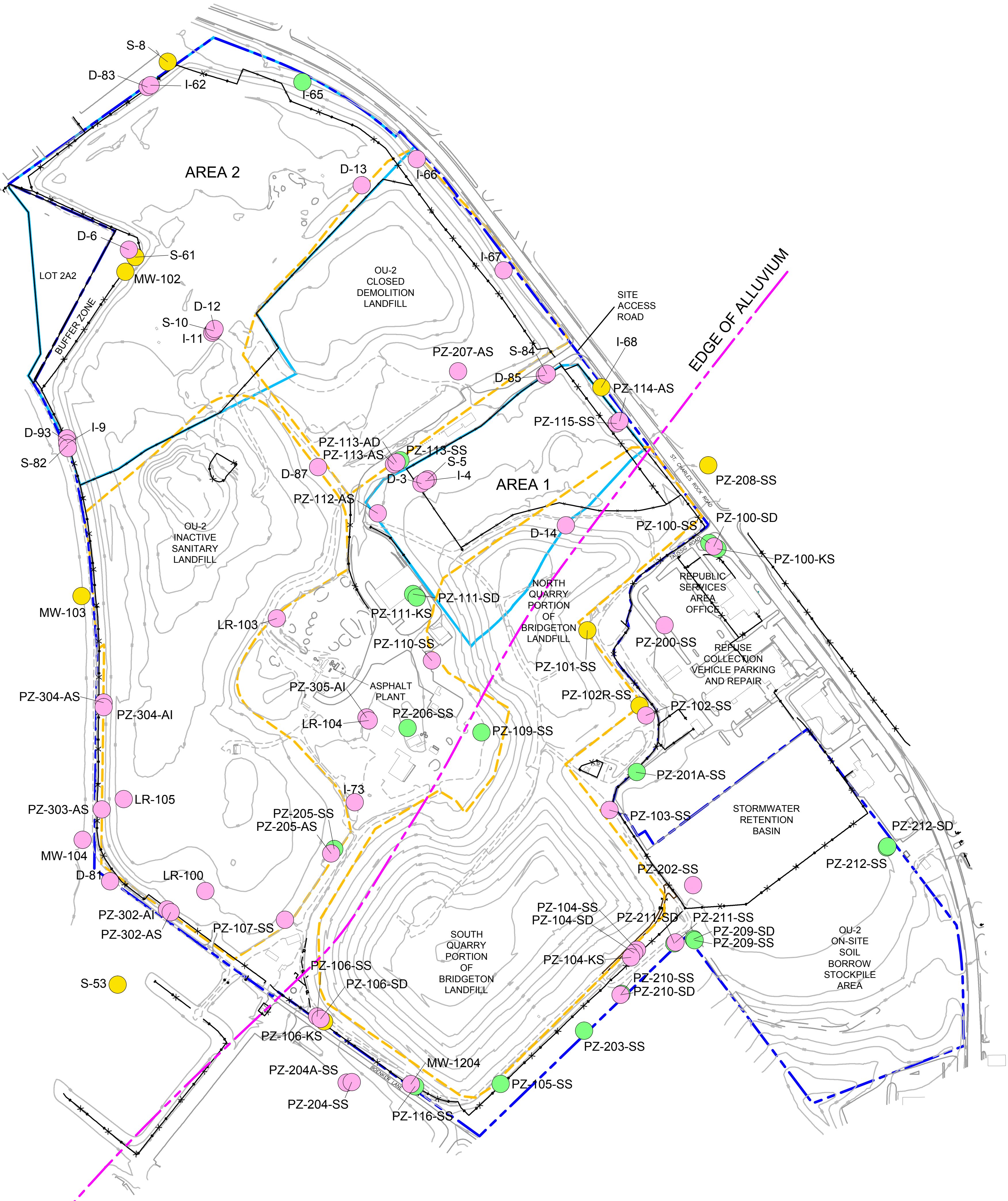
Figure 2-30

Total Iron in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-31-Hist-Diss-Fe_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
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D or AD: Alluvial Deep Well
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SD: Salem Formation Well
KS: Keokuk Formation Well

NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

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IRON EXPLANATION

- Dissolved Iron greater than the Secondary Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)
- Dissolved Iron greater than the Secondary Maximum Contaminant Level of 300 $\mu g/L$ for Iron (at least one sampling date but not all sampling dates)
- Dissolved Iron less than the Secondary Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)

NORTH

0 250 500
SCALE IN FEET

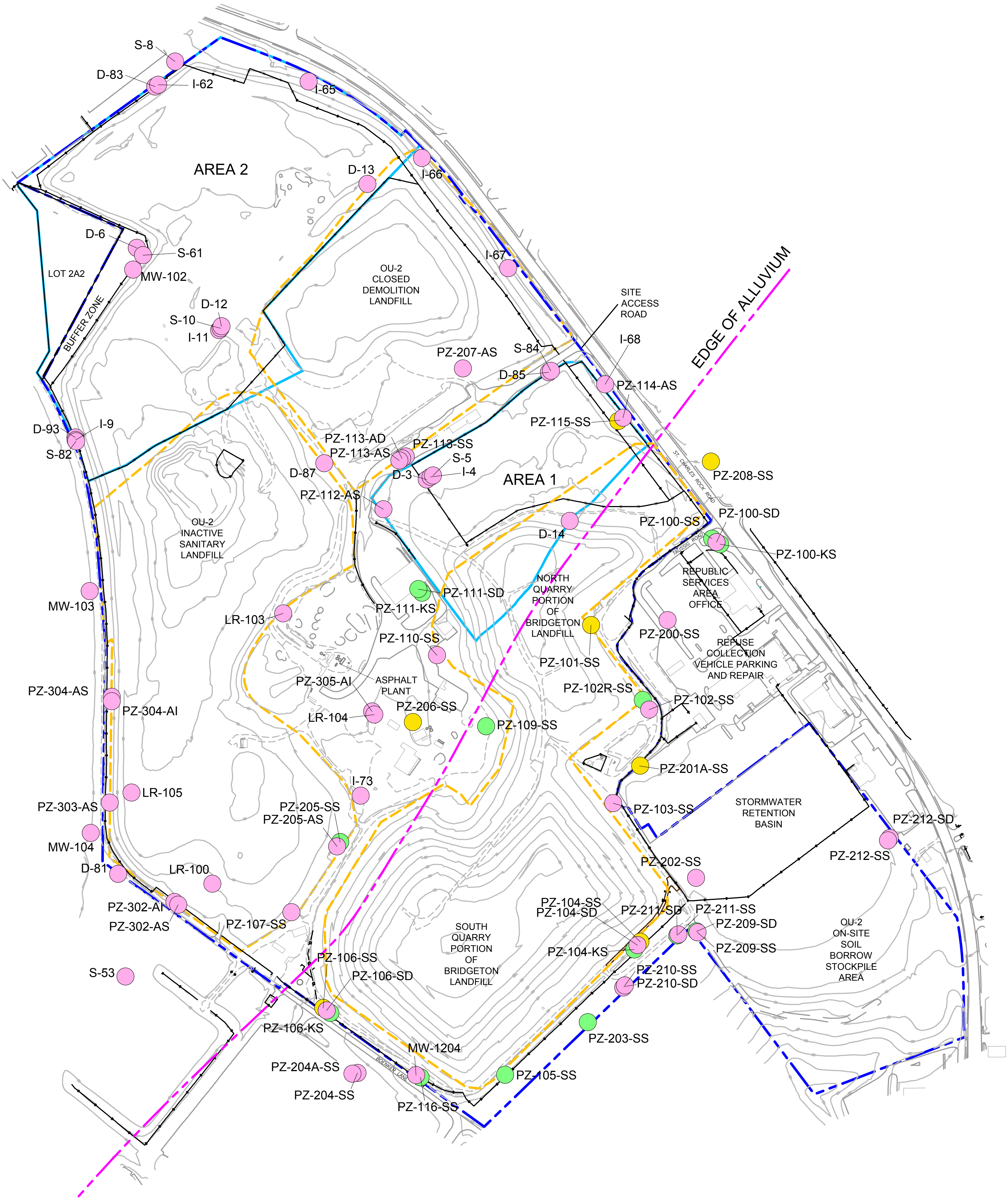
Figure 2-31

Dissolved Iron in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-32-Hist-Mang_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
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NOTES:

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3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

MANGANESE EXPLANATION

- (pink) Total Manganese greater than the Secondary Maximum Contaminant Level of 50 µg/L for Manganese (all sampling dates)
- (yellow) Total Manganese greater than the Secondary Maximum Contaminant Level of 50 µg/L for Manganese (at least one sampling date but not all sampling dates)
- (green) Total Manganese less than the Secondary Maximum Contaminant Level of 50 µg/L for Manganese (all sampling dates)

DRAFT

NORTH

0 250 500
SCALE IN FEET

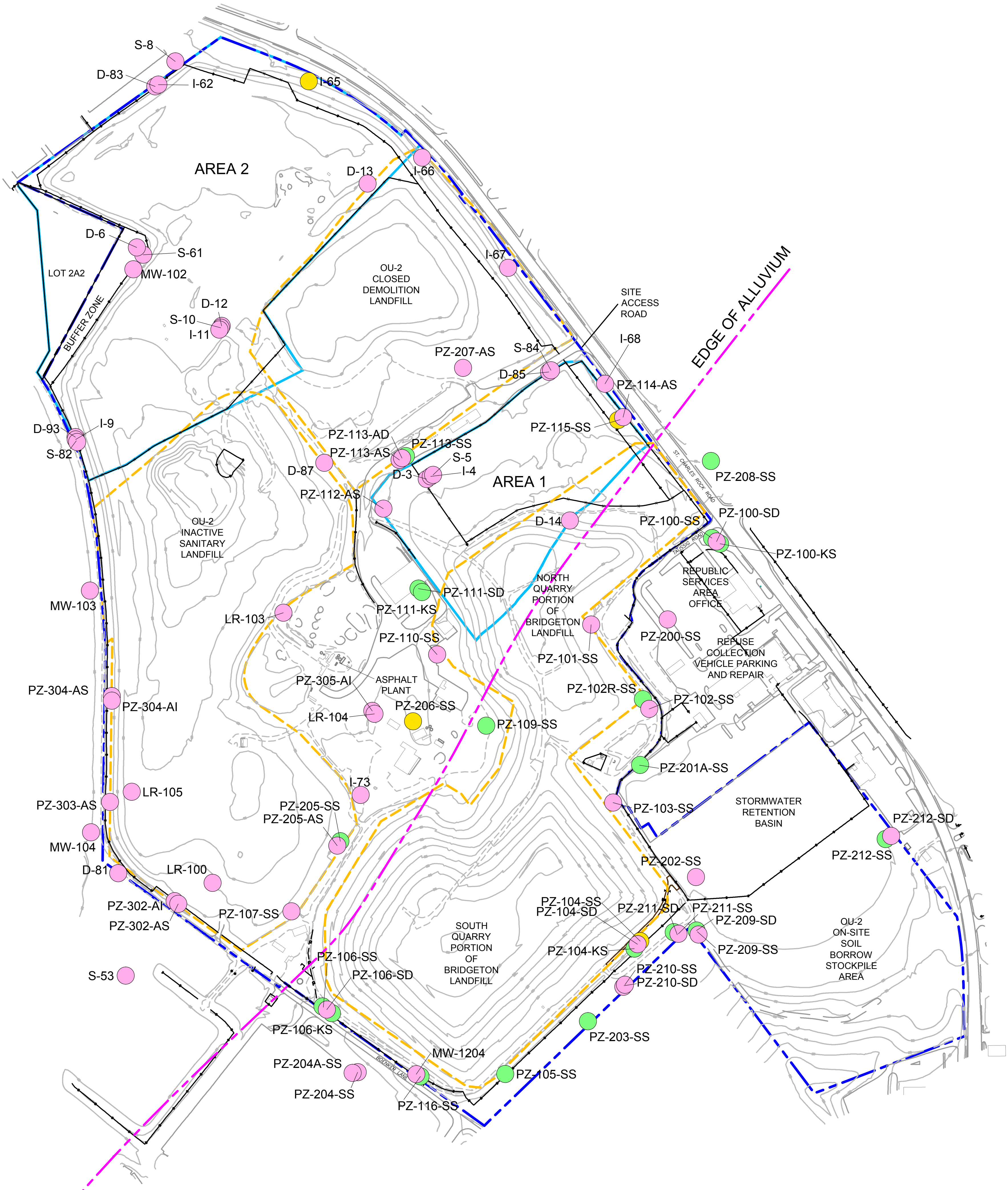
Figure 2-32

Total Manganese in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-33-Hist-Diss-Mang_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

- LR or MW: Undifferentiated
- S or AS: Alluvial Shallow Well
- I or AI: Alluvial Intermediate Well
- D or AD: Alluvial Deep Well
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4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

MANGANESE EXPLANATION

- Dissolved Manganese greater than the Secondary Maximum Contaminant Level of 50 μg/L for Manganese (all sampling dates)
- Dissolved Manganese greater than the Secondary Maximum Contaminant Level of 50 μg/L for Manganese (at least one sampling date but not all sampling dates)
- Dissolved Manganese less than the Secondary Maximum Contaminant Level of 50 μg/L for Manganese (all sampling dates)

DRAFT

NORTH

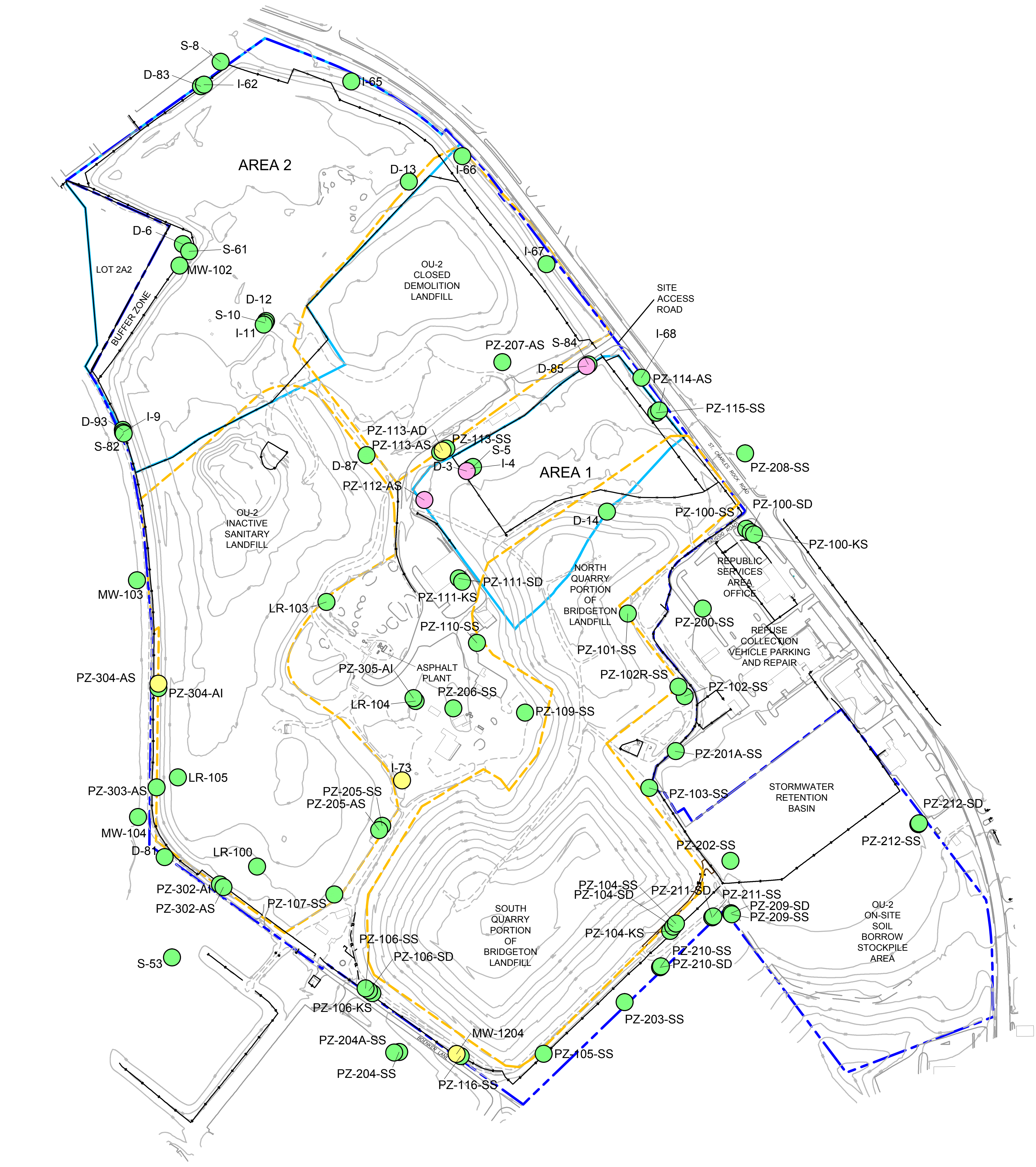
0 250 500
SCALE IN FEET

Figure 2-33

Dissolved Manganese in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

- LR or MW: Undifferentiated
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4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

