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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 evaluations 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), the EPA's December 9, 2015 Statement of Work (SOW) for the RI Addendum and FFS, and the May 6, 2016 Abbreviated Work Plan for the RI Addendum and FFS.

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) and a 1.78-acre parcel of land known as the Buffer Zone/Crossroad Property 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 these areas ended in 1974, at which time MSW disposal was shifted to other portions of the Site. 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, the use of Site soil and quarry spoil material that did not contain radionuclides above background levels as cover material during the same period of time, and the waste decomposition, consolidation and differential settlement that occurred over the subsequent 40 years has resulted in the occurrences of radionuclides in soil being interspersed and intermixed within portions of the MSW in Areas 1 and 2. In addition, although the Buffer Zone/Crossroad property was 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 2016 RI Addendum.

Consistent with the NCP, a Remedial Investigation (RI) and Feasibility Study (FS) were previously completed for OU-1 and approved by the 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 also conduct a similar analysis of two new alternatives to excavate all 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)[1].

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 Supplemental Feasibility Study (SFS) completed in 2011 and the original Feasibility Study (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 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). This FFS also presents additional evaluations of (1) the "complete rad removal" with off-site disposal alternative, which was one of two "complete rad removal" alternatives previously evaluated in the 2011 SFS; (2) a partial excavation alternative that would remove material containing either combined radium or combined thorium activities above 52.9 pCi/g and located within 16 feet of the 2005 topographic surface; and (3) a partial excavation alternative that would remove material containing either combined radium or combined thorium above 1,000 pCi/g, regardless of depth. The option to re-dispose the excavated material in an on-site engineered cell was previously removed from consideration by EPA, and therefore was not presented in the FFS. 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 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

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[1] Although a "complete rad removal" with on-site disposal alternative was evaluated in the SFS, EPA did not require this alternative to be further evaluated in the FFS.

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 potential effects of climate change, potential impacts of a tornado, the potential impacts of a subsurface reaction, and 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:

1. Protection of Public Health and the Environment

    - All of the remedial alternatives -- the ROD-selected remedy, the "complete rad removal" with offsite disposal alternative, and the two 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, 2016)).

2. Compliance with ARARs

    - All of the alternatives, except No Action, would comply with ARARs.

Because the No Action Alternative did not meet the threshold criteria of protection of public 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 No Action, 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.

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

    - 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, none of the alternatives include treatment technologies that would reduce the toxicity, mobility or volume through treatment as a primary component.

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

    - All of the alternatives would 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 "complete rad removal" and partial excavation alternatives are projected to exceed EPA's acceptable risk range.

    - The ROD-selected remedy is not expected to pose risks to workers above EPA's generally accepted risk range, whereas, all of the excavation alternatives are projected to expose workers to unacceptable risks from exposure to chemicals; however, these risks may be mitigated through use of personal protective equipment and appropriate health and safety procedures.

    - None of the alternatives are expected to result in radiation doses to workers above the limits established by OSHA and NRC.

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

    - The time required to achieve the RAOs would be shortest for the ROD-selected remedy, would take twice as long for the 52.9 partial excavation alternative compared to the ROD-selected remedy, three times as long for the 1,000 partial excavation alternative and five times longer for the "complete rad removal" with off-site disposal alternative compared to the ROD-selected remedy.

6. Implementability

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

    - The "complete rad removal" 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, because performing the excavation remedies would (1) open up larger areas of the landfilled waste to excavation; (2) require the excavation, handling, and relocation of larger volumes of waste material; and (3) take significantly longer to complete than the ROD-selected remedy.

- The “complete rad removal” and the partial excavation alternatives would 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 would require buyout of the asphalt plant lease in order to provide space for the relocated transfer station building

7. Cost

- Of the four remedial alternatives (excluding the No-Action alternative), the cost estimate for the ROD-selected remedy is the lowest, followed by the partial excavation alternatives and then the “complete rad removal” 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 remedial action objectives, 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

	ROD-Selected Remedy	**52.9 pCi/g to a 16-ft depth Partial Excavation Alternative**	**1,000 pCi/g Partial Excavation Alternative**	**"Complete Rad Removal" with Off-Site Disposal**
Long-term residual cancer risk after 1,000 years	<1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people)	<1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people)	<1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people)	<1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people)
Short-term risks during cleanup	<u>On-Site Workers</u> Industrial accidents: 2.8 Cancer risk: 9.2 x 10^{-5} (0.92 extra incidences in 10,000 people) Hazard Index 1.12 Worker dose: 187 mrem/yr	<u>On-Site Workers</u> Industrial accidents: 8.5 Cancer risks: 1.2 x 10^{-3} (12 extra incidences in 10,000 people) Hazard Index 1.12 Worker dose: 720 mrem/yr	<u>On-Site Workers</u> Industrial accidents: 11.7 Cancer risks: 2.4 x 10^{-3} (24 extra incidences in 10,000 people) Hazard Index 1.12 Worker dose: 867 mrem/yr	<u>On-Site Workers</u> Industrial accidents: 17.8 Cancer risks: 2.2 x 10^{-3} (22 extra incidences in 10,000 people) Hazard Index 1.12 Worker dose: 405 mrem/yr
	<u>Community</u> Transportation accidents: 0.61 Cancer risk: <1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people) Greenhouse gas emissions: 19,000 tons Waste excavation volume 126,000 bcy	<u>Community</u> Transportation accidents: 10.6 Cancer risks: <1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people) Greenhouse gas emissions: 43,000 tons Waste excavation volume 501,000 bcy	<u>Community</u> Transportation accidents: 16.6 Cancer risks: <1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people) Greenhouse gas emissions: 53,000 tons Waste excavation volume 825,000 bcy	<u>Community</u> Transportation accidents: 34.9 Cancer risks: <1 x 10^{-7} (less than 0.1 extra incidence in 1,000,000 people) Greenhouse gas emissions: 83,000 tons Waste excavation volume 1,572,000 bcy
Time to reach remedial action objectives	2.7 years	5.9 years	9 years	13.4 years
Estimated Costs	Capital construction: $67,000,000 OM&M per year: $167,000 to $326,000 Present Worth (millions $) Discount rate 7% 1.5% 0% 30 years 64 70 73 200 years 64 77 102 1,000 years 64 78 241	Capital construction: $313,000,000 OM&M per year: $167,000 to $326,000 Present Worth (millions $) Discount rate 7% 1.5% 0% 30 years 265 305 318 200 years 265 312 348 1,000 years 265 312 487	Capital construction: $361,000,000 OM&M per year: $167,000 to $326,000 Present Worth (millions $) Discount rate 7% 1.5% 0% 30 years 275 342 365 200 years 276 349 395 1,000 years 276 350 534	Capital construction: $616,000,000 OM&M per year: $167,000 to $326,000 Present Worth (millions $) Discount rate 7% 1.5% 0% 30 years 420 566 619 200 years 420 573 649 1,000 years 421 573 788

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Legend

▬	Operable Unit-1 Areas
- - -	Operable Unit-2 Areas

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Figure ES-1

Areas of Landfill Operations

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

Table of Contents

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

Table of Contents (cont.)