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BARIUM EXPLANATION

- (Pink) Total Barium greater than the Maximum Contaminant Level of 2,000 μg/L for Barium (all sampling dates)
- (Yellow) Total Barium greater than the Maximum Contaminant Level of 2,000 μg/L for Barium (at least one sampling date but not all sampling dates)
- (Green) Total Barium less than the Maximum Contaminant Level of 2,000 μg/L for Barium (all sampling dates)

NORTH

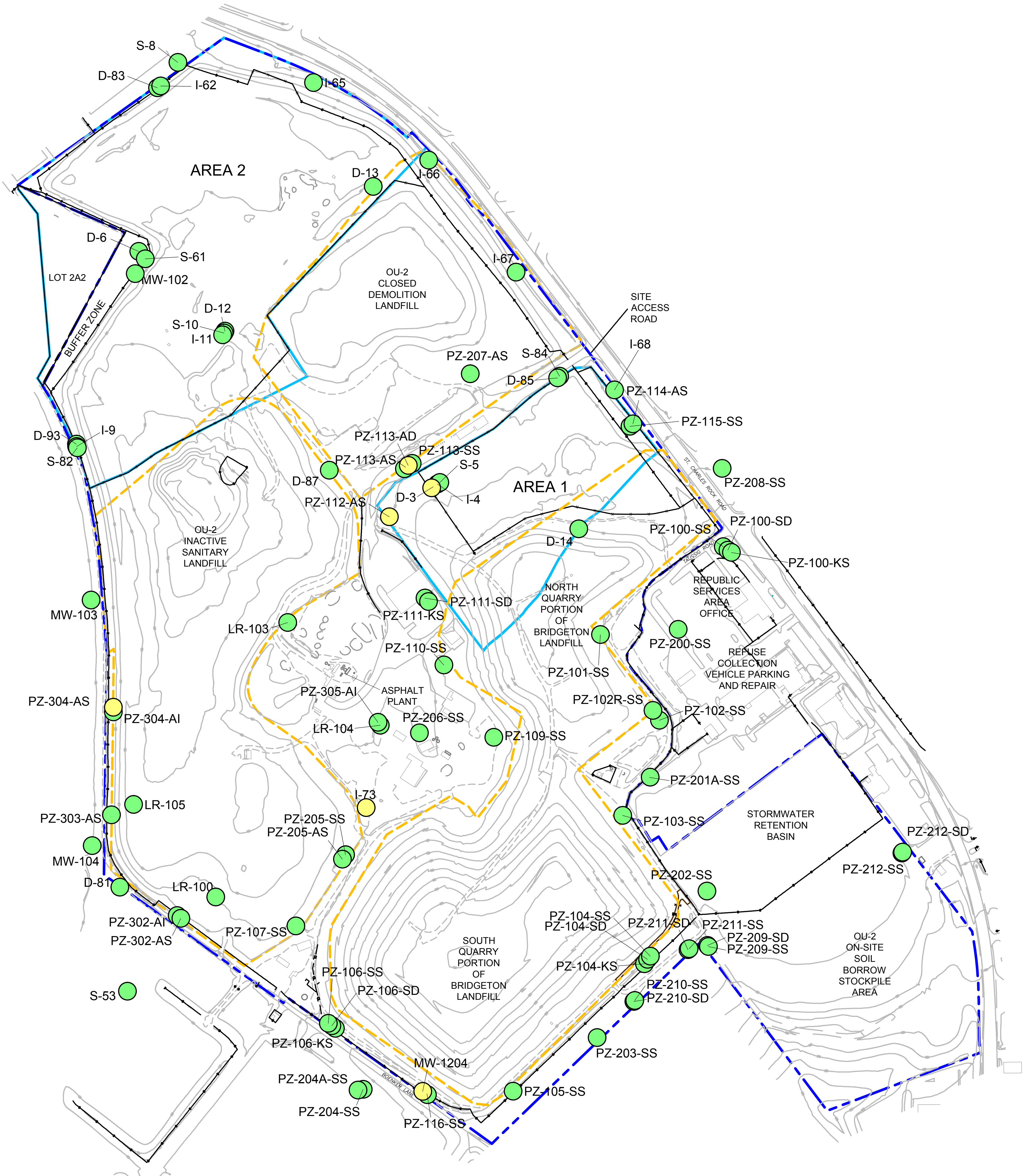
0 250 500
SCALE IN FEET

Figure 2-34

Total Barium in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
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NOTES:

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3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

BARIUM EXPLANATION

- Dissolved Barium greater than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (all sampling dates)
- Dissolved Barium greater than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (at least one sampling date but not all sampling dates)
- Dissolved Barium less than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (all sampling dates)

DRAFT

NORTH

0 250 500
SCALE IN FEET

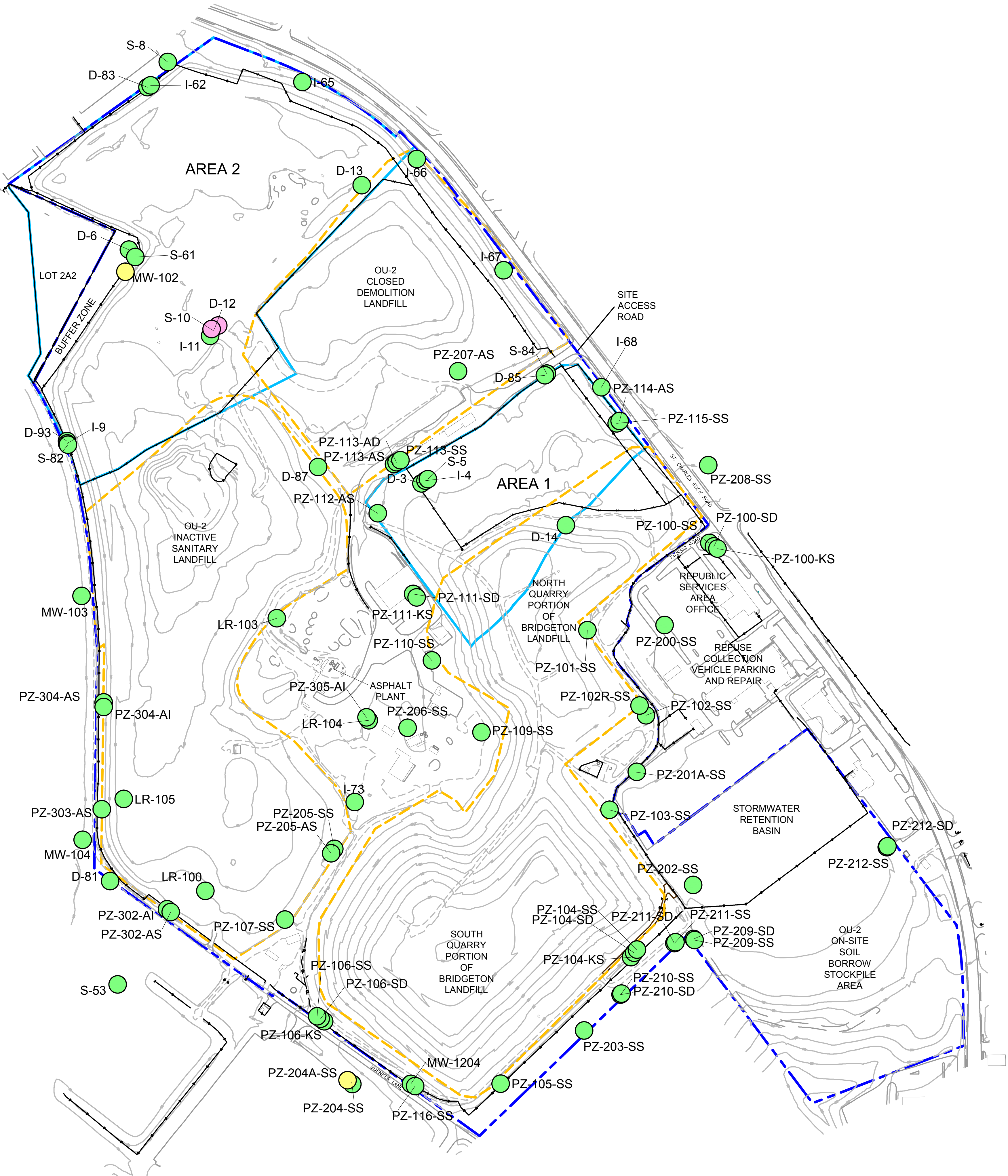
Figure 2-35

Dissolved Barium in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-36-Hist-Sulfate_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

WELL FORMATION DESIGNATIONS

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3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

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SULFATE EXPLANATION

- Total Sulfate greater than the Secondary Maximum Contaminant Level of 250 mg/L for Sulfate (all sampling dates)
- Total Sulfate greater than the Secondary Maximum Contaminant Level of 250 mg/L for Sulfate (at least one sampling date but not all sampling dates)
- Total Sulfate less than the Secondary Maximum Contaminant Level of 250 mg/L for Sulfate (all sampling dates)

NORTH

0 250 500
SCALE IN FEET

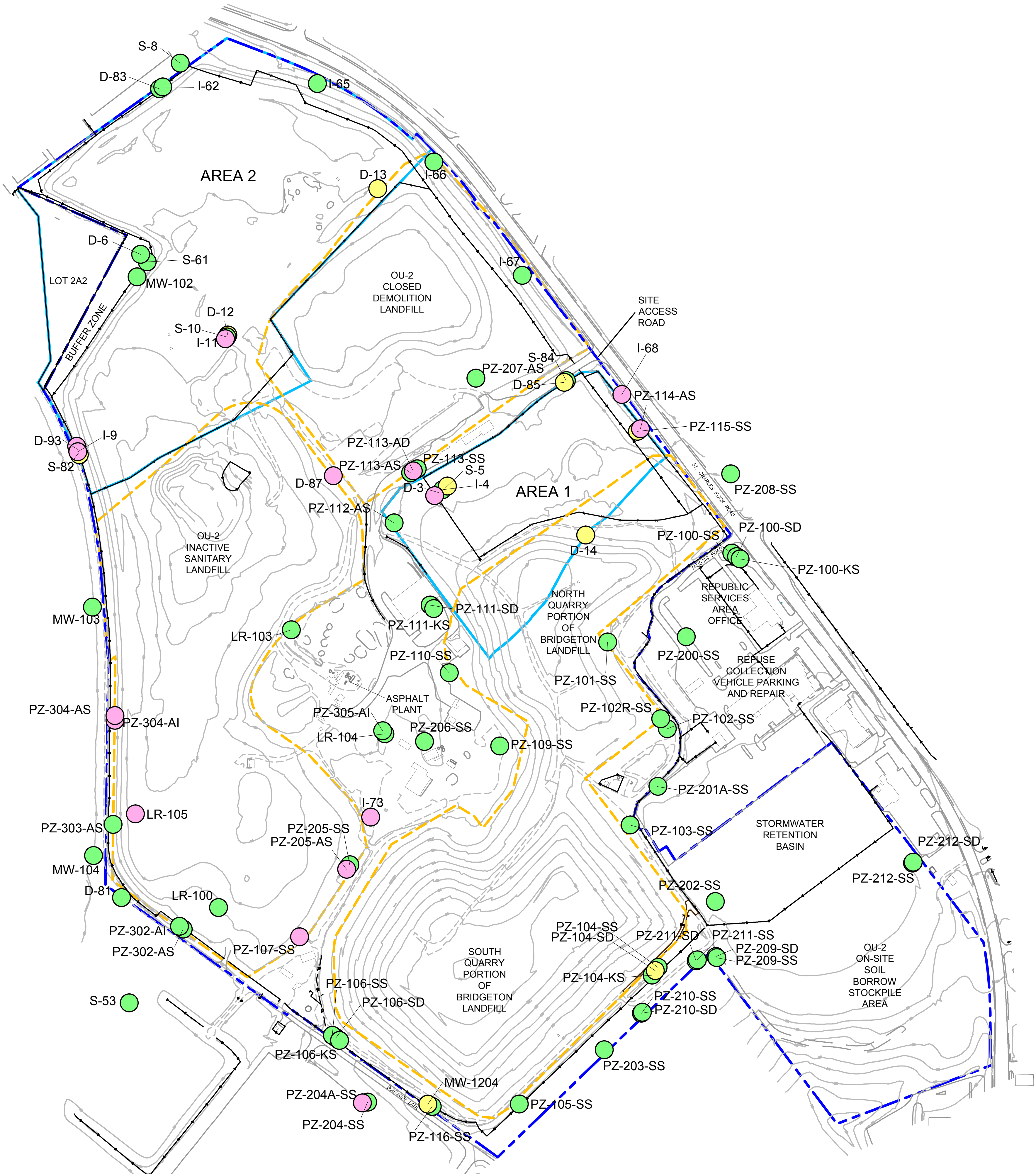
Figure 2-36

Sulfate in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-37-Hist-Chloride_PYG.dwg 12/11/17



LEGEND

- Landfill Boundary
- OU-1 Area Boundary
- OU-2 Area Boundary
- Index Contour
- Paved Road
- Unpaved Road
- Building
- Fence

CHLORIDE EXPLANATION

- (pink) Chloride greater than the Secondary Maximum Contaminant Level of 250 mg/L for Chloride (all sampling dates)
- (yellow) Chloride greater than the Secondary Maximum Contaminant Level of 250 mg/L for Chloride (at least one sampling date but not all sampling dates)
- (green) Chloride less than the Secondary Maximum Contaminant Level of 250 mg/L for Chloride (all sampling dates)

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: Alluvial Deep Well
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DRAFT

NOTES:

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2. Elevations Based on U.S.G.S. Datum.
3. Existing Grade Contours are from the Aerial Survey Completed by the Sanborn Mapping Company on July 20, 2011.
4. Base Map Prepared by Aquaterra Environmental Solutions, Inc.

NORTH

0 250 500
SCALE IN FEET

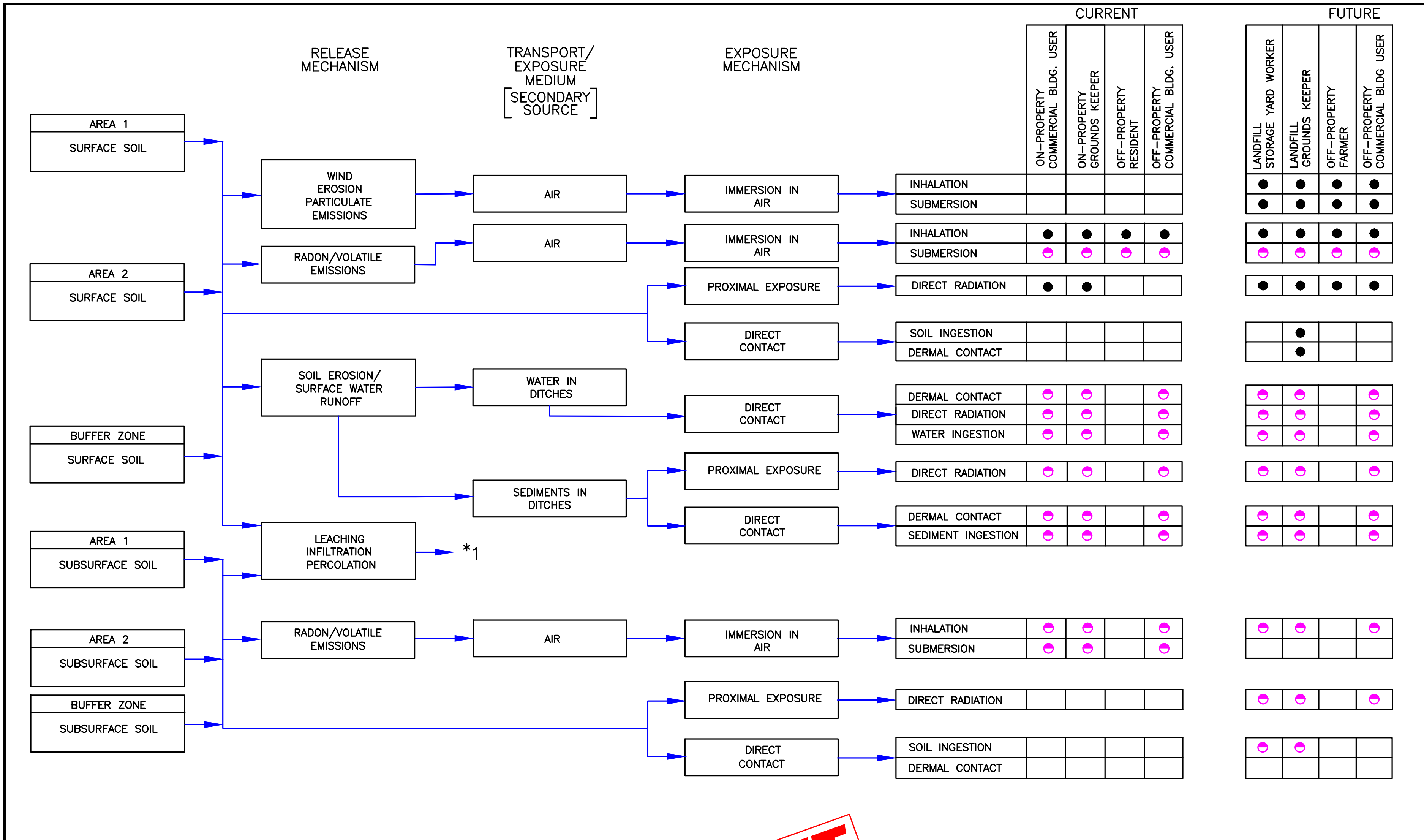
Figure 2-37

Chloride in Groundwater, August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 2\FIG-2-38-Pot-Exposure-Routes.dwg 1/10/18



LEGEND

NOT APPLICABLE

● EXPOSURE PATHWAY EVALUATED IN THE QUANTITATIVE RISK ASSESSMENT

◓ A PRELIMINARY SCREENING (OR INFORMATION PROVIDED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY [RAGS, PART B]) HAS DEMONSTRATED THAT THE CONTRIBUTION TO EXPOSURE FROM THIS EXPOSURE PATHWAY IS NEGLIGIBLE.