List of Tables

List of Figures

Table of Contents (continued)

List of Figures (continued)

Appendices

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	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
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
EDTA	ethylenediaminetetraacetic acid
EJ	Environmental Justice
EMSI	Engineering Management Support, Inc.
ENRCCI	Engineering News Record Construction Cost Index
E.O.	Executive Order
EPA	United States Environmental Protection Agency

List of Acronyms (continued)

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	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
K	Potassium
kg	kilogram
L	liter
LAACC	Large Area Activated Charcoal Canisters
LBSR	Leached barium sulfate residues
lbs	pounds
lcy	loose cubic yard
LDR	Land Disposal Restrictions
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
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

List of Acronyms (continued)

MeV	Million electron volts
m	meter
mg	milligram
mm	millimeter
mo `	month
MOU	Memorandum of Understanding
Mrem	millirem
MSD	Metropolitan St. Louis Sewer District
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
NORM	Naturally occurring radioactive material
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NS	Norfolk Southern
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
pCi	pico Curie
PFLT	Paint Filter Liquids Test
Po	Polonium
POTW	Publicly-Owned Treatment Works
PPE	Personal protective equipment
PRG	preliminary remediation goal
RA	Remedial action
Ra	Radium
RACM	Regulated asbestos-containing material
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDWP	Remedial Design Work Plan

List of Acronyms (continued)

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
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
SSPA	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
t	ton
TAL	Target Analyte List
TBC	To-be-considered
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total dissolved solids
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
Th	Thorium
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
USACOE	United States Army Corps of Engineers

List of Acronyms (continued)

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). 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.

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 as 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. Although the Buffer Zone has never been used for landfilling, RIM has been documented to be present on this parcel of land as well. 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 instructed the OU-1 Respondents to perform a Supplemental Feasibility Study (SFS) (EPA, 2010). 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, 2016b) and updated BRA (Auxier & Associates, Inc. 2016a).

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 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.

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.

Subsequent discussions between EPA Region 7 and EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) identified the following additional performance standards for the ROD-selected remedy:

- The proposed cover should meet Uranium Mill Tailings Remediation Control Act (UMTRCA) guidance for a 1,000-year design period including an 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.

These items were addressed through performance of additional evaluations and additional monitoring as described below.

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 were described in the RI Addendum (EMSI, 2016b).

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, 2016b).

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) have determined that Areas 1 and 2 are located outside of the Missouri River floodplain.

1.3 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.

1.3.1 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 (“complete rad removal”) – 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 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.

The EPA definition (EPA, 2010) of the “complete rad removal” 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 "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.

1.3.2 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.

1.3.2.1 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[1]; 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).

1.3.2.2 Other Additional Evaluations

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

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

- Discussion and consideration of the occurrence of an exothermic subsurface reaction (SSR)[2] and evaluation of an Isolation Barrier (IB), including a brief discussion of pending/ongoing IB-related design and field work;

- Acknowledgement of any environmental justice concerns;

- Updates to the evaluation 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 SSE 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);

- Evaluation of the Use of Apatite/Phosphate Treatment Technology (EMSI, 2013d);

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[2] This reaction has previously been called a "subsurface smoldering event" (SSE). However, the current understanding of the reaction is that it is occurring within saturated landfill materials 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 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).

1.3.3 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.

1.4 FFS Approach

This FFS has been developed pursuant to a 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 Useability 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, 2016b), 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/Crossroads 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, 2016a);

- 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 six remedial alternatives to be evaluated, evaluation of the six 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.

1.5 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, 2016b) 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, 2016a).

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 “complete rad removal” 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 “complete rad removal” with off-site disposal alternative, and the ROD-selected 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 remedial alternatives relative to the threshold and balancing criteria defined by the NCP.

Section 7: Comparative Analysis of Alternatives – Presents a summary comparison of the six remedial alternatives in terms of the threshold and balancing criteria defined by the NCP.

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, and FAA ROD, MOU and Advisories
Appendix B: Estimated Three-Dimensional Extent of Radiologically Impacted Material
Appendix C: Off-site Disposal Facilities – Waste Acceptance Criteria
Appendix D: Evaluation of the Use of Apatite/Phosphate Treatment Technologies
Appendix E: Technical Memorandum: Evaluation of Potential “Hot Spot” Occurrences and Removal of Radiologically-Impacted Soil
Appendix F: Cover Thickness Calculations
Appendix G: Conceptual Bases for Costs of Occupational and Environmental Monitoring Associated with Each Remedial Alternative
Appendix H: Evaluation of Potential Risks Associated with the Proposed Remedial Alternatives
Appendix I: Estimated Greenhouse Gas Emissions Associated with the Alternatives
Appendix J: Estimated Project Schedules for the Remedial Alternatives
Appendix K: Estimated Costs for the Remedial Alternatives
Appendix L: RIM Average Activity Levels
Appendix M: Excavation and Final Grading Plans.

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/Crossroads Property; 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.

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, 2016b).

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 is also included as part of OU-1.

OU-2 consists of the other landfill areas at the Site that are not impacted by radionuclides, 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. The Closed Demolition Landfill and the Bridgeton Landfill, while designated as part of OU-2, are regulated by the MDNR pursuant to State of Missouri solid waste regulations and are not being actively addressed by EPA. 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.

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 controls runoff to the adjacent properties.

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 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, residential land use has been precluded at the West Lake Landfill (including Areas 1 and 2) by restrictive covenants recorded in May 1997 by each of the fee owners against their respective parcels. These restrictive covenants also prohibit use of groundwater from beneath the Site. Construction activities and commercial and industrial uses have also been precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc. in January 1998, prohibiting the placement of buildings and restricting the installation of underground utilities, pipes, and/or excavation upon its property. These covenants automatically renew fifty (50) years from the date first recorded and every twenty five (25) years thereafter. 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 Field). Much of the Site, including more than half of Area 1, is located at its closest point within approximately 9,166 feet of the start of Runway 11 (end of Runway 29), which is 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. Similarly, bird flocks also pose a serious risk to aircraft (by, e.g., being sucked into the jet engines of commercial aircraft, thereby causing complete engine failure).

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 nearly 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 mixed single and multi-family residential units as well as 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, 2016b). Portions of the Site, including all of Area 2 and much of Area 1, are located within the geomorphic floodplain of the Missouri River.

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 entire Site is now located above and outside of the 500-year floodplain of the Missouri River (Figure 2-9).[3]

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 Crossroads Property occurred in 1993 or 1995 during the 500- and 300-year flood events that occurred in those years, respectively.

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[3] 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 entire West Lake Landfill Site is outside the 0.2-percent annual chance (500-year) floodplain.

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, 2016b). 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. In some portions of Areas 1 and 2, radiologically-impacted materials are present at the surface; however, the majority of the radiological occurrences are present in the subsurface beneath these two areas. At the Buffer Zone/Crossroads Property, the radiologically-impacted materials are found in surface soil believed to have been carried by erosion from the Area 2 berm prior to growth of the current onsite vegetation. See additional discussion in Section 2.2.5, below.