*1The groundwater pathway will be addressed by the OU–3 RI/FS.

DRAFT

Figure 2-38

Potential Exposure Routes

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG5-1_5-2-25%-Slopes.dwg 1/10/2018

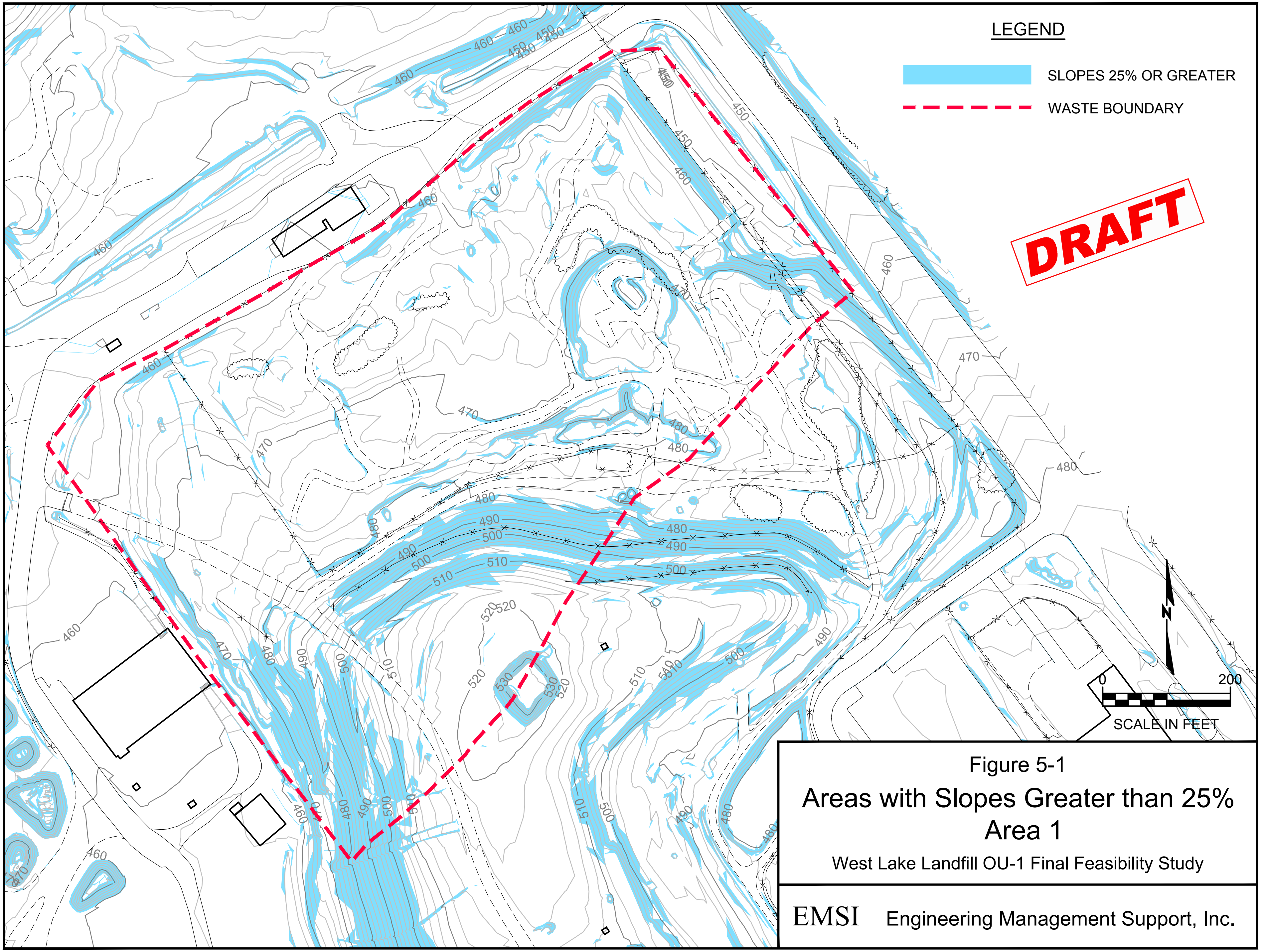
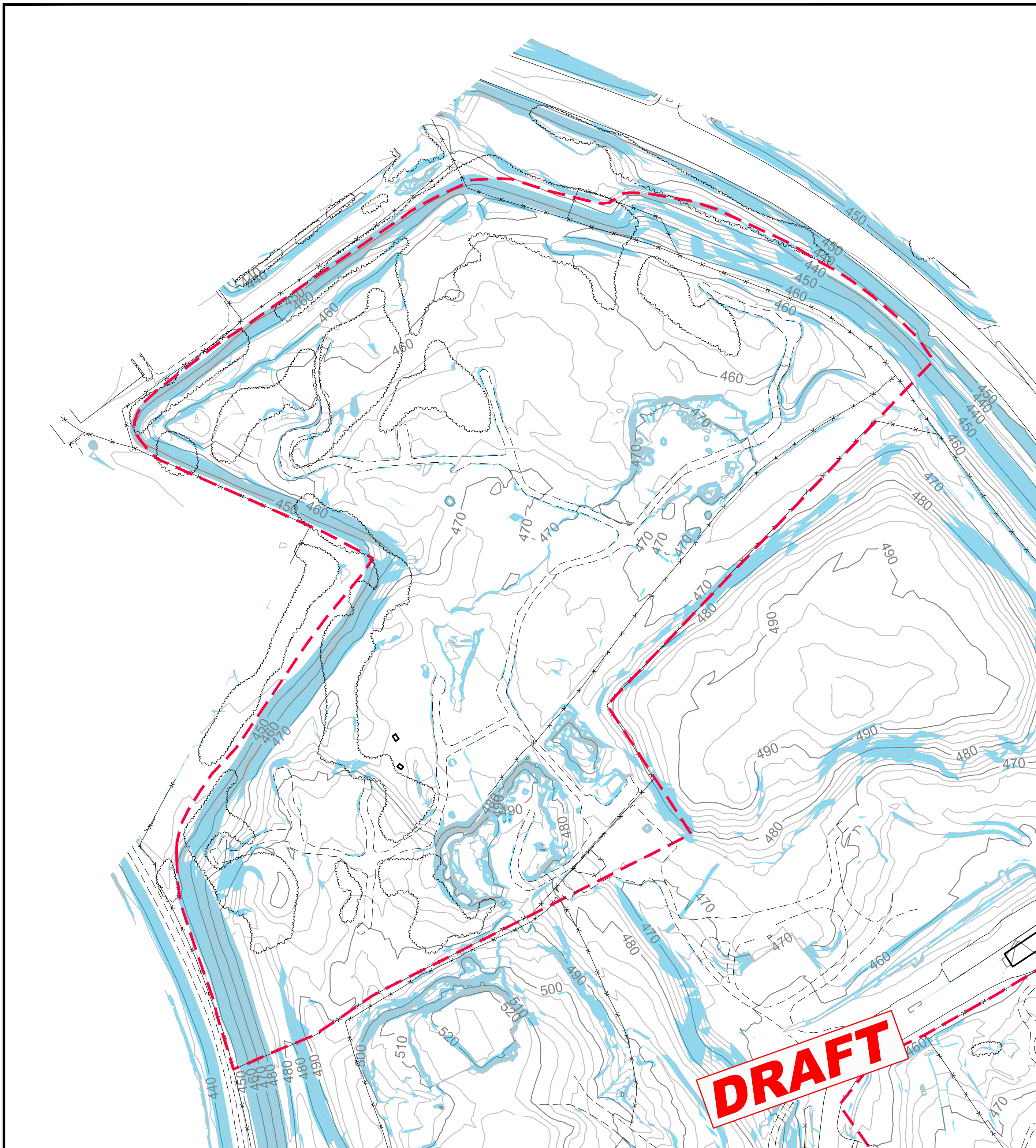


Figure 5-1
Areas with Slopes Greater than 25%
Area 1
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

SLOPES 25% OR GREATER

WASTE BOUNDARY

0 300

SCALE IN FEET

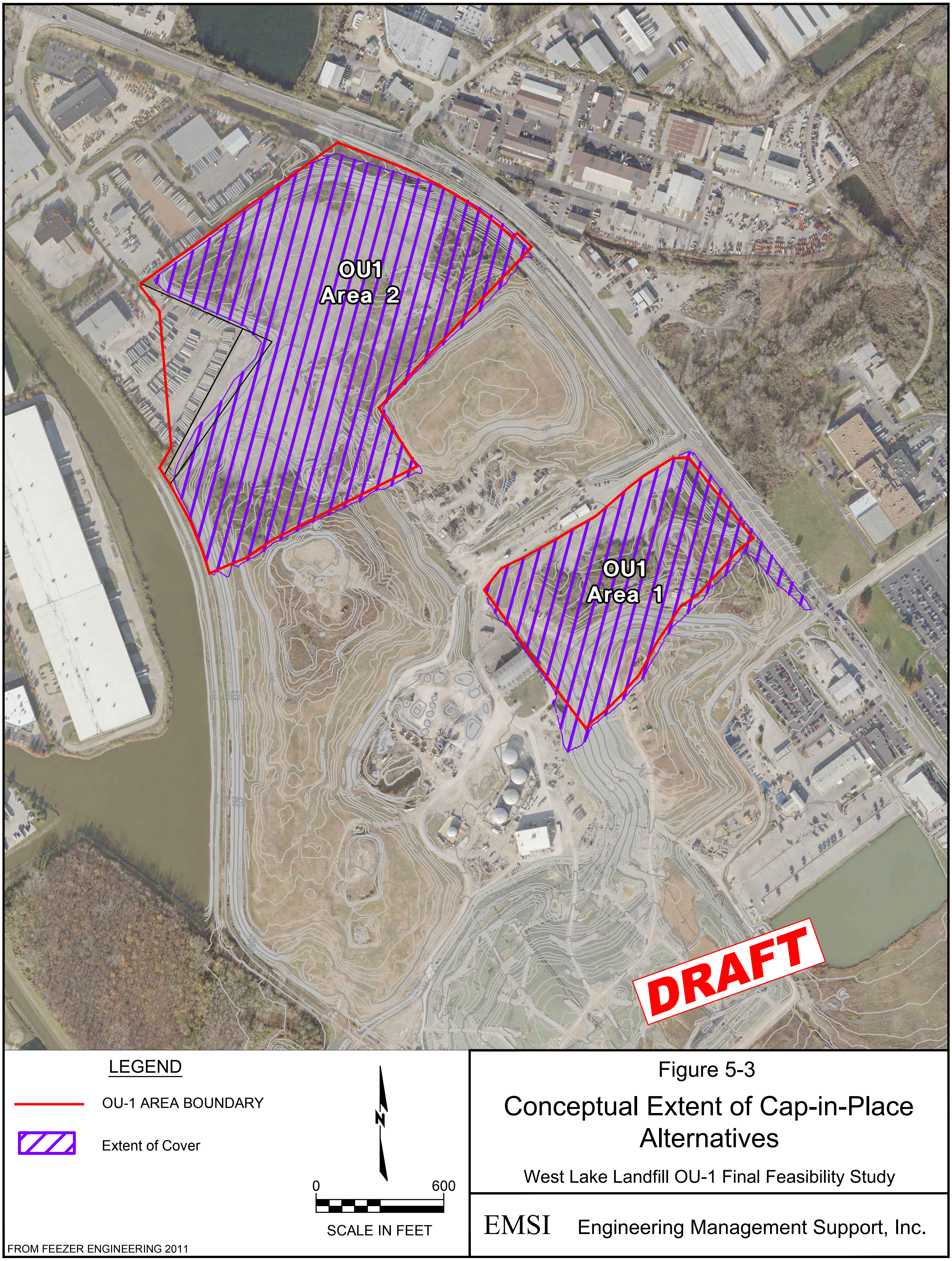
Figure 5-2

Areas with Slopes Greater than 25%
Area 2

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG5-1_5-2-25%-Slopes.dwg 1/10/2018



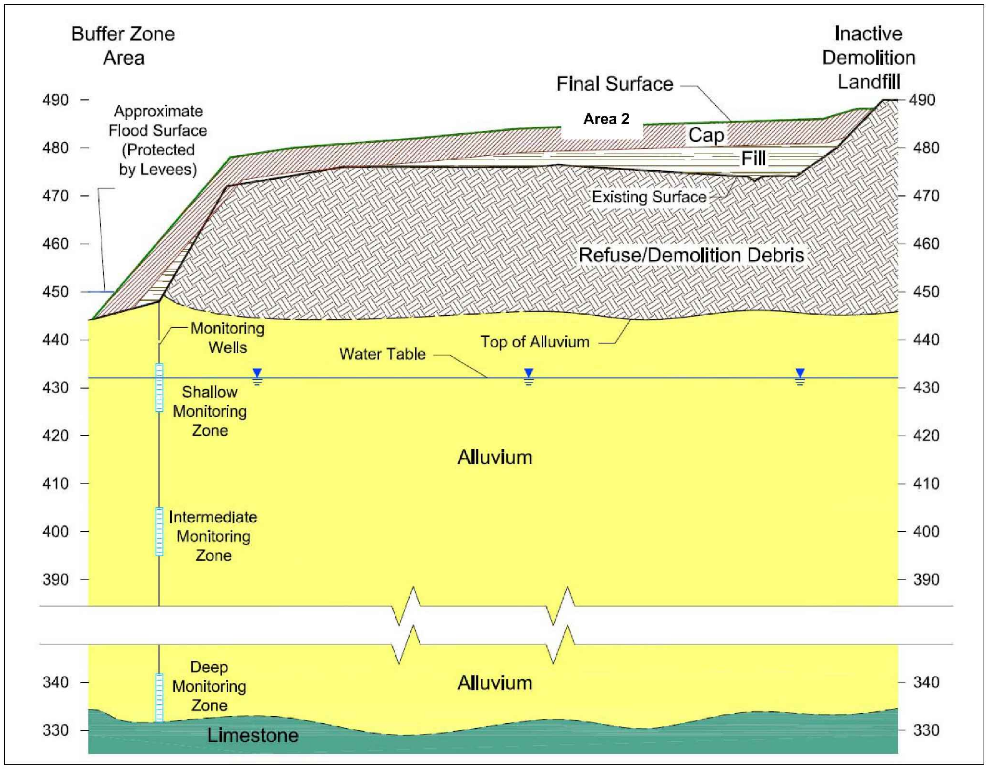
M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\Fig-5-3-Extent-ROD.dwg 1/10/2018

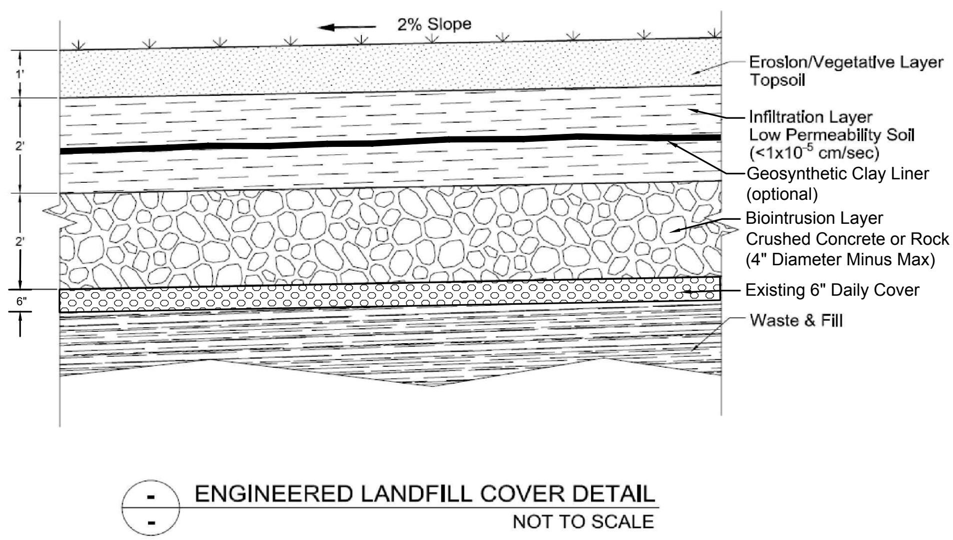
Figure 5-3

Conceptual Extent of Cap-in-Place Alternatives

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.





DRAFT

Figure 5-4

Conceptual Cross-Section of the ROD Remedy Landfill Cover

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\Fig-5-4-Concept-Xsec.dwg plotted: 01/10/2018

LEGEND

OU-1 AREA BOUNDARY

N

0 600

SCALE IN FEET

FROM FEEZER ENGINEERING 2011

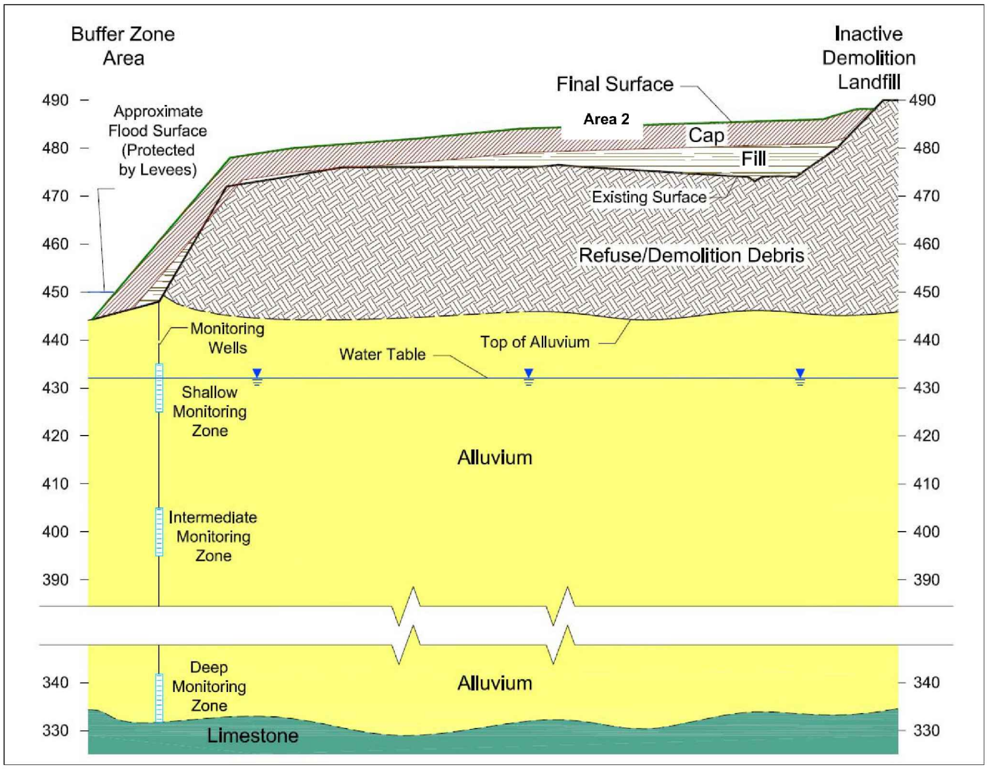
Figure 5-5

Potential Material Stockpile Areas

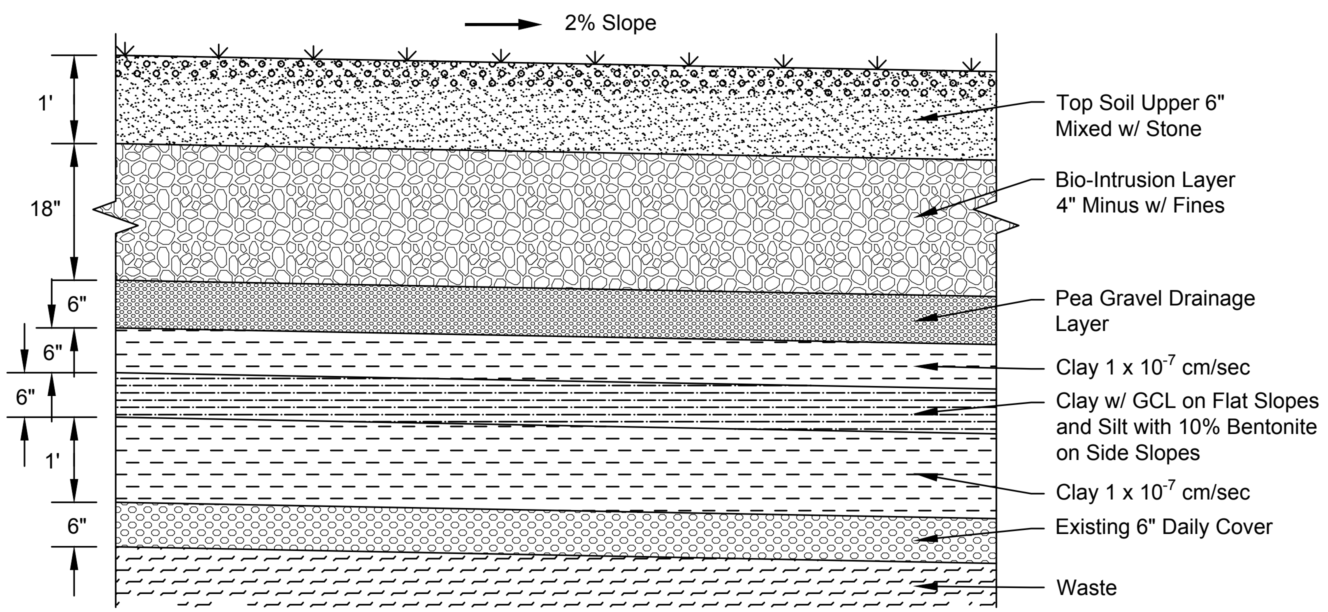
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\Fig-5-5-Pot-Stkpile-areas.dwg 4/14/2015



West Lake Concept Final Cover



DRAFT

NOT TO SCALE

Figure 5-6
Conceptual Cross-Section of UMTRCA Cap

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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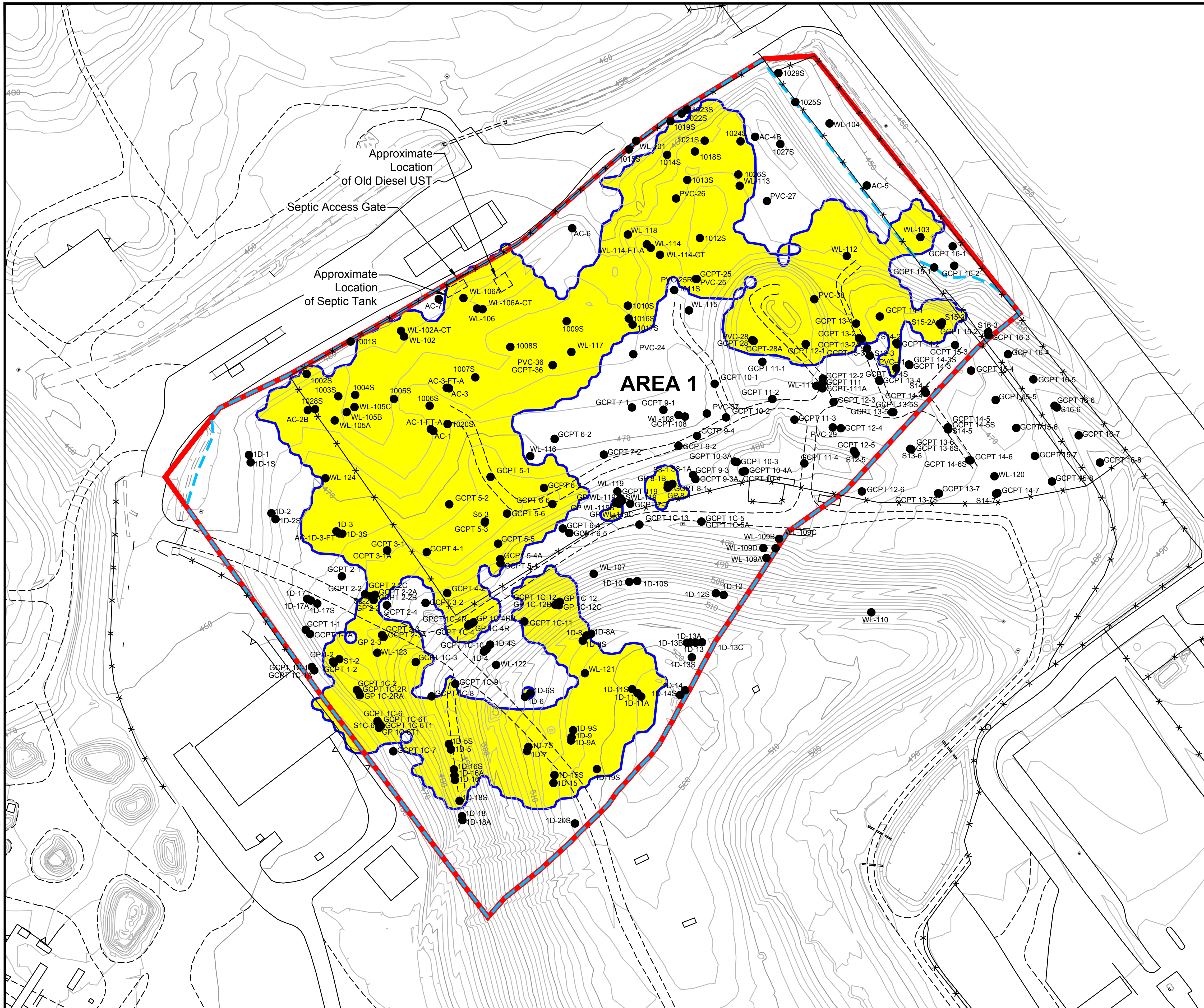

LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- Geostatistical-Based Estimate of RIM Extent (>7.9 pCi/g)
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

DRAFT

150 0 150
SCALE IN FEET

Figure 5-7
Approximate Extent of RIM-Area 1 "Full Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-7_5-8-Extent-RIM-7_9.dwg 1/10/18

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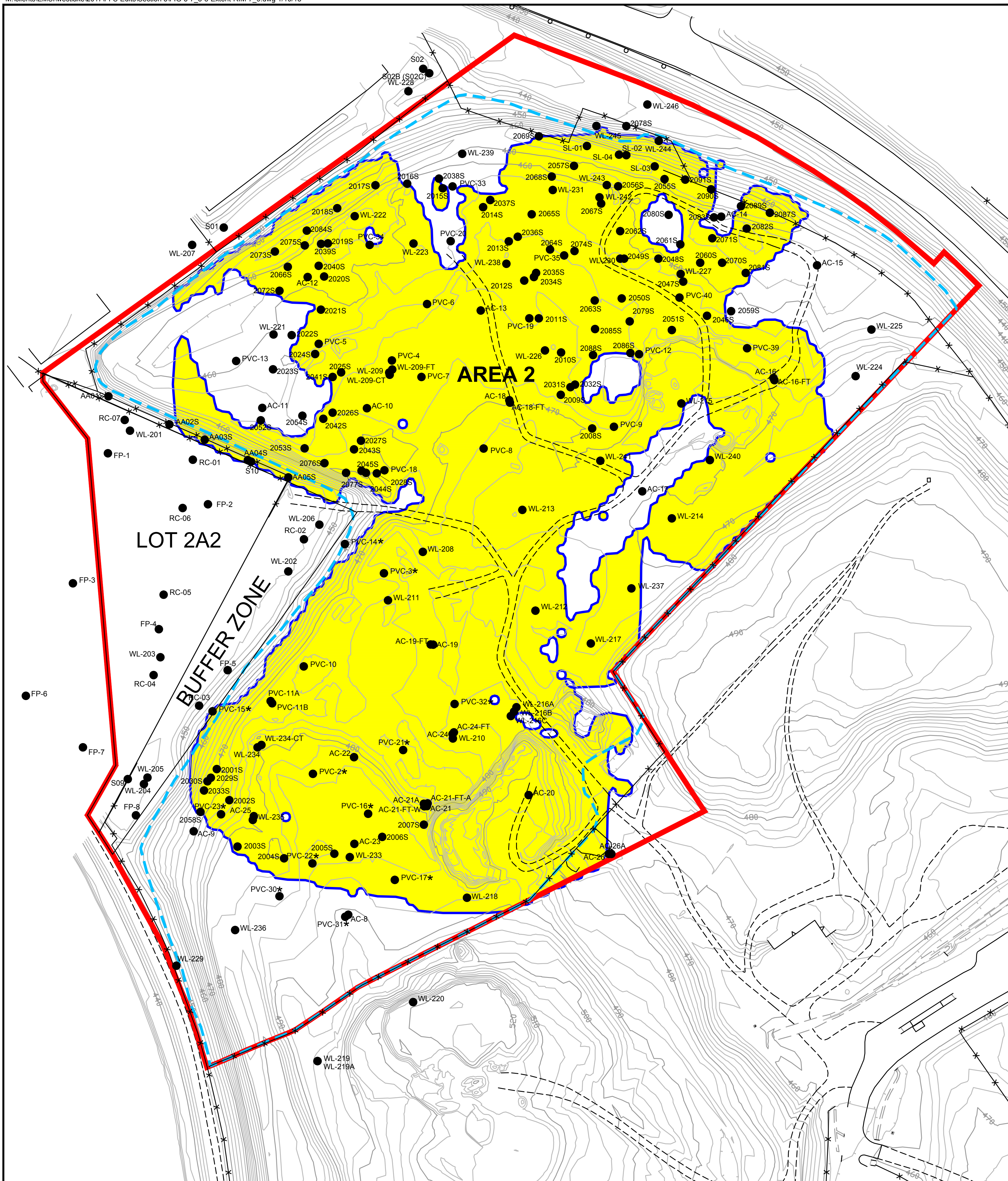


LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- ● Soil Boring or Surface Soil Sample
- * Location Approximate-No Survey Data Available
- Geostatistical-Based Estimate of RIM Extent (>7.9 pCi/g)
- 490 Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

DRAFT

200 0 200
SCALE IN FEET

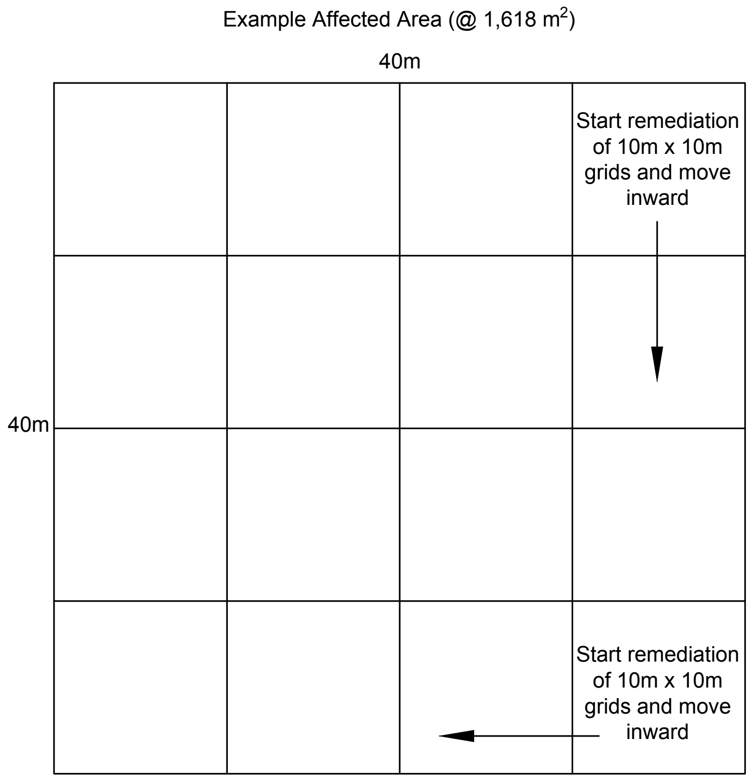
Notes:
- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 5-8
Approximate Extent of RIM-Area 2 "Full Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

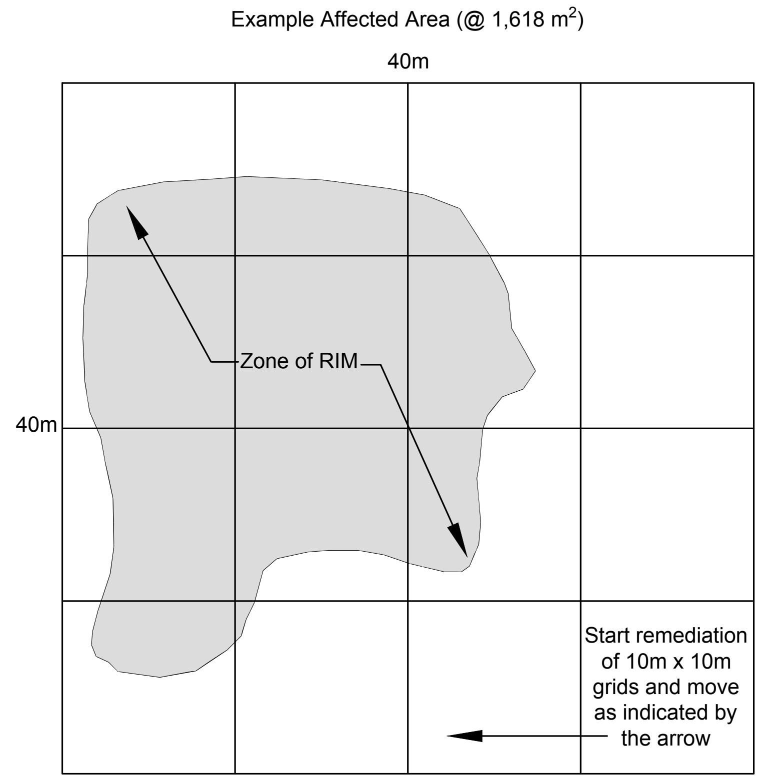
EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\Fig-5-9-RIM-Seq.dwg 1/10/2018



The soil would be excavated from the boundary inward, allowing movement of the hauling equipment closer to the excavator to try to increase efficiency and prevent the spread of contamination.