In general, the primary radionuclides detected at levels above background concentrations at the Site are part of the uranium-238 decay series. 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 Source of the Radionuclides

The NRC reported (1976, 1988) that disposal of radioactive materials mixed with soil occurred at the West Lake Landfill in 1973. Reportedly, approximately 8,700 tons of leached barium sulfate residues (LBSR) were mixed with approximately 39,000 tons of topsoil from a site located at 9200 Latty Avenue in Hazelwood, MO (the Latty Avenue Site) and transported to the West Lake Landfill over a three-month period from July 16 through October 9, 1973 (EPA, 2008; NRC, 1976 and 1988; and RMC, 1982). The LBSR was derived from uranium ore processing for the production of uranium metal from 1942 to 1957 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).

Prior to 1966, these materials 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). Most of the uranium and radium had previously been removed from the LBSR in multiple extraction steps (EPA, 2008 and NRC, 1988), and the LBSR reportedly contained only approximately 0.05% to 0.1% of uranium (NRC, 1976 at page 2).

Over time, the radiologically-impacted materials within Areas 1 and 2 have been intermixed 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. Use of soil mixed with LBSR as landfill cover, combined with the placement and compaction of additional MSW and other soil material both during and after placement of RIM-containing materials, and the subsequent natural decomposition, consolidation, and settlement of the MSW over the years, have also resulted in RIM being dispersed and intermixed within portions of the overall matrix of MSW in Areas 1 and 2. As a result, the Site contains areas comprised of both radiologically-impacted and non-radiologically-impacted materials that cannot be visually distinguished, and both of which are intermixed with solid waste materials.

2.2.3 Criteria for Defining RIM Occurrences

EPA previously determined for purposes of evaluating “complete rad removal” alternatives (EPA, 2010) 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, 2010) indicated 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 (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.[4] In particular, EPA has 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, 2010). 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. Based on the uranium remediation goal of 50 pCi/g established for the SLDS and SLAPS in the RODs for those sites (USACOE, 1998, and EPA, 2005, respectively), for purposes

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[4] 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.

of identifying RIM at the Site, the criteria of 50 pCi/g plus background total uranium will be used to identify RIM. 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).

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[5]
- Th-230 plus Th-232 = 7.9 pCi/g
- 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 FFS, and in particular, for the purpose of identifying the materials included within the scope of the "complete rad removal" alternative.

2.2.4 Occurrences of RIM in Areas 1 and 2

Radionuclides (specifically, Th-230, Ra-226, and U-238) have been identified as primarily present in soils at two distinct and separate 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 47.8-acre portion of the Site along the northern boundary of the West Lake Landfill property (Figure 2-3).

Procedures used to identify RIM occurrences based on the results of the field investigations and laboratory testing are detailed in Section 6.3 of the RI Addendum (EMSI, 2016b). The RIM occurrences in Areas 1 and 2 are provided in Tables 2-1 and 2-2, respectively.

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:

	Area 1	Area 2
Minimum RIM thickness (ft)	0.2	1
Average RIM thickness (ft)	4.3	7.4
Maximum RIM thickness (ft)	19	25

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[5] 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

The depths to the top of the identified intervals containing RIM in Area 1 average approximately 28 ft bgs (average elevation of 450.0 ft amsl), ranging from 0 (at the surface) to 89 ft bgs (elevations ranged from 425.4 to 470.5 amsl)[6]. The base of the RIM intervals occurs at an average depth of 32 ft bgs (average elevation of 446.0 amsl), ranging from 5 to 96 ft bgs (elevations ranging from 420.3 to 462.3 amsl). Part of the reason for these 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.

The average depth to the top of the intervals identified as containing RIM in Area 2 ranges 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 occurs at depths ranging from 1 to 49.5 ft bgs (elevations from 428.3 to 484.5 ft amsl).

2.2.5 Estimated Volume of RIM and Overburden Material

A geostatistical evaluation of the extent and volume of RIM using an IK approach was performed by S.S. Papadopoulos & Associates (SSPA). Specifically, the extent of RIM within OU-1 Areas 1 and 2 was estimated in three dimensions (3D) using indicator kriging (IK). The IK 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 value. The transformed indicators are interpolated using kriging, resulting in a continuous 3D distribution of values ranging between zero and one that, in the simplest case, reflect the probability that the criterion is exceeded at the corresponding location. All indicator kriging calculations were completed using a recent release of the Fortran-based Geostatistical Library (GSLIB: Deutsch and Journel, 1992) program IK3D, compiled with dynamic memory allocation. A more complete description of the methods and results obtained by the IK evaluations is included in Appendix B.

The data available to estimate the extent of RIM include (a) thorium and radium obtained from laboratory analysis of landfill materials; and (b) a comparatively larger number of vertically continuous gamma and alpha recordings obtained during downhole logging or logging of drill core sample material. The reported values of thorium and of radium comprise direct measurements of the quantity of interest, and as such are referred to here as “hard” data. In contrast, measurements of gamma and alpha radiation are indirect indicators of the presence, and likely relative concentration of, radiological constituents including (but not limited to) thorium and radium: as such, radioactivity counts are referred to here as “soft” data. Indicator kriging

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[6] Note that the borings used to define RIM were drilled before construction of the Non-Combustible Cover removal action construction activities, and therefore the reported depth intervals discussed in this section do not reflect placement of an additional eight (8) inches (or in some areas, an even greater thickness) of material over portions of Areas 1 and 2 in 2016.

enables such “soft” data to be incorporated in the estimate of the primary “hard” variable under the assumption that the “soft” quantity exhibits a correlation with the “hard” quantity.

The interpolation grid used for the kriging was defined to provide estimates of the presence or absence of RIM on a vertical and horizontal discretization suitable for evaluating combined Ra-226 plus Ra-228 or combined Th-230 plus Th-232 values greater than 7.9 pCi/g (the EPA defined value for identification of RIM). The grid size was selected based upon UMTRCA regulations, 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.

The areal extent of RIM (*i.e.*, material containing combined radium or combined thorium activities greater than 7.9 pCi/g) based on results of the IK for Area 1 is 6.4 acres (Figure 2-10). The estimated extent of RIM in Area 2 is 22.9 acres (Figure 2-11). Details regarding the methods used to perform the IK and the results obtained are presented in Appendix B.

In order to meet the schedule for preparation of the FFS, SSPA provided results of the IK in May 2016 (referred to in the SSPA report contained in Appendix B as “Initial Best-Estimates”). These results were used for characterization of the extent and volume of RIM in the RI Addendum. The results of these evaluations were also used to develop excavation and grading plans (Appendix M), cost and schedule estimates, and risk evaluations for the complete and partial excavation alternatives for the FFS. After further review of the initial IK results, SSPA revised its analyses to better reflect the Site data, which resulted in slight modifications to the estimated RIM volumes (SSPA, 2016a). Specifically, the updated best-estimates were 4.3% larger for Area 1, 3.2% lower for Area 2, and 1.9% lower overall compared to the initial best-estimates. Given the timing of these revisions and the schedule constraints associated with preparation of the draft FFS, these revised values of the RIM volumes (referred to in the SSPA report contained in Appendix B as “Updated Best-Estimates”) have not been incorporated into the evaluations contained in this draft FFS. Moreover, these variations are within the estimate level of precision of the volume calculations.