Example of Excavation Plan Logistics



Continue Excavation Along Edges of RIM

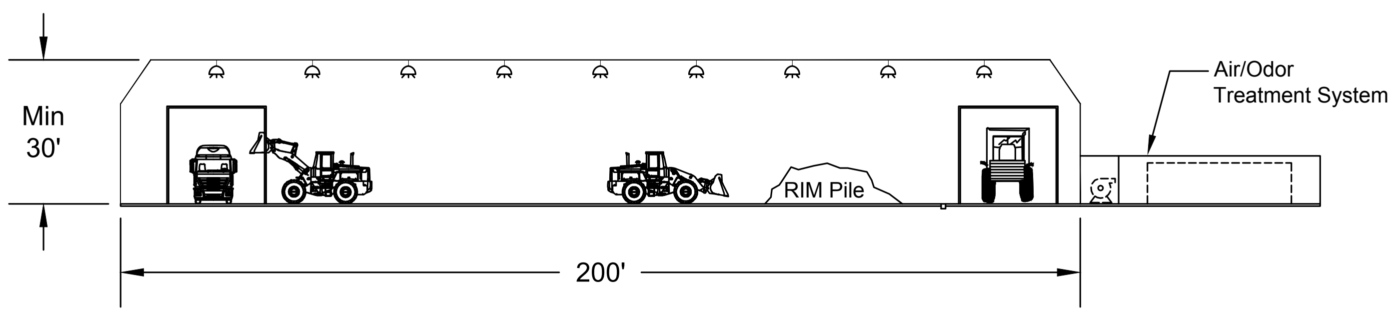
DRAFT

Figure 5-9

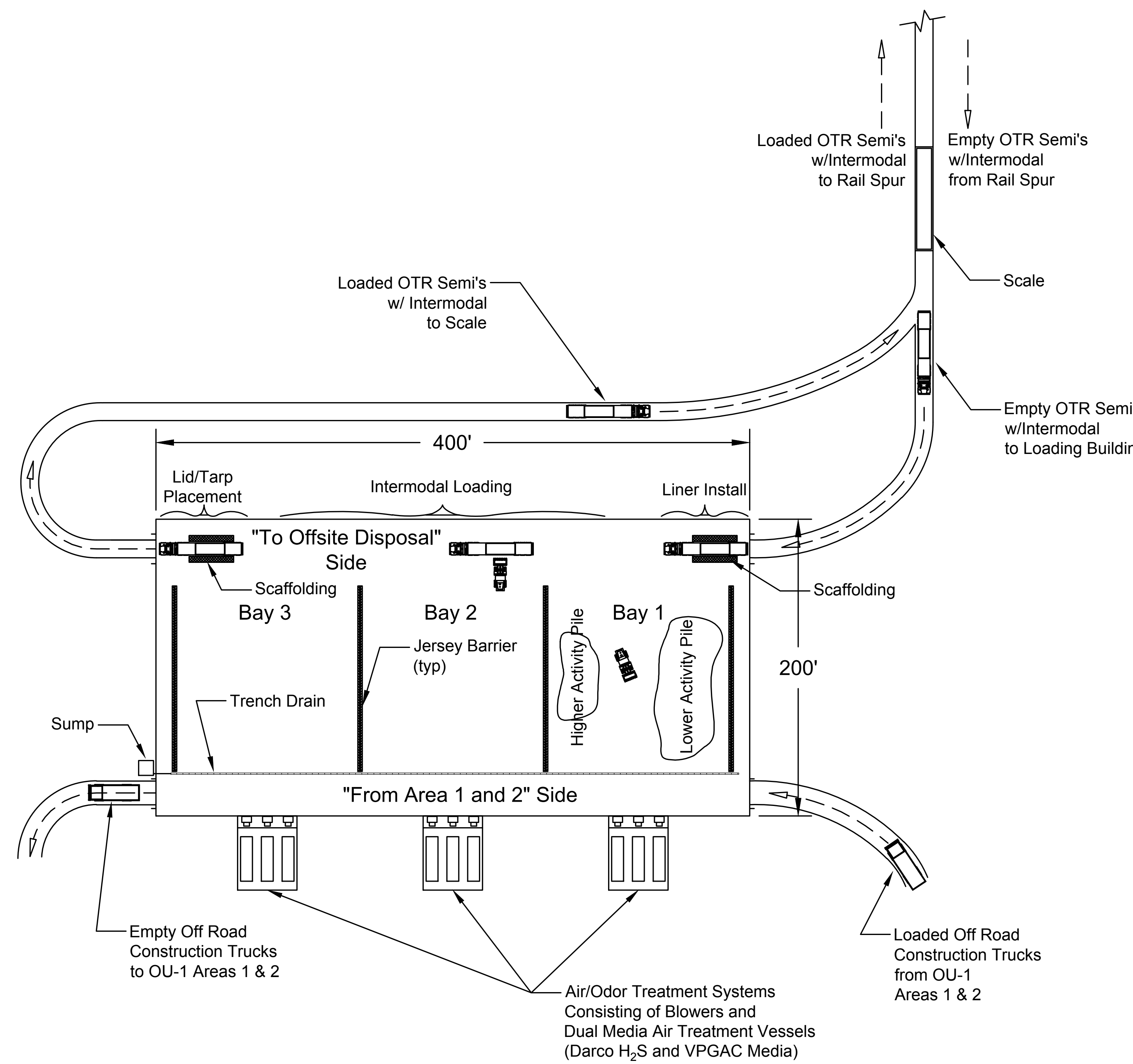
RIM Excavation Sequencing

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



END VIEW
(End Wall Removed for Clarity)
N.T.S.



PLAN VIEW
N.T.S.

DRAFT

Figure 5-10

RIM Staging and Loading Building Layout

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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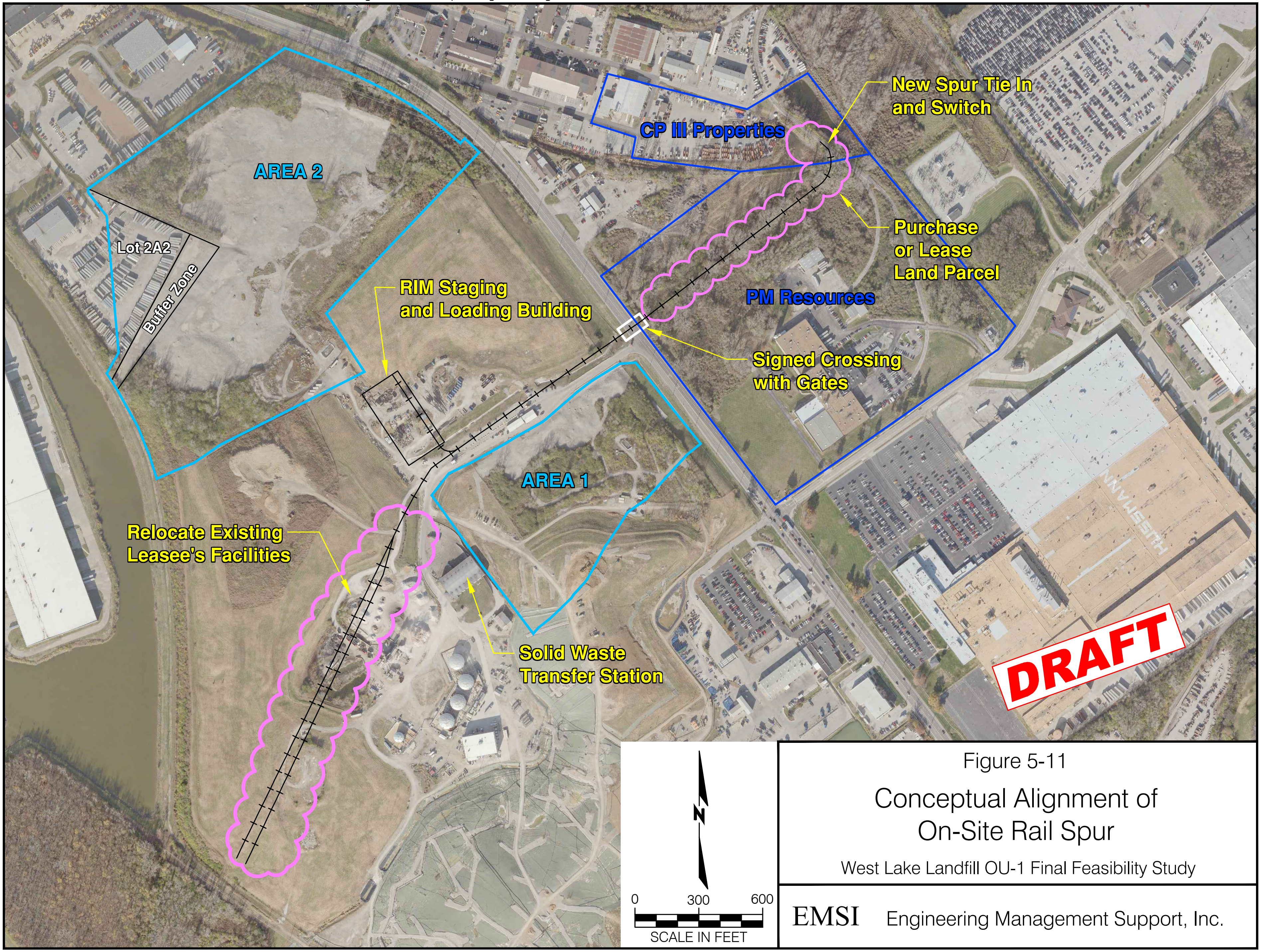
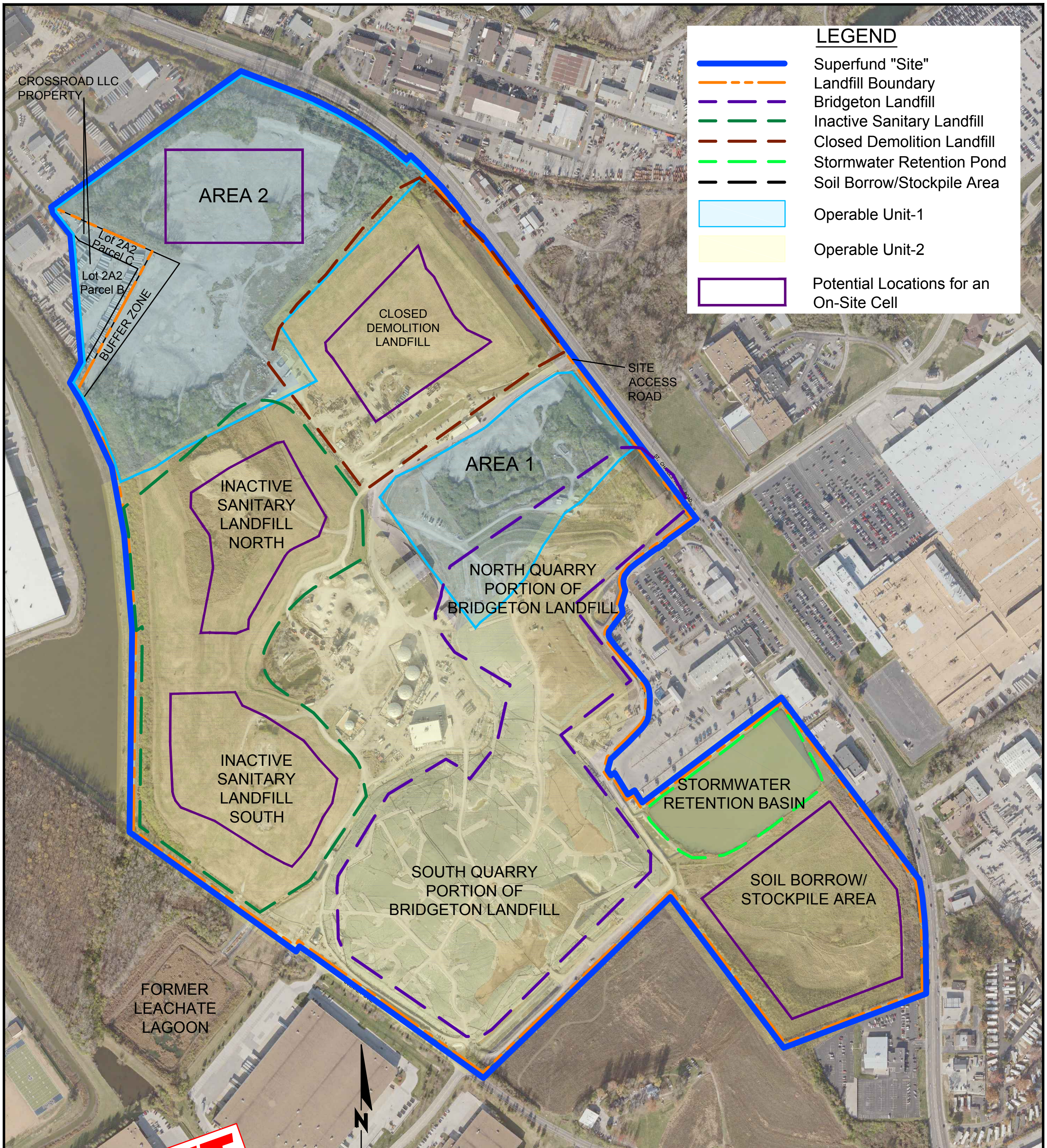


Figure 5-11

Conceptual Alignment of
On-Site Rail Spur

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-12-On-Site-Cells.dwg 1/10/2018

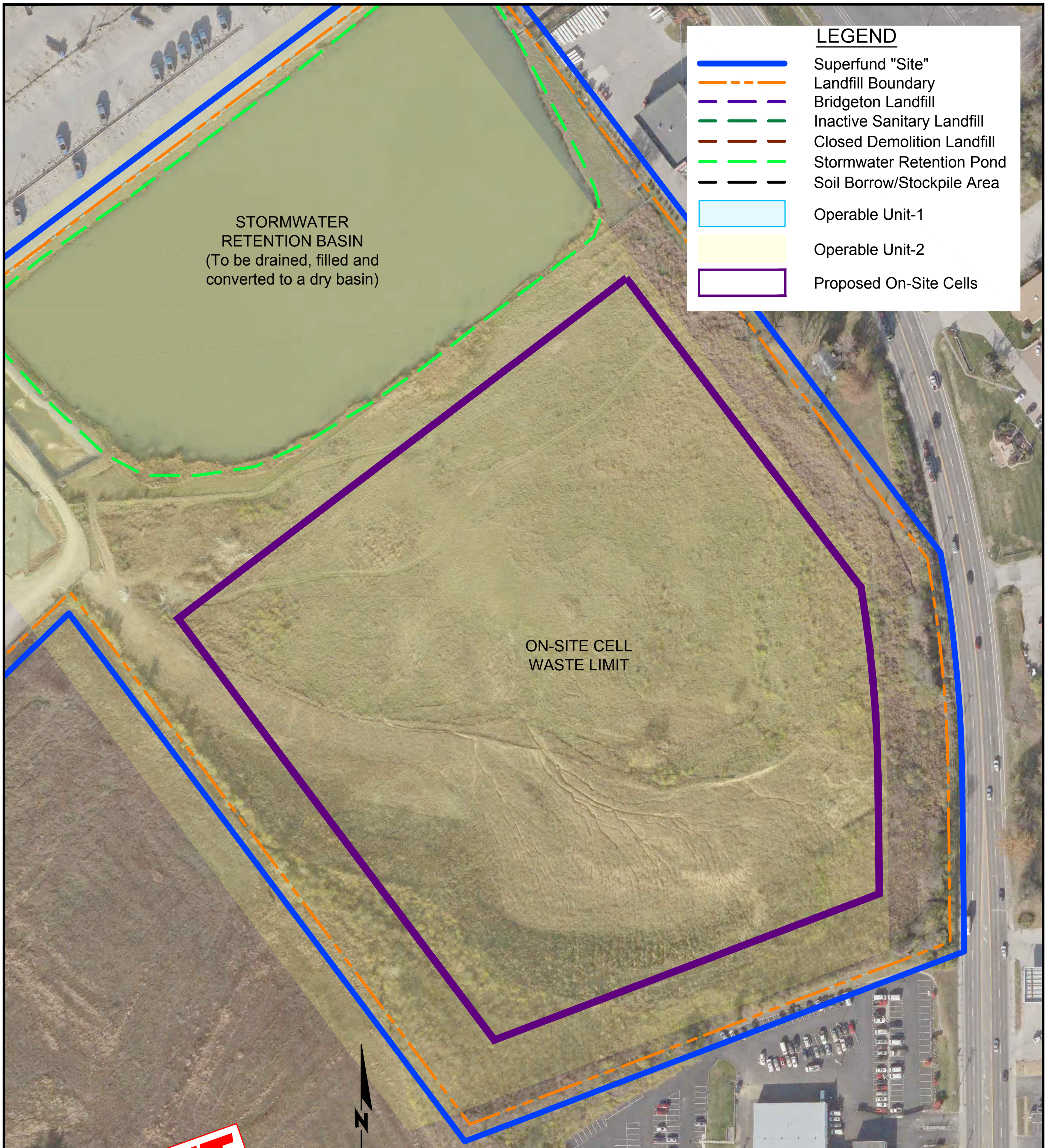
Figure 5-12

Potential Locations for an On-Site Disposal Cell

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

Notes:
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)



DRAFT

N

0 100 200

SCALE IN FEET

Notes:

- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 5-13

Conceptual On-Site Cell Location

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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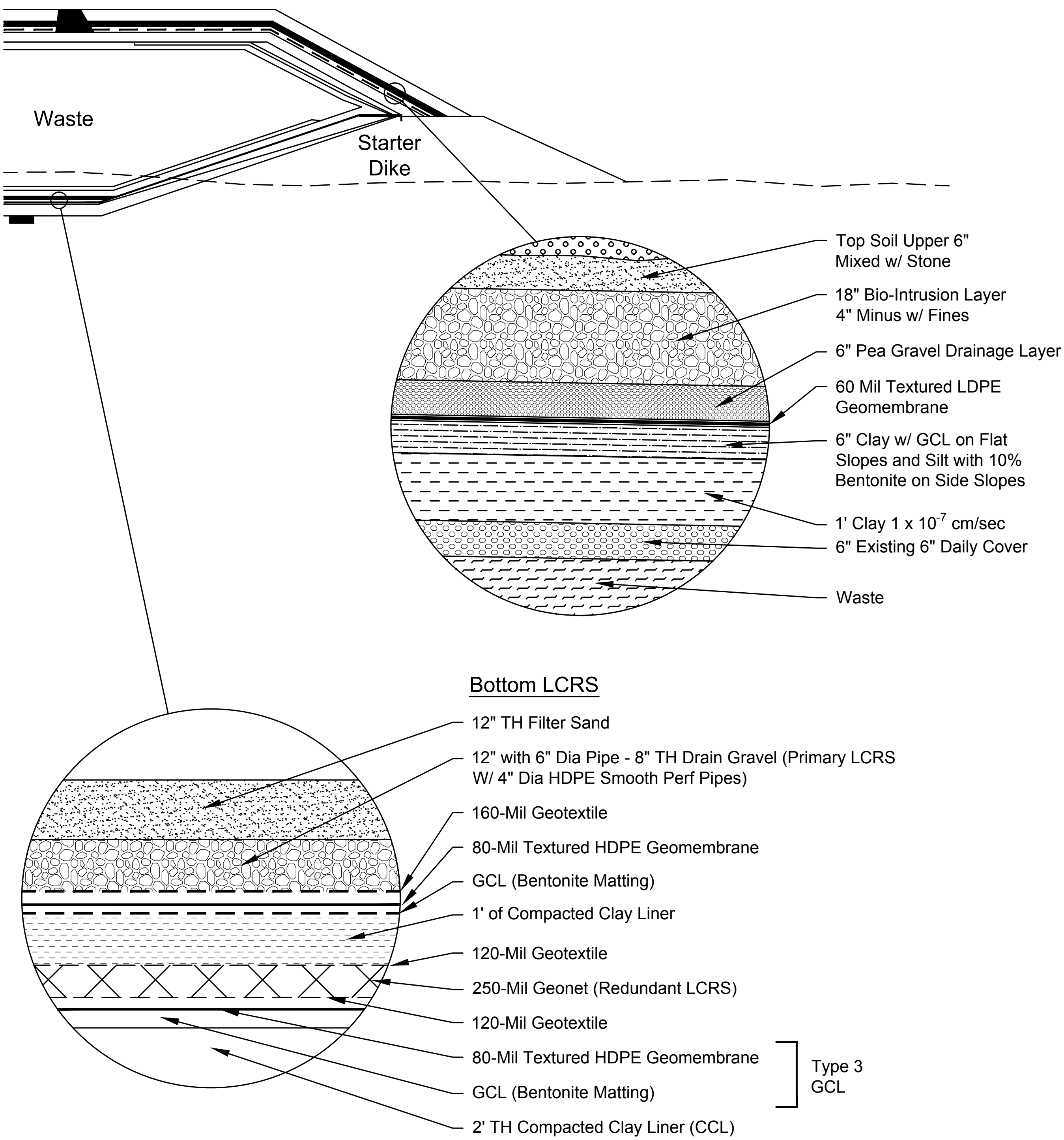


DRAFT

NOT TO SCALE

Figure 5-14

Conceptual Design of On-Site Cell

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\Fig-5-14-Conceptual-Design-Cell.dwg 1/10/2018

LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- Geostatistical-Based Estimate of RIM Extent (>52.9 pCi/g <16' Below 2005 Topographic Surface)
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

Notes:

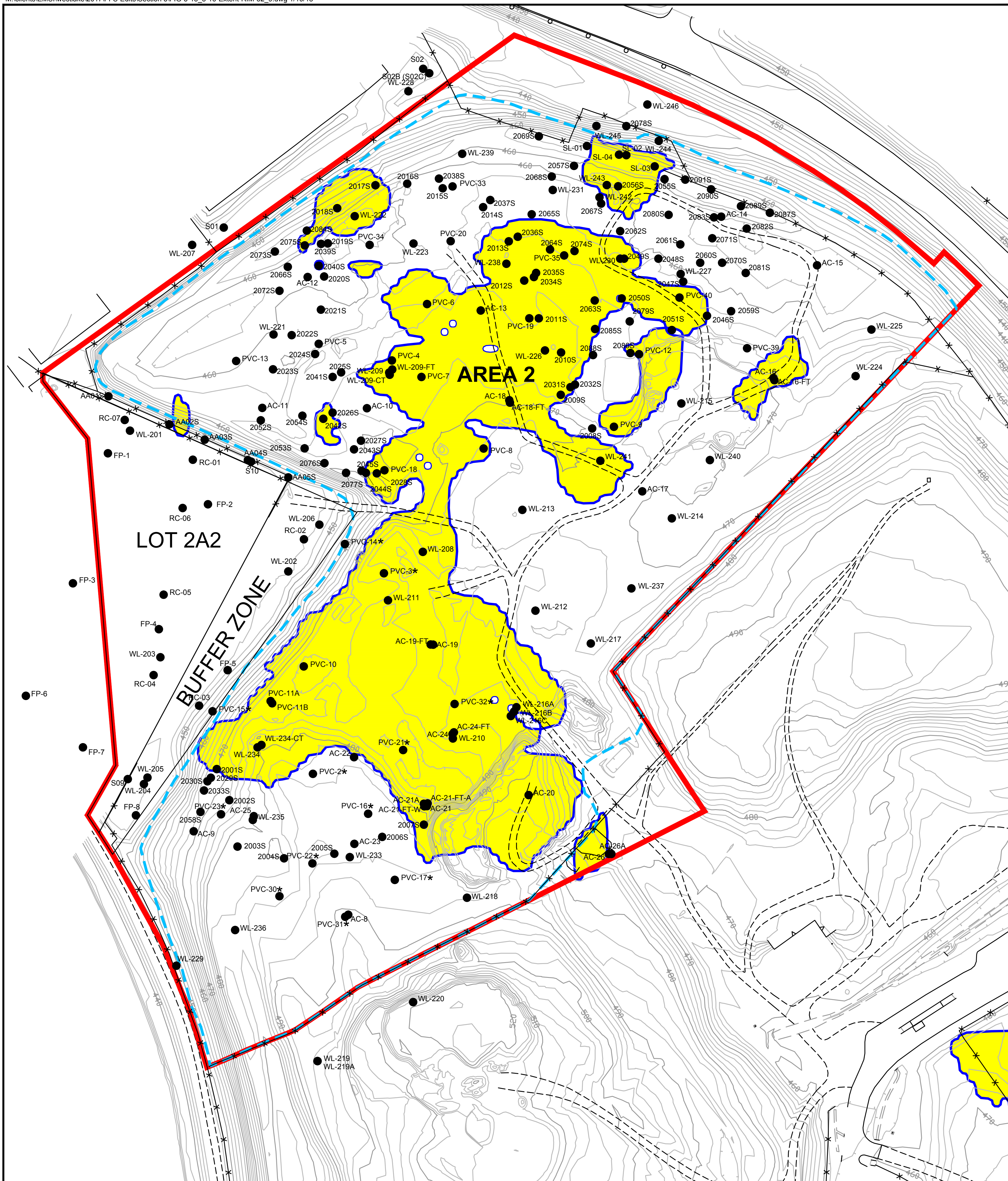
- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 5-15
Approximate Extent of RIM-Area 1 (>52.9 pCi/g & <16' Deep) "Partial Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-15_5-16-Extent-RIM-52_9.dwg 1/10/18



LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- * Location Approximate-No Survey Data Available
- Geostatistical-Based Estimate of RIM Extent (>52.9 pCi/g & <16' Below 2005 Topographic Surface)
- 490 Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

DRAFT

200 0 200

SCALE IN FEET

N

Notes:

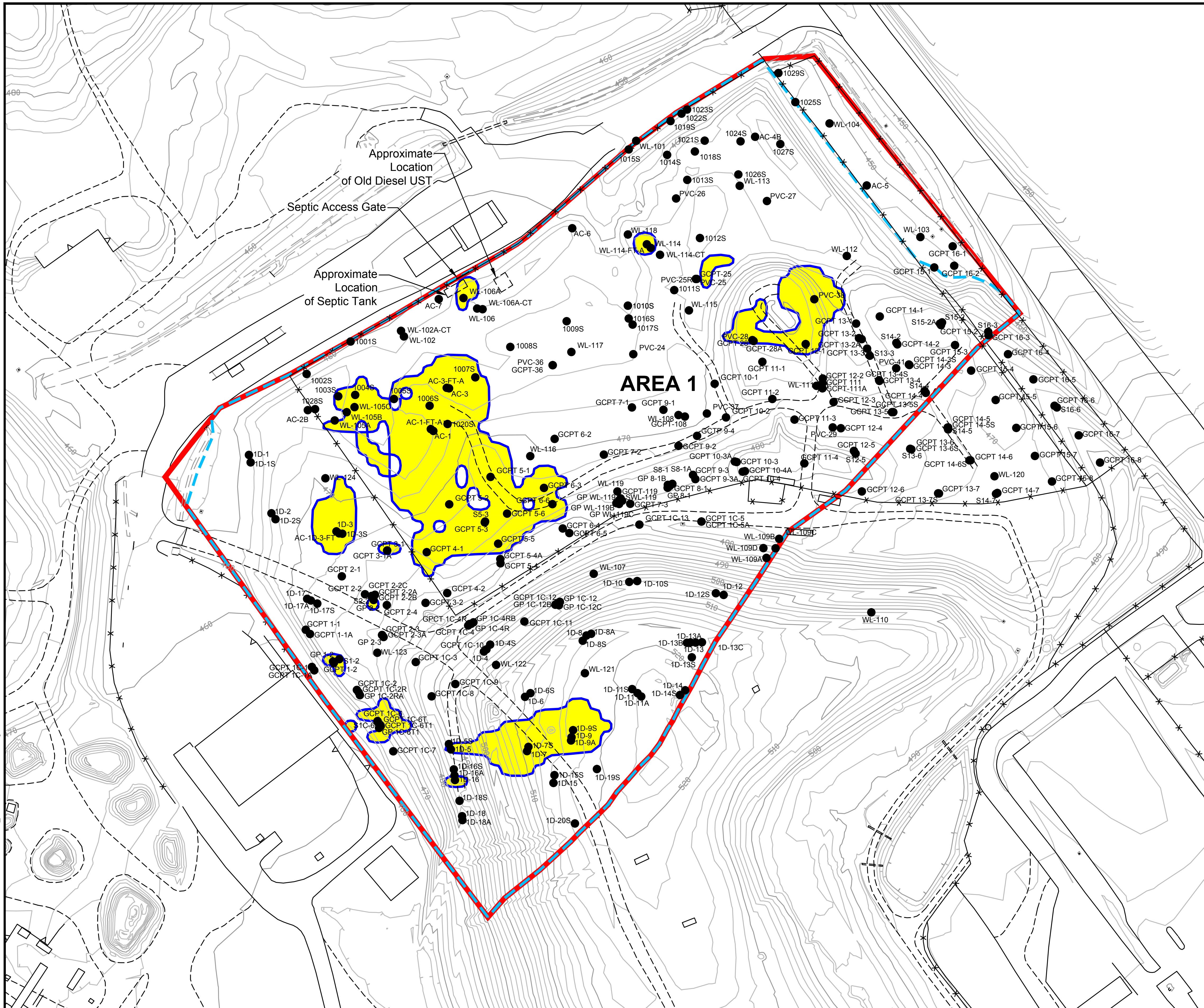
- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 5-16

Approximate Extent of RIM-Area 2 (>52.9 pCi/g & <16' Deep) "Partial Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- Geostatistical-Based Estimate of RIM Extent
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

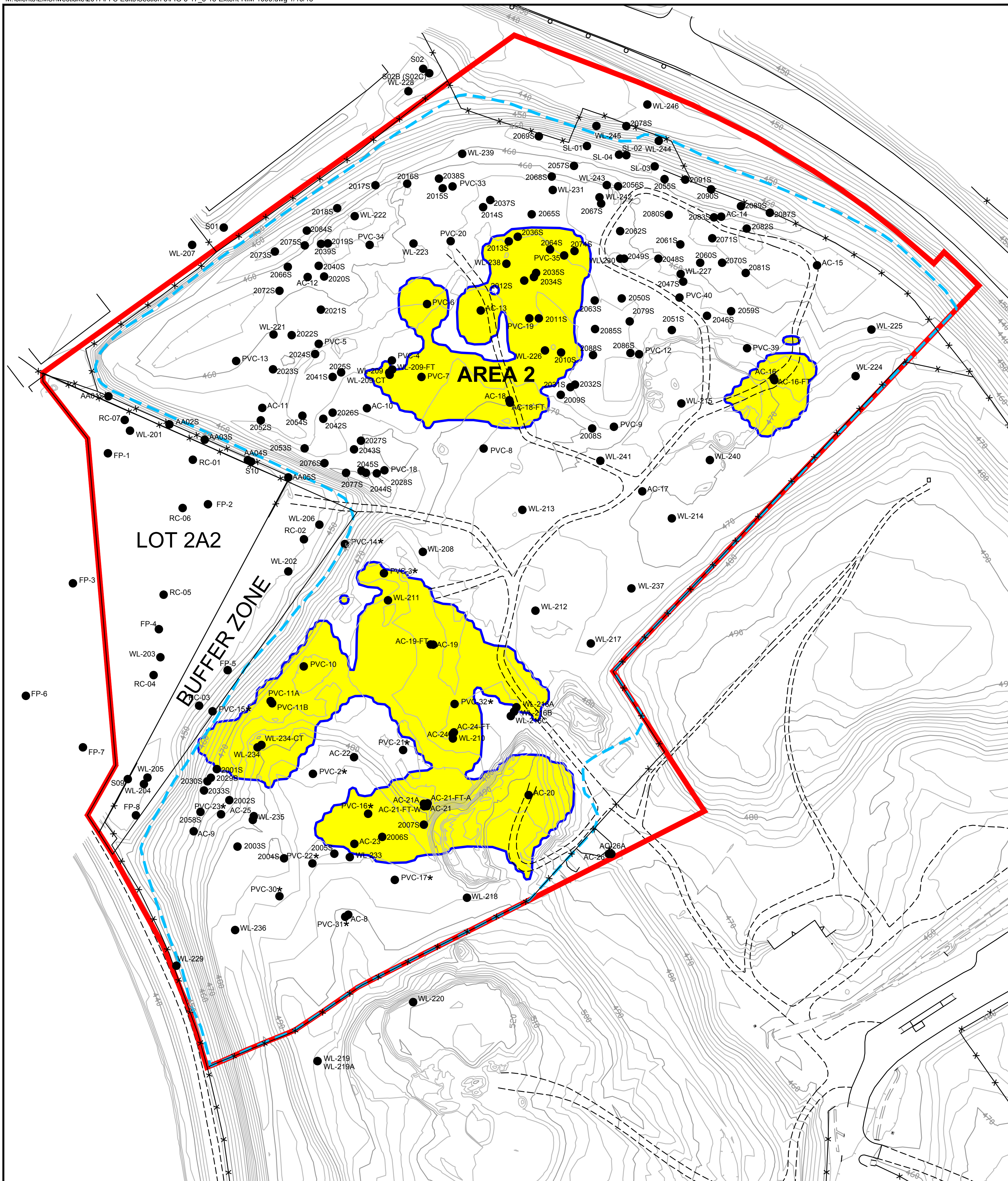
150 0 150
SCALE IN FEET

Figure 5-17
Approximate Extent of RIM-Area 1
1,000 pCi/g
"Partial Excavation" Alternative
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-17_5-18-Extent-RIM-1000.dwg 1/10/18