Based on the geostatistical evaluations, the initial best-estimate total volumes of RIM contained in Areas 1 and 2 were estimated to be as follows:

Area 1 RIM	46,200 bank cubic yards (bcy)
Area 2 RIM	220,000 bcy
Total RIM	266,200 bcy

A “bank cubic yard” refers to the volume of an in-place, undisturbed material such as soil or refuse. Conversely, a “loose cubic yard” refers to a volumetric measurement of material when it is in a loose state after it has been excavated. When material is excavated, it typically swells relative to its in-place volume. For example, a “loose cubic yard” of soil will typically occupy 20 to 30 percent more volume than a “bank cubic yard” of soil, and a “loose cubic yard” of refuse may occupy up to 60 percent more volume than a “bank cubic yard” of refuse. For purposes of estimating quantities in the SFS, it was assumed that a “loose cubic yard” of combined overburden and RIM (matrix of soil and refuse) in Areas 1 and 2 would occupy 50 percent more volume than a “bank cubic yard”.

Based on the geostatistical estimate of the depths and extent of RIM in Areas 1 and 2, the volume of non-radiological overburden soil and waste materials (including material directly above the RIM plus material that would need to be removed to lay back the excavation sidewalls) that would have to be removed to allow for excavation of the RIM was estimated to be as follows:

Area 1 overburden	702,000 bcy
Area 2 overburden	493,000 bcy
Total overburden	1,195,000 bcy

Additional information and supporting calculations used to estimate the extent and volumes of RIM above levels that would allow for unrestricted use, as well as the uncertainties associated with the estimates, are presented in Appendix B and discussed in Section 5.

2.2.6 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 while Table 2-4 summarizes the results for samples obtained from Area 2.[7]

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[7] Although the analytical results from the additional samples collected by Cotter are included on Tables 2-3 and 2-4, these data have not been included in the evaluation of the statistical estimates of radium and thorium levels in Areas 1 and 2, as certain of those samples are still being analyzed. The Cotter data were collected in part to “help determine the presence of radiological materials with chemical compositions diagnostically different from LBSR.” (Arcadis, 2015a and b). Consequently, collection of samples by Cotter was heavily biased toward collection of samples with the highest levels of radium and thorium at the Site with the goal of “identification and evaluation of any non-LBSR material[.]” (Arcadis, 2015a and b). Furthermore, in response to some questions from EPA with regard to the ratio of the Th-230 and Ra-226 reported for several of the Cotter samples, EPA has requested that the remaining materials associated with these samples be provided to EPA for re-analysis to verify the results (EPA, 2016b). Therefore, until this issue is resolved, the Cotter data will be reported but not integrated into the overall evaluations of the nature of the radiological occurrences in RIM.

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, only the original sample results have been used, and therefore field duplicate results and lab duplicate results were not considered in these calculations.

It should be noted that although an average value is presented in Table 2-5, the data sets were not normally distributed and therefore, an arithmetic average is not an appropriate measure of central tendency of the data sets. Similarly, the 95% UCL values listed on Table 2-5, although based on a non-parametric distribution and estimation technique, are also not considered to be appropriate based on the distribution of the data sets.

Review of the data sets indicates that these data represent two separate populations (that is, the data represent a bimodal distribution) that have a small degree of overlap. As discussed in the RI Addendum (EMSI, 2016b), weighted mean values and weighted 95% upper confidence limits were calculated based on the percentages of data values contained within each subpopulation. The resultant values are provided on Table 2-5.

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. There is also a relatively close correlation between the Ra-226 and Th-230 results obtained from each area. Furthermore, review of the data indicates that for all of the results that are greater than the unrestricted use criteria (*i.e.*, 7.9 pCi/g combined Ra-226 + 228 or combined Th-230 + 232), the Th-230 activities are greater than the Ra-226 activities.

2.2.7 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 arithmetic average values of the Th-230 and Ra-226 data for the Area 1 and Area 2 soil/waste samples (see Section 2.2.6) were used to estimate the anticipated in-growth of Ra-226 from decay of Th-230 over time. These values were used to estimate the average amount of Ra-226 that would be present in Area 1 and Area 2 in 1,000 years. Accounting for the in-growth of Ra-226 due to the decay of Th-230 results in an estimated average Ra-226 activity level of 1,337 pCi/g in Area 1 and 6,882 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 Figures 2-12 and 2-13.

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 Baseline Risk Assessment and Updated Baseline Risk Assessment (Auxier & Associates, 2000 and 2016a), 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.

2.2.8 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 “complete rad removal” and partial excavation alternatives relative to the ROD-selected remedy, it is conservatively assumed 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.

2.2.9 Radiological Occurrences on the Buffer Zone and Crossroads Property

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), 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 materials 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.

Based on an estimated areal extent of 196,000 square feet and a presumed 6-inch thickness, the volume of radiologically-impacted materials located on the former Ford Property was estimated to be 3,600 cubic yards (EMSI, 2000 and 2006a).

In November 1999, third parties scraped the vegetation and surface soil on Crossroads 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 2A1 (Figure 2-14).

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 Crossroads Property 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 Crossroads Property 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 Crossroads Property are unknown. Additional soil sampling to determine current conditions with respect to radionuclide occurrences in the Buffer Zone and Crossroads Property soil will be conducted as part of implementation of the selected remedy for this area.

2.2.10 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.[8] 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.

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[8] 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.

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. In addition, during the time period in which wastes were disposed of 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 detected in any of the RI or subsequent investigation (Phase 1D, Additional Characterization or Cotter Investigation) soil/waste samples to the maximum concentration of contaminants using 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 be classified as hazardous wastes based upon the presence of TC metals, or their benzene, chloroform, or 1-4 dichlorobenzene concentrations. 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.

2.2.11 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[9], 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. The average flux for all other portions of Area 2, excluding these two locations, was only 0.94 pCi/m^2s, which is approximately 5% of the allowable flux for uranium mill tailings piles.

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

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[9] Radon flux was measured rather than concentration because no structures are present in either Area 1 or Area 2 that would result in the buildup of radon concentrations. Instead, the potential transport pathway is the migration of the gas from the Site to the atmosphere.

where RIM previously existed at the ground surface. The arithmetic mean value of the results was 0.061 pCi/m^{2}s, which is far below the UMTRCA standard of 20 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. Under natural conditions, radon emissions from the Site are immediately dispersed by atmospheric movement as the gas migrates from the ground surface, resulting in far less exposure to the potential receptors than was measured using the LAACCs. Measurement of radon levels in atmospheric air were conducted at the 13 air monitoring stations installed in 2015 and operated to obtain baseline air monitoring data for the Site (Auxier and EMSI, 2014 2016a, 2016b, and 2016c). Recorded radon concentrations were all less than 0.4 pCi/L during the first quarterly (12-week) monitoring event (May through August 2015), ranged from less than 0.4 up to 0.7 pCi/L in the second quarterly event (September through November 2015), and ranged from less than 0.4 up to 0.6 pCi/L during the third quarterly event (October 2015 through January 2016). Table 2-10 presents a summary of the perimeter air monitoring results for radon obtained through January 2016.