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-17_5-18-Extent-RIM-1000.dwg 1/10/18



LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample
- * Location Approximate-No Survey Data Available
- Geostatistical-Based Estimate of RIM Extent
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

DRAFT

200 0 200

SCALE IN FEET

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

Figure 5-18

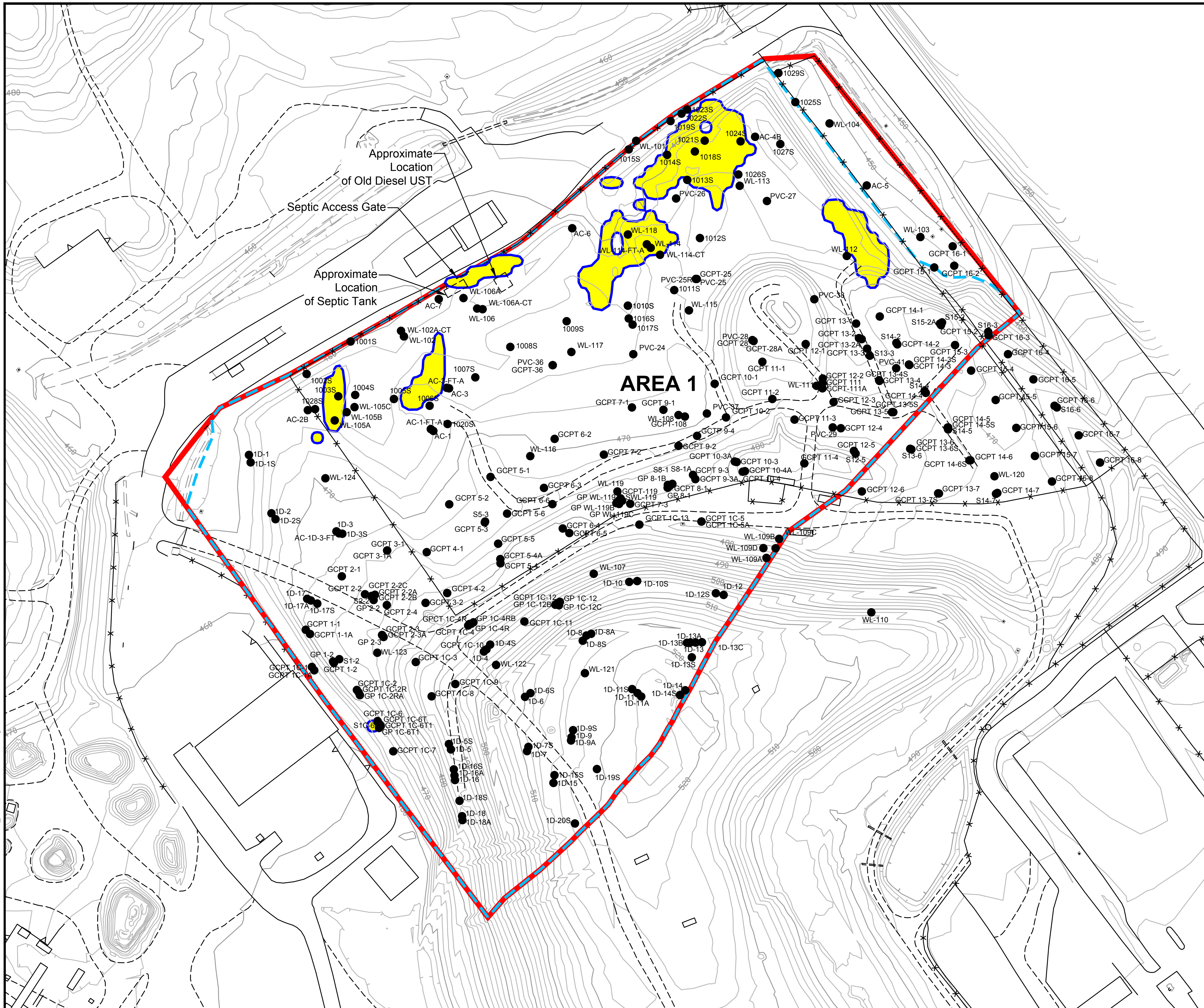
Approximate Extent of RIM-Area 2

1,000 pCi/g

"Partial Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- Soil Boring or Surface Soil Sample (See Figure 4-5 for Additional Information)
- Geostatistical-Based Estimate of RIM Extent
- Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

150 0 150

SCALE IN FEET

Figure 5-19

Approximate Extent of RIM-Area 1 "Risk Based Partial Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 5\FIG-5-19_5-20-Extent-RIM-RBPE.dwg 1/10/18

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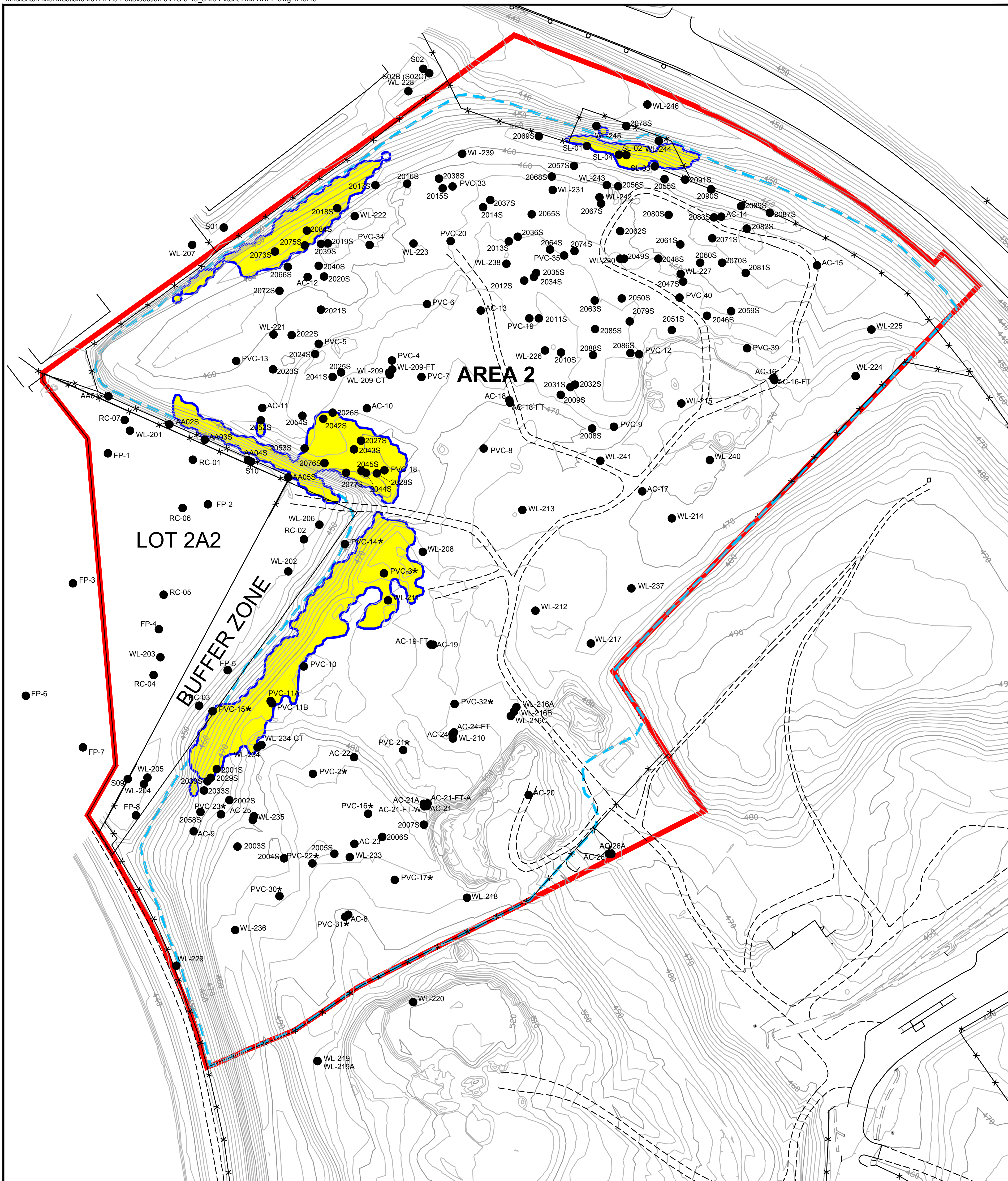


LEGEND

- OU-1 Area Boundary
- Approximate Edge of Refuse
- ● Soil Boring or Surface Soil Sample (See Figure 4-5 for Additional Information)
- * Location Approximate-No Survey Data Available
- Geostatistical-Based Estimate of RIM Extent
- 490 Index Contour
- Intermediate Contour
- Depression Contour
- Building/Structure
- Paved Road
- Unpaved Road
- Fence
- Retaining Wall

DRAFT

Notes:

- The Areal Extent of RIM Shown on this Figure does not Represent a Contiguous Layer, but Rather Portrays the Composite Occurrence of RIM at all Depths/Elevations
- Aerial Topography Provided By Cooper Aerial Surveys Co. and is Dated December 2, 2016
- All Elevations Are Above Mean Sea Level (amsl)

N

200 0 200

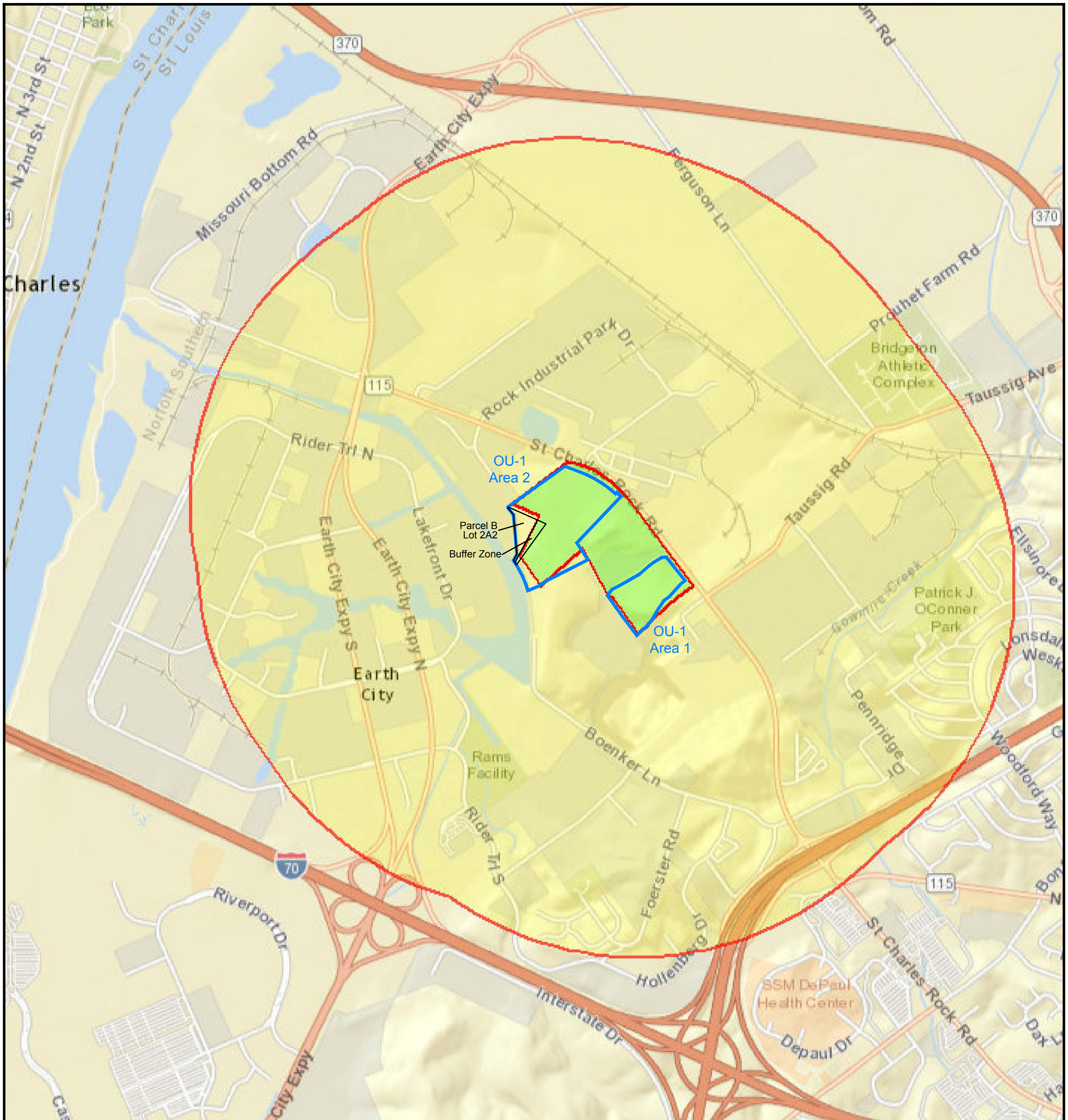
SCALE IN FEET

Figure 5-20

Approximate Extent of RIM-Area 2 "Risk Based Partial Excavation" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



August 13, 2016

Digitized Polygon

1 Mile Buffer Area

1:36,112

0 | 0.3 | 0.6 | 1.2 mi

0 | 0.5 | 1 | 2 km

DRAFT

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 6-1

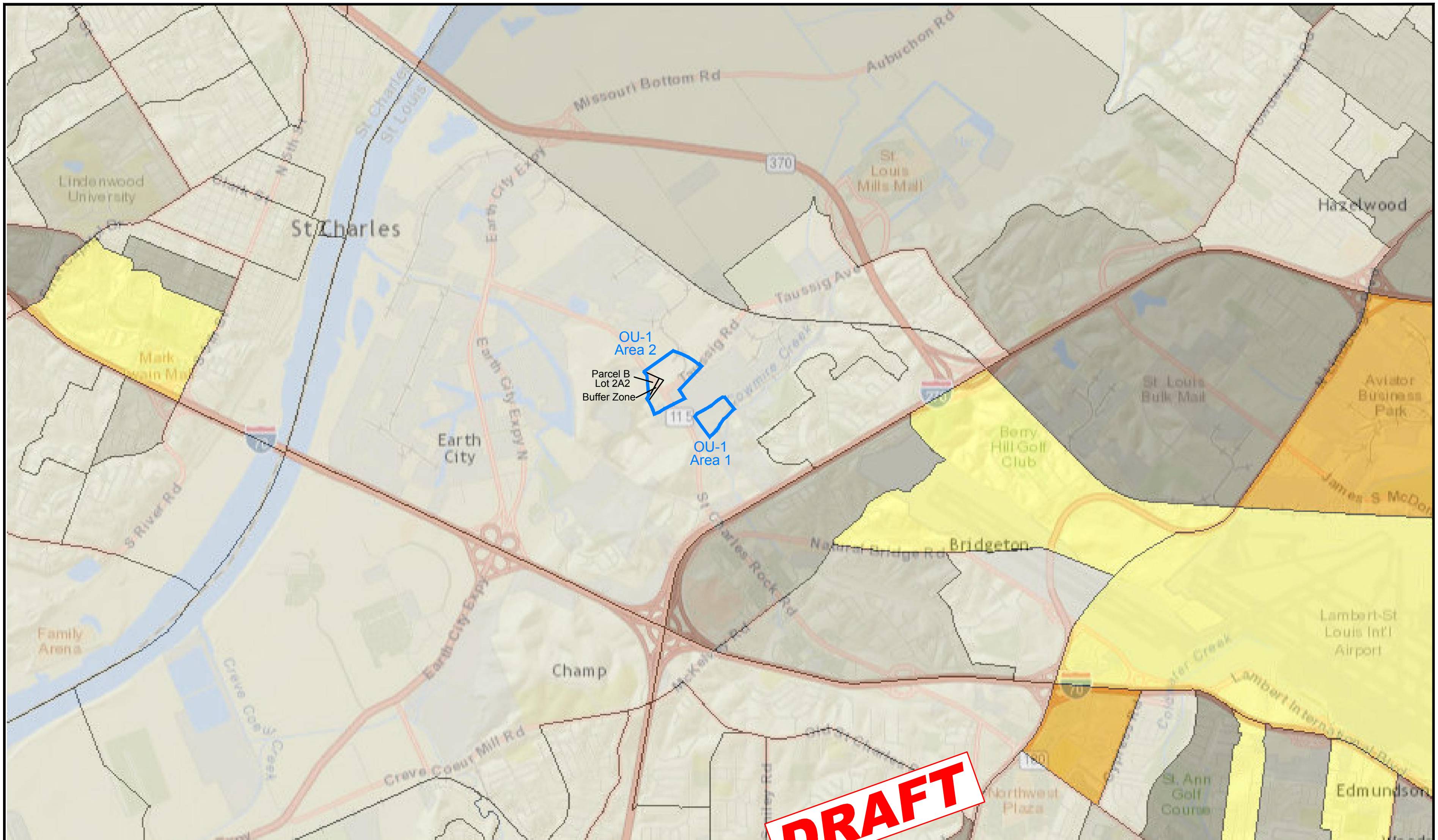
1 Mile Buffer

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-1_1mile-Buffer.dwg 8/21/2017

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-2_Demographic-Index.dwg 8/21/2017