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, 2015, 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

Fugitive dust monitoring was conducted at one location in Area 1 and one location in Area 2 during the OU-1 RI field investigations. Sampling for fugitive dust was performed at locations that contained some of the highest radionuclide concentrations in surface soil samples. Based on the monitoring results, as well as the presence of the prior vegetative cover and the subsequent rock cover over Areas 1 and 2, atmospheric transport of radionuclides in fugitive dust does not appear to have been, or currently be, a significant pathway for offsite migration (EMSI, 2000).

After the OU-1 RI sampling in 1996, the surface areas of Areas 1 and 2 became heavily vegetated, and inert fill was placed over portions of the surface, thereby reducing the potential for fugitive dust emissions at the Site. This reduction is confirmed by the absence of increased levels of radionuclides in the fugitive dust samples collected from around the perimeters of Areas 1 and 2 in 2015 and 2016, as described below. In addition, those portions of Areas 1 and 2 where RIM was previously present at the ground surface were covered in 2016 (after development of the most recent air monitoring results available) with rock/roadbase material as part of the construction of the non-combustible cover over these areas, thereby further reducing the potential for emissions of radionuclides in fugitive dust.

Measurements of radionuclides in fugitive dust (particulate samples) have been obtained at the 13 air monitoring stations installed in 2015 and operated to collect baseline air monitoring data for the Site (Auxier and EMSI, 2014, 2016a, b and c). 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 three quarters (May 2015 through January 2016) 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 three 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). Overall, the gross alpha results obtained from the 13 on-site stations are similar to or slightly higher than the results obtained from EPA's five off-site stations.[10] 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.

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 (the middle of each respective three-month monitoring period) were also submitted for isotopic analysis and gamma spectroscopy. As expected, the isotopic and the gamma spectroscopy results demonstrate only naturally-occurring radioactive materials. 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 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).

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[10] Whether this difference is statistically significant cannot be determined until additional on-site data are obtained (sampling is ongoing at this time). The differences may reflect dust levels, seasonal conditions (pollen levels), differences in precipitation (*i.e.*, soil moisture), or differences in the total particulate levels between the period covered by EPA's air monitoring program and the period covered by the on-site air monitoring program.

In almost all cases, the isotopic uranium and thorium and combined radium results obtained from the 13 on-site stations are lower than the results obtained from EPA's five off-site stations. The isotopic results were converted to µCi/ml and compared to 10 CFR 20 Appendix B Effluent Limits. The results are well below the applicable effluent limits (Auxier and EMSI, 2016a, b, and c).

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).

It should be noted that this section discusses sampling results performed in 1995-1997 as part of the OU-1 field investigations – before inert fill material was placed on the surface of Areas 1 and 2, and before the recent (2016) installation of a non-combustible cover over areas where RIM is present at the ground surface. All of these actions would serve to greatly reduce and, ultimately, likely eliminate the potential for radionuclide transport in surface water. This conclusion is supported by results of the recent stormwater monitoring activities (discussed below) conducted in conjunction with installation of the non-combustible cover.

Current surface water runoff patterns for Areas 1 and 2 are presented on Figure 2-15. 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 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 2-15). 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.[11] 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) did not exceed or even come close to the drinking water standard of 5 pCi/L.

Stormwater samples were also collected in 2016 during construction of the non-combustible cover over surface RIM in Areas 1 and 2. With one possible exception, all of these samples contained only background levels of radium and uranium. The reported activity concentrations of combined Ra-226 plus Ra-228 for these samples were all less than the radium drinking water standard of 5 pCi/L. Total uranium results were all less than 20 pCi/L (estimated equivalency to 30 µg/L drinking water standard), except for one sample from NCC-002 obtained on April 13, 2016, which was reported to contain 30 pCi/L of combined uranium isotopes. Subsequent stormwater samples were analyzed for total uranium as a metal and were below the 30 µg/L standard.

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.[13] The surface water sampling locations associated with these two water bodies are shown on Figure 2-15. Analytical results for these samples did not exceed the drinking water MCL of 5 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 2-15. 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.

Additional 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. Only Th-230 (14.7 pCi/g) in the sample from SED-4 exceeded the unrestricted use standards; however, radionuclides were not detected in these samples at levels above the EPA PRGs for outdoor workers (19.8 pCi/g for Th-230). In response, additional sediment samples were also obtained in 2016 from the

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[11] 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).

[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 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.

[13] Based on topographic conditions, it does not appear that runoff from Areas 1 or 2 could enter the Flood Control Channel.

Northeast Perimeter Drainage Ditch at the location of SED-4 and at approximately 100-foot increments 100, 200 and 300 feet to the north of SED-4. Analytical results for these samples did not detect the presence of any radionuclides at levels above the unrestricted use criteria.

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 a year or two after disposal activities in Area 2 ceased. This historic erosional scour resulted in transport of soil, some of which contained radionuclides, from Area 2 down onto the adjacent former Ford Property where it meets the toe of the landfill berm. This runoff and erosion was subsequently stopped through the construction of runoff diversion berms and natural re-vegetation of the landfill slope.

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 the Buffer Zone and Crossroads Lots 2A1 and 2A2) are 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 2.2.9).

2.5 Groundwater Conditions

This section briefly summarizes the results of the most recent groundwater sampling events at the Site as of the writing of this FFS.

Sampling of all of the groundwater monitoring wells at the Site (up to 85 wells per event) was conducted as part of four comprehensive groundwater sampling events performed in 2012-2013. The following results were obtained:

- Generally, only background levels of uranium and thorium were detected in groundwater during these events.
- Certain wells at the Site contained combined total radium at levels greater than the MCL (5 pCi/L) during all four of the 2012-2013 sampling events.
- Overall, no spatial correlation between occurrences of radium at levels greater than the MCL and Areas 1 and 2 could be identified.
- No contiguous area of radium occurrences indicative of a plume of groundwater contamination was present.
- The most probable source of the radium occurrences in bedrock groundwater around the North and South Quarry portions of the Bridgeton Landfill is release of naturally-

occurring radium in the bedrock units, or release of radium that was adsorbed onto iron and manganese oxides and hydroxides which have become soluble under reducing conditions associated with anaerobic (oxygen-deficient) decomposition of the MSW in the landfill.

- Based on the relatively low solubility of radionuclides in water and their affinity to adsorb onto the soil matrix, leaching of radionuclides into groundwater and subsequent transport in groundwater to off-site areas does not appear to be a significant migration pathway.

Additional evaluations of the potential for leaching and vertical transport of radionuclides in the landfill mass are currently being conducted.

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, 2016b) 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, 2016b).

EPA has previously indicated that groundwater conditions at the Site will be separately characterized as part of a new Operable Unit (OU-3).

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 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).

2.5.2 Hydrogeology

Alluvial deposits of varying thickness are present beneath Areas 1 and 2 (See Section 5.5.1 of the RI Addendum, EMSI 2016b). The landfill debris varies in thickness from 5 to 56 feet in Areas 1 and 2, with an average thickness of approximately 36 feet in Area 1 and approximately 30 feet in Area 2. 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). Water level measurements performed during the 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. 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 and 2 in the underlying alluvium near or below the base of the landfill debris.

The regional direction of groundwater flow is generally northward within the Missouri River alluvial valley, parallel or sub-parallel to the river alignment. The RI data indicate that only a very small amount of difference (less than one foot) exists in the water table surface beneath the Site, making interpretations of the directions of groundwater flow based only on water level data difficult. Based on the water level data, the direction of groundwater flow beneath Area 1 during the RI appeared to be generally to the south toward the Bridgeton Landfill. Water level elevations beneath Area 2 displayed areal 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 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 registered well 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. Accordingly, the nearest registered well is not downgradient of the Site. 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 comprehensive 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). None of the 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, 2016b) and the OU-1 and OU-2 RI reports (EMSI, 2000 and Herst & Associates, 2005).

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. 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.[14] 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, 2016b).

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). Background levels of naturally-occurring Ra-226 in groundwater are expected to range from 1 to 5 pCi/L, and background levels of naturally-occurring Ra-228 in groundwater are expected to range from 1 to 7 pCi/L. However, Ra-226 levels as high as 35 pCi/L and Ra-228 levels as high as 26 pCi/L have been reported for samples obtained from wells located to the south (upgradient) and away from the disposal units at the Site, and more particularly upgradient of Areas 1 and 2.

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 2-16. A graphical display of the results of the comparisons of the combined dissolved (filtered samples) radium results to the MCL is shown on Figure 2-17. The overall distribution of wells that contain combined total and/or combined dissolved radium levels greater than the MCL indicates that a mechanism other than leaching to and migration within groundwater from Areas 1 and 2 is responsible for these radium occurrences.

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[14] 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.

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. 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 2-18.

Chlorobenzene was detected in 24 to 25 monitoring wells during each of the 2012 – 2013 groundwater monitoring events (Figure 2-19). 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 2-19).

Vinyl chloride was detected in 4 to 10 wells during each event (Figure 2-20). 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 2-20).

Overall, VOC occurrences in groundwater at the Site are isolated and do not indicate the presence of an extensive area or plume of VOC contamination. Most of the benzene in the groundwater is near the South Quarry portion of the Bridgeton Landfill and the southern portion of the Inactive Sanitary Landfill.

2.5.4.2 Semivolatile 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. Overall, SVOCs were detected in only a few groundwater samples from the Site and generally at levels below their respective drinking water standards.

2.5.4.3 Trace Metals

Most of the 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/colloidal matter 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 2-21 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 2-22 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 MCL (300 µg/L) were found throughout the Site area (Figures 2-23 and 2-24). The highest levels of iron were generally detected near the Inactive Sanitary Landfill and Area 1. The iron in the groundwater at the Site is consistent with 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 MCL (50 µg/L) were found throughout the Site area (Figures 2-25 and 2-26). 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 levels above its MCL (2,000 µg/L) are summarized on Figures 2-27 and 2-28.

As shown, three wells (D-3, D-85, and PZ-113-AD) contained barium in the total fraction (unfiltered) samples at 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) contained total barium above its MCL during some, but not all, of the 2012-2013 monitoring events. No other wells displayed total barium levels above its MCL.

Six wells contained dissolved barium levels 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 South Quarry portion of the Bridgeton Landfill; 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 detected barium at 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, 2016b).

2.5.4.4.1 Sulfate

Only four wells contained sulfate at 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 South Quarry portion of the Bridgeton Landfill (Figure 2-29). Of these, sulfate was reported at concentrations above its MCL during all 2012-2013 events for wells S-10 and D-12 and during the last two 2013 events for wells MW-102 and PZ-204A-SS.

2.5.4.4.2 Chloride

Chloride is a common constituent of landfill leachate. The highest levels of chloride were detected 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 MCL of 250 mg/L were detected in nine of the 85 wells sampled during all 2012-2013 events (Figure 2-30). Chloride was detected at concentrations greater than its MCL during one or more, but not all four, events in 14 additional wells (Figure 2-30). Occurrences of chloride above the MCL were generally found in wells located around the South Quarry portion of the Bridgeton Landfill, the west side of the Inactive Sanitary Landfill, around Area 1, and along the east and south sides of Area 2 (Figure 2-30).

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

The results of the 2012–2013 groundwater monitoring activities clearly indicate 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 reducing conditions, which often occur in and around MSW landfills.

Evaluation of potential radium contributions to groundwater from Areas 1 and 2 is influenced by the presence of higher levels of radium in upgradient bedrock wells. All of the radium results obtained from alluvial monitoring wells located within or downgradient of Areas 1 and 2 were less than or similar to the radium levels observed in bedrock and alluvial monitoring wells located upgradient or upgradient/cross-gradient from Areas 1 and 2. This observation is consistent with the conclusion offered by the USGS 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.” (USGS, 2014, p. 43).

With the possible exception of benzene occurrences in the southwestern portion of Area 1 (*i.e.*, wells D-14, I-4, and PZ-112-AS), chlorobenzene in PZ-112-AS, and vinyl chloride occurrences in the southwestern portion of Area 2 (*i.e.*, wells I-9 and D-93), there are no VOC impacts to groundwater beneath or immediately downgradient of Areas 1 and 2. The majority of wells in or around Areas 1 and 2 were either non-detect for VOCs or contained trace levels of VOCs (less than their respective MCLs).

Occurrences of arsenic, iron, manganese, barium and sulfate were detected 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 significantly 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

To be provided in a subsequent submittal.

3 POTENTIAL ARARS AND REMEDIAL ACTION OBJECTIVES

This section of the FFS describes environmental laws which may represent potentially applicable or relevant and appropriate requirements (ARARs) for remedial actions for OU-1. This section also describes additional requirements associated with offsite disposal. 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. 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 potentially applicable or relevant and appropriate requirements for remedial actions 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, the "complete rad removal" and the partial excavation alternatives. In addition, this section addresses additional ARARs evaluation specified by EPA in the SOW.

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 are summarized on Table 3-1 and are discussed below. No additional chemical-specific ARARs have been identified as a result of work performed for this FFS or relative to the additional evaluations of the "complete rad removal" and partial excavation alternatives.