August 13, 2016

EJSCREEN_Indexes

- Data not available
- Less than 50 percentile
- 50 -60 percentile
- 60 -70 percentile
- 70 -80 percentile
- 80 - 90 percentile
- 90 - 95 percentile
- 95 - 100 percentile

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand),

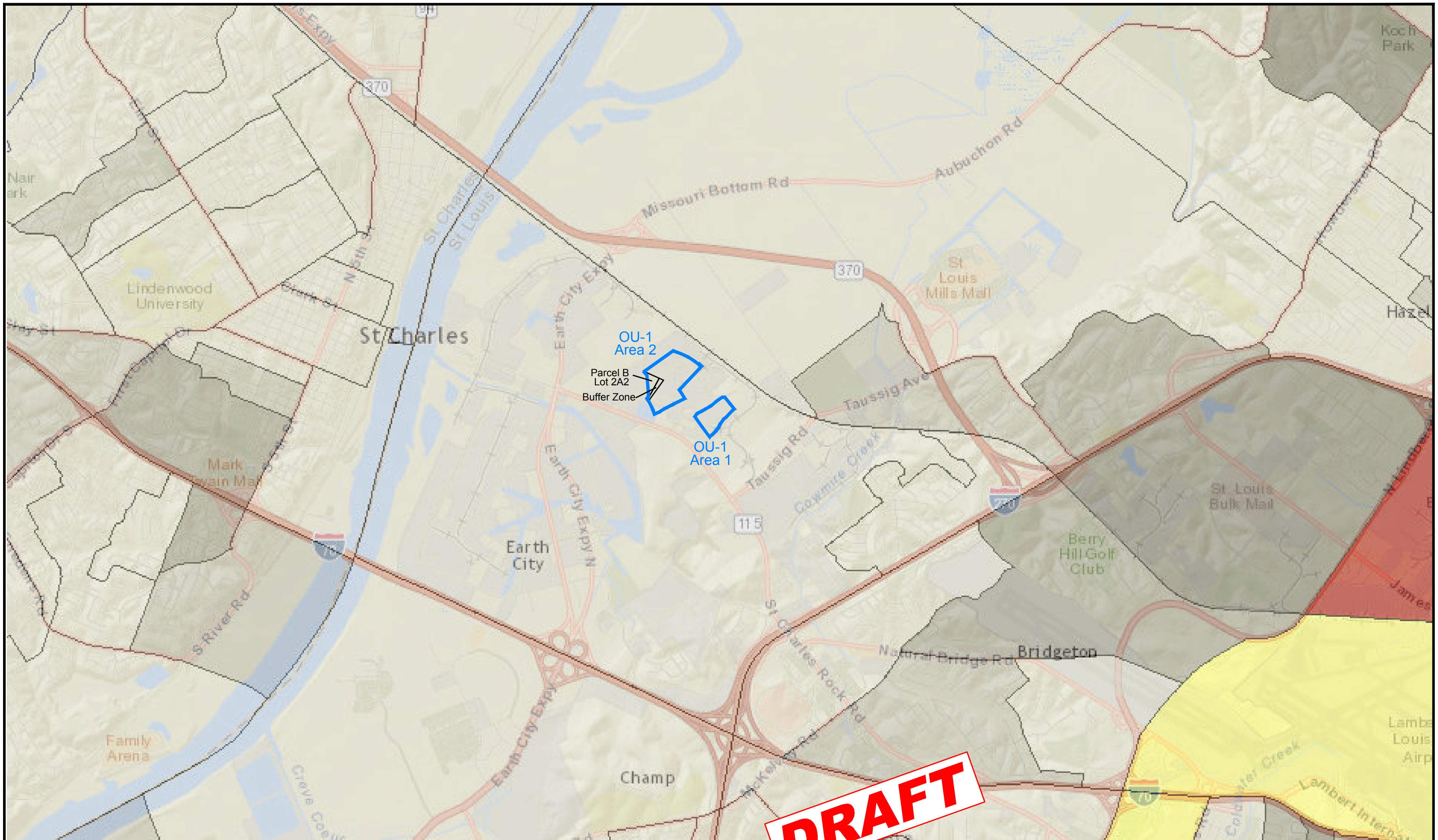
Figure 6-2

Demographic Index

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-3_Minority.dwg 8/21/2017



August 13, 2016

EJSCREEN_Indexes

- Data not available
- Less than 50 percentile
- 50 -60 percentile
- 60 -70 percentile
- 70 -80 percentile
- 80 - 90 percentile
- 90 - 95 percentile
- 95 - 100 percentile

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand),

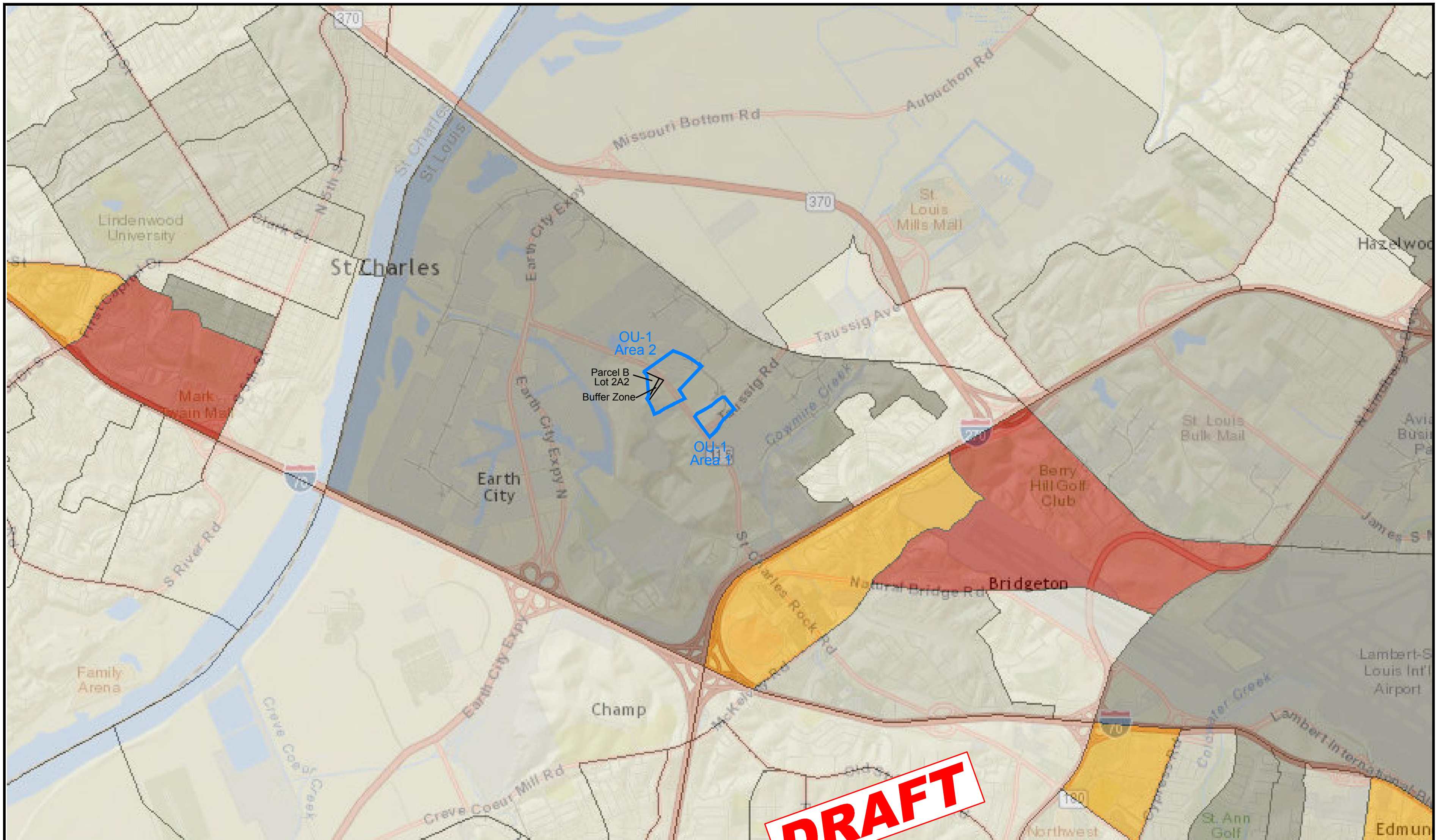
Figure 6-3

Minority Population Index

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-4_Low Income.dwg 8/21/2017



August 13, 2016

EJSCREEN_Indexes

- Data not available
- Less than 50 percentile
- 50 -60 percentile
- 60 -70 percentile
- 70 -80 percentile
- 80 - 90 percentile
- 90 - 95 percentile
- 95 - 100 percentile

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand),

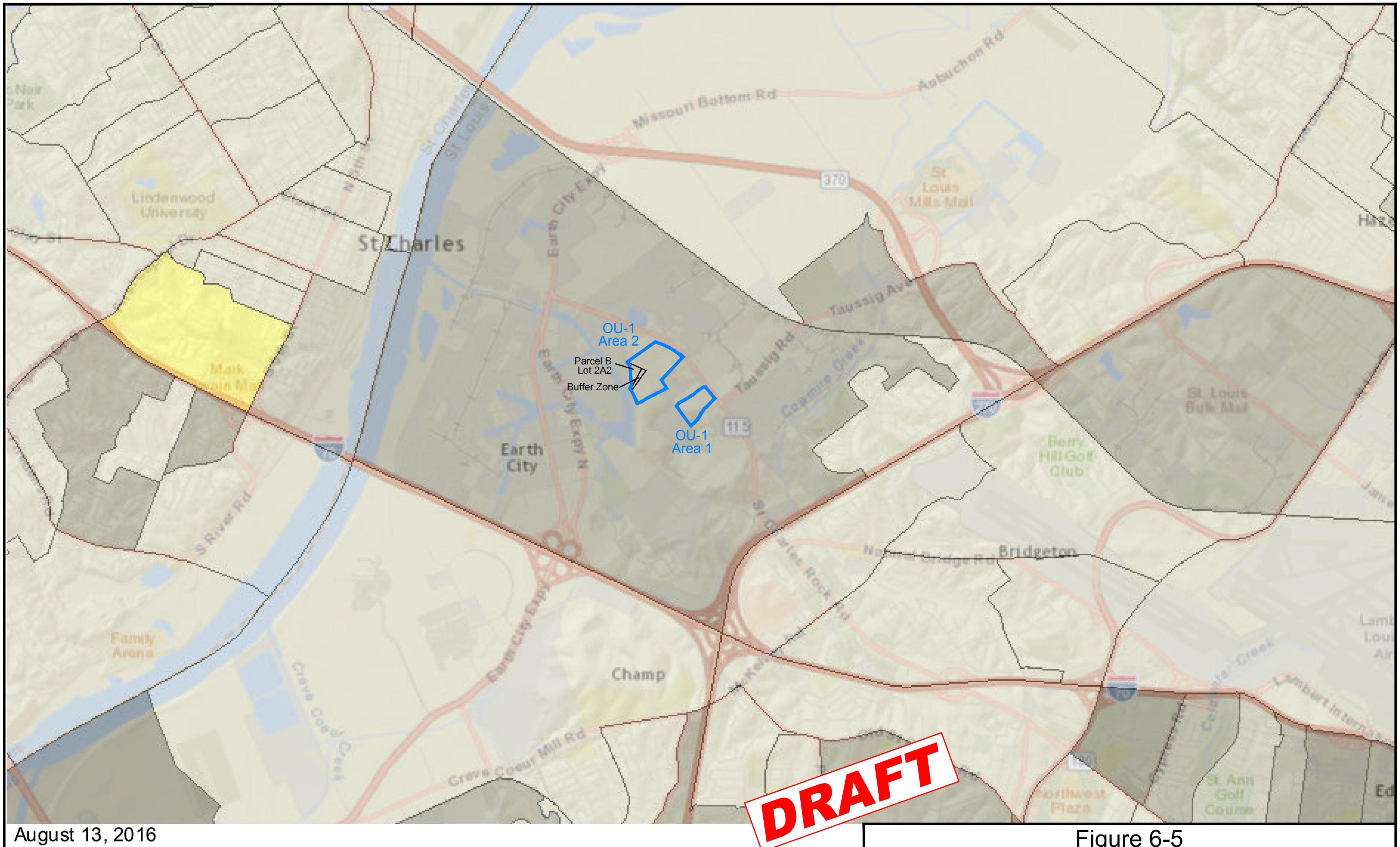
Figure 6-4

Low Income Index

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-5_Linguistically-Isolated.dwg 8/21/2017



August 13, 2016

EJSCREEN_Indexes

☐	Data not available
☐	Less than 50 percentile
☐	50 -60 percentile
☐	60 -70 percentile
☐	70 -80 percentile
☐	80 - 90 percentile
☐	90 - 95 percentile
☐	95 - 100 percentile

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand),

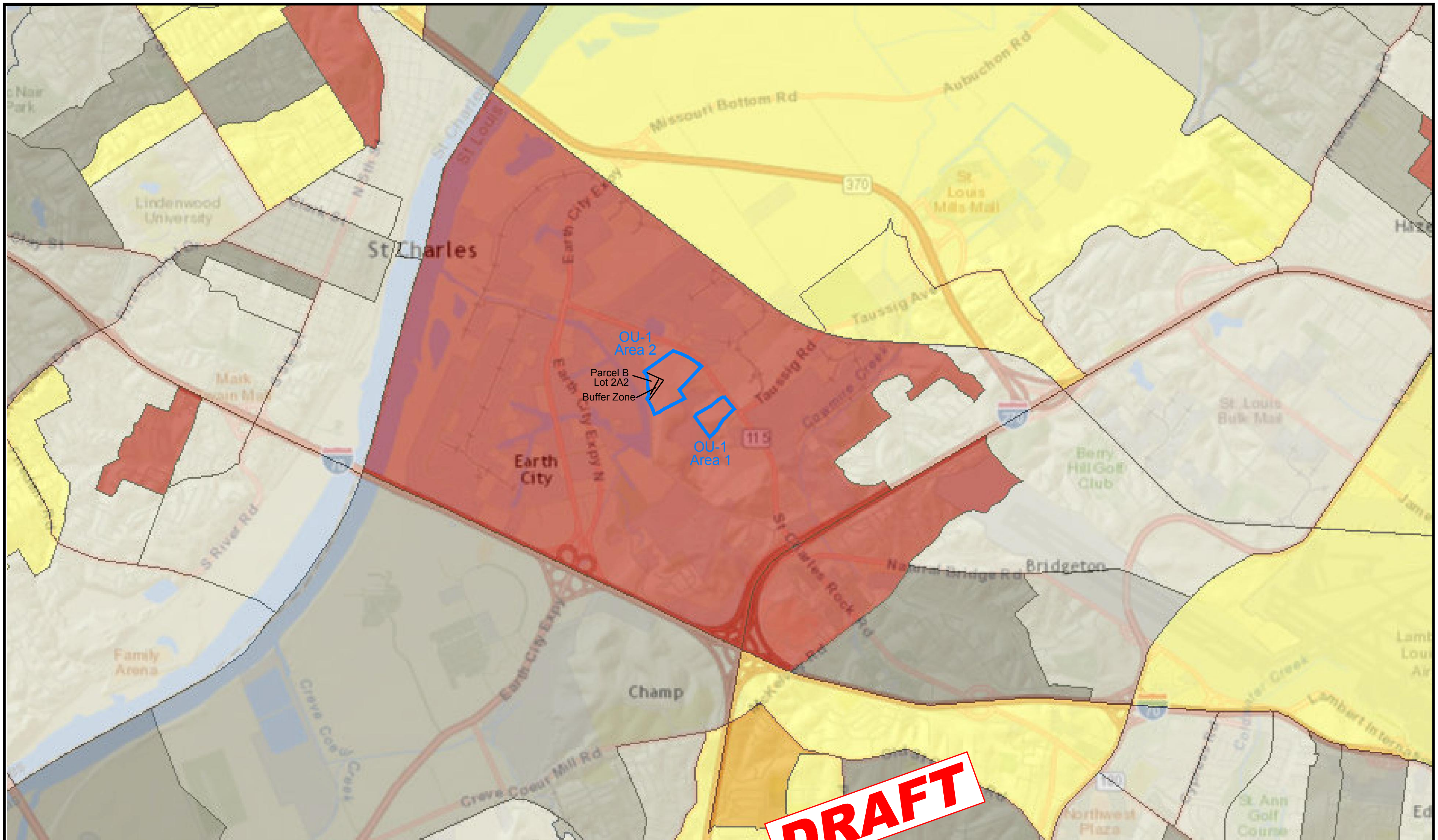
Figure 6-5

Linguistically Isolated Index

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2017\FFS-Edits\Section 6\FIG-6-6_Over-64.dwg 8/21/2017



August 13, 2016

EJSCREEN_Indexes

Legend	
Data not available	50 -60 percentile
Less than 50 percentile	60 -70 percentile
80 - 90 percentile	70 -80 percentile
90 - 95 percentile	95 - 100 percentile

1:72,224

0 0.5 1 2 mi

0 1 2 4 km

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand),

Figure 6-6

Over 64 Years of Age Index

West Lake Landfill OU-1 Final Feasibility Study

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