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

The FS report (EMSI, 2006) includes an evaluation of the health and environmental protection standards promulgated under the Uranium Mill Tailings Radiation Control Act (UMTRCA) (40 CFR Part 192) for potential chemical- and action-specific requirements. Because the UMTRCA standards only apply to certain designated uranium mill tailings sites, they are not applicable to the Site. The UMTRCA standards may nonetheless represent potentially relevant and appropriate requirements for remedial actions at the Site.

The UMTRCA regulations establish specific standards for waste disposal units containing residual radioactive material and for land outside of such waste disposal units that has been contaminated with radionuclides as a result of uranium processing or waste disposal activities. Standards associated with management of a tailing pond or waste disposal unit are evaluated for potential relevance with respect to the solid waste disposal units in Areas 1 and 2, while standards associated with occurrences of radionuclides in land outside of a waste disposal unit (such as the Buffer Zone and Crossroads Industrial Park) are evaluated relative to areas outside of the Areas 1 and 2.

Specifically, the FS and SFS addressed requirements relative to the standards for radon emissions from closed tailing impoundments (40 CFR Part 192 Subpart A), standards for cleanup of contaminated land and buildings (40 CFR Part 192 Subpart B), and groundwater protection standards (40 CFR Part 192 Subparts A and B). Additional discussion of these standards as they relate to the ROD-selected remedy and the “complete rad removal” and partial excavation alternatives is presented below.

3.1.1.1.1 Radon Emissions Standards – 40 CFR § 192.02(b)

The UMTRCA regulations establish standards of release of radon to the atmosphere from residual radioactive material (40 CFR § 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, and also represent potential performance criteria for the design of a cover system for Areas 1 and 2 included in the ROD-selected remedy and the partial excavation alternatives.

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 as a result of the presence of three high value samples. Additional radon flux monitoring was performed as part of the construction of a non-combustible cover over Areas 1 and 2 and 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 no more than 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 associated with the ROD-selected remedy and the partial excavation alternatives necessary to meet the 20 pCi/L 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 or the partial excavation alternatives 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 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.

The UMTRCA radon standards relative to any occupied or habitable building (40 CFR § 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 CFR § 192.12(b)(1)). In any case, the radon decay product concentration (including background) shall not exceed a 0.03 WL (40 CFR § 192.12(b)(1)). 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 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. One Working Level is equal to approximately 200 pCi/L.

3.1.1.1.2 Standards for Cleanup of Contaminated Land – 40 CFR § 192.12(a)

Requirements relative to standards for cleanup of land contaminated with residual radioactive materials from an inactive uranium processing site (40 CFR § 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.

OSWER Directive 9200.4-25, titled “Use of Soil Cleanup Criteria in 40 CFR 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. In addition, 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 CFR § 192.11(b)). Therefore, these requirements are not relevant or appropriate to the solid waste disposal units within OU-1 Areas 1 and 2.

Further, the UMTRCA standards are not relevant and appropriate requirements for remedial actions related to Areas 1 and 2 because they do not address specific conditions which are sufficiently similar to conditions at the Site. The UMTRCA mine tailings standards for cleanup of land and buildings contaminated with residual radioactive materials established pursuant to 40 CFR § 192.12(a) were not developed or intended to address conditions at solid waste disposal units. As indicated in the CERCLA UMTRCA guidance, “[t]he purpose of these standards [is] 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.” The Site is a solid waste landfill that is subject to controls on future land use which will prevent the construction of houses or other inhabitable structures over the waste materials within Areas 1 and 2, regardless of whether radiologically-impacted materials are present or not. Institutional controls to restrict residential use of the property have previously been developed and implemented by the owners of the various parcels of land that comprise the Site, including OU-1, OU-2 and other portions of the Site. In addition, implementation of institutional controls to restrict future use of solid waste disposal sites is required by the Missouri Solid Waste Regulations (10 CSR 80-3.010(20)(C)2.C.II). Further, even if a "complete rad removal" alternative were to be implemented, non-radiological waste materials would still remain onsite, thereby requiring institutional controls as required for RCRA Subtitle D landfills which would prevent construction of houses or other inhabitable structures on the Site (EPA SOW, 2010b). Therefore, the standards established pursuant to 40 CFR § 192.12(a) do not address situations sufficiently similar to those present within the solid waste management units at the Site, so the standards are neither relevant nor appropriate. However, the FS concluded that the portion of these regulations addressing cleanup levels for offsite impacted soil may be potentially relevant and appropriate criteria for remedial action, if any, involving excavation of radiologically-impacted soil on the Buffer Zone/Crossroads Property.

The CERCLA UMTRCA guidance further indicates 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 to the combined level of thorium-230 and thorium-232, in order 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 the CERCLA UMTRCA guidance, the standards established pursuant to 40 CFR § 192.12(a) do 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 Area 2 indicated that soil containing radionuclides eroded from the surface of Area 2 and was deposited on the surface of the adjacent Buffer Zone and a portion of the Crossroads Industrial Park. Subsequent site development of the Crossroads Industrial Park resulted in regrading and placement of surface soil previously located on Lots 2A1 and 2A2, which are owned by Crossroad Properties, LLC (Crossroad), onto the Buffer Zone. Current conditions relative to occurrences of radionuclides at the Buffer Zone and Crossroad Lots 2A1 and 2A2 are unknown but are to be the subject of additional investigation and sampling as part of the ROD-selected remedy for OU-1. Remaining occurrences of radionuclides, if present, on these properties would represent a condition that may be sufficiently similar to the conditions associated with the "vicinity" sites addressed by the UMTRCA regulations. Therefore, the standards established pursuant to 40 CFR § 192.12(a) potentially may represent relevant and appropriate requirements for remedial actions that may be taken to address radionuclides in soil at the Buffer Zone/Crossroads Property.

3.1.1.1.3 Groundwater Protection Standards – 40 CFR 192 Subparts A and B

The concentration limits established under the groundwater protection standard of the UMTRCA regulations (40 CFR § 192.02(c)(3)) present potentially relevant and appropriate standards for groundwater quality at the Site. With only two exceptions, none of the hundreds of measurements of uranium concentrations in groundwater obtained during the 1995 – 1997 RI, 2004 FS and the 2012-2013 groundwater sampling events approached the UMTRCA standard of 30 pCi/L for uranium. The first exception was the total fraction uranium result from well S-53 obtained in April 2013, after a long period over which this well had not been sampled. Neither the associated dissolved sample nor the subsequent two (July 2013 and October 2013) total and dissolved samples from this well contained uranium activities close to the UMTRCA standard. The other exception was the first total fraction sample obtained from newly installed well PZ-211-SD in November 2013. Again, neither the contemporaneous dissolved fraction sample nor the subsequent total or dissolved fraction samples from this well in February 2014 displayed uranium activities levels near the UMTRCA standard. The groundwater monitoring data indicate that upon proper development and continued sampling of the monitoring wells, the uranium levels in groundwater at the Site meet the UMTRCA standard.

As previously discussed in Section 2.5.3 and in more detail in the RI Addendum, wells containing total (unfiltered samples) and dissolved (filtered samples) combined radium (Ra-226 plus Ra-228) levels greater than the UMTRCA standard were identified throughout the Site including at locations upgradient and distant from Areas 1 and 2. The overall broad distribution of wells containing combined total and dissolved radium levels greater than the MCL, including occurrences in areas of the Site that are upgradient or cross-gradient of Area 1 and 2, indicates that another mechanism, beyond leaching to and migration in groundwater from Areas 1 and 2, is responsible for these radium occurrences. The most likely mechanism responsible for the broad distribution of radium at the site is mobilization of naturally-occurring radium from the soil and rock in response to the presence of reducing conditions associated with decomposition of the landfilled wastes.

Concentrations of trace metals in groundwater were previously discussed in Section 2.5.4. Occurrences of arsenic, iron, manganese, barium and sulfate were detected 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 significantly greater amounts of trace metals or inorganic constituents than occur in other landfill areas onsite or at other offsite landfills.

Based on the presence of radioactive materials at OU-1 and the potential for leaching trace metals to groundwater, the groundwater protection standards (40 CFR §§ 192.02(c)(3) and (4)) and monitoring requirements (40 CFR § 192.03) of the UMTRCA regulations are potentially relevant and appropriate to the ROD-selected remedy and the partial excavation alternatives.

3.1.1.2 Other Potential Chemical-Specific ARARs

Other potential chemical-specific ARARs are identified and evaluated in the FS (EMSI, 2006) 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 and partial excavation alternatives. These include the following:

- The National Emissions Standards for Hazardous Air Pollutants (NESHAPs) standards for radon-222 emissions (40 CFR Part 61 Subpart T);
- The Missouri Radiation Regulations for Protection Against Ionizing Radiation (19 CSR 20-10.040); and
- Missouri Maximum Contaminant Levels (10 CSR Division 60 Chapter 4)

3.1.1.2.1 National Emissions Standards for Hazardous Air Pollutants

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 CFR Part 61 Subpart T). Because West Lake Landfill OU-1 is not a designated uranium mill tailings site, this 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 the ROD-selected remedy and the partial excavation alternatives.

The “complete rad removal” with off-site disposal alternative includes removal of all RIM above the cleanup standards from Areas 1 and 2 and from the Buffer Zone/Crossroads Property, 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 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.

3.1.1.2.2 Nuclear Regulatory Commission Standards for Protection Against Radiation

The Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation (10 CFR Part 20) apply only to persons licensed by the NRC to use or handle nuclear materials under certain, defined circumstances. *See* 10 CFR § 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 the course of 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 in the course of 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 the course of a remedial action for purposes of identifying occupational radiation dose limits. In such case, various protective measures required by Part 20 and NRC guidance may also apply, such as establishment of radiation monitoring and protection programs to control occupational doses within limits. *See, e.g.*, 10 CFR 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). As a precaution, these protective measures previously have been implemented at the Site, and will be 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 CFR 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 offsite for treatment or disposal).

3.1.1.2.3 Missouri Maximum Contaminant Levels

EPA has established MCLs and Maximum Contaminant Level Goals (MCLGs) pursuant to the Safe Drinking Water Act (40 CFR 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.

These regulations (10 CSR Division 60 Chapter 4) establish MCLs for public drinking water systems. Because the Site does not operate a public drinking water system, 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. These regulations are potentially relevant and appropriate for remedial actions for OU-1 insofar as they identify MCLs for certain chemicals in drinking water, and some of the chemical constituents that are the subject of these regulations have been detected in one or more groundwater monitoring wells located within or adjacent to Areas 1 and 2. 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.

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 proximity to airport runways and floodplains. The requirements of these regulations are discussed below.

3.1.2.1 Floodplain Management

Executive Order 11,988, 40 CFR § 6.302(b), and the Missouri Governor's Order 82-19 relative to floodplain management are identified in the FS (EMSI, 2006) as potential location-specific ARARs relative to floodplain management (Table 3-2 in the FS). The Buffer Zone and Crossroads Property are located within the historic 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, other than the OU-2 stormwater retention basin and on-site soil borrow and stockpile area, the entire West Lake Landfill site (including all of the disposal areas) is outside the 0.2-percent annual chance (500-year) floodplain.

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 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 Site is 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 reach the Buffer Zone and Crossroads Property[15]. Due to the 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 CSR 80.3.010(4)). 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, certain of them are considered to be potentially relevant and appropriate to Areas 1 and 2. In particular, the regulatory requirements relating to airport safety and floodplains are potential ARARs for the ROD-selected remedy, the partial excavation alternatives, and the “complete rad” removal alternatives because regrading or excavation of wastes within Areas 1 and 2 is a component of each of these alternatives. 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 CSR 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.

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[15] 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.

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 CSR 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 CSR 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.

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 CSR 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.

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 CSR 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.

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 CSR 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 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 potentially 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 "complete rad removal" and partial excavation alternatives.

3.1.2.8 FAA Guidance

The Federal Aviation Administration (FAA) has developed guidance to address safety issues associated with aircraft bird strikes (Appendix A). The FAA also issued a Record of Decision (the Lambert Airport ROD) (FAA, 1998) (Appendix A) 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) addressing aircraft-wildlife strikes. These advisories, decision document, and memorandum 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 therefore are not potential 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), the FAA noted that the end of the proposed runway would be located within 10,000 feet of a then-existing active landfill (the Bridgeton Landfill) and therefore would not be consistent with FAA's current runway siting guidelines without mitigation. The decision document indicated 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.

The FAA decision document states:

> "STLAA will attempt to develop an agreement with the operator of the landfill to implement one of the following options:
>
> - Re-prioritize the landfill utilization plan so that the subject portion (i.e., that portion within the FAA's 10,000-foot radius of incompatibility) of the landfill is utilized first;
>
> - Require that STLAA be able to direct available fill that cannot be reasonably recycled from the construction projects to the subject portions of the landfill;
>
> - Require that organic waste be capped in the landfill before the new runway is opened and that only clean fill (such as construction materials) be placed in the subject portions of the landfill once the runway is operational.
>
> Should it not be practical to completely fill the subject landfill through the above measures, the STLAA will purchase an easement from the landfill operator which will provide the operator compensation for any lost revenue associated with the unused excess capacity. Any plan to convert or close the landfill must provide for a one-year bird-repelling program. Repelling efforts will begin 6 months before opening of the new runway and continue for a minimum of 6 months thereafter. The program will be in effect from dawn until dusk.
>
> (FAA ROD, September 30, 1998, pp 42 – 43).

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). 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 the remedial alternatives considered in this FFS, this guidance does not provide any criteria that would affect any of the anticipated remedial actions.

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). 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.

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). 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 represent a "to be considered" criterion (TBCs). 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).

EPA and representatives of Bridgeton Landfill, LLC previously 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. The STLAA sent a letter to EPA regarding the potential remedial actions under consideration for the Site (included in Appendix A). 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.

3.1.2.9 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 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 the potential for birds to interfere with airport operations. As part of this closure plan, a Negative Easement and Declaration of Restrictive Covenants Agreement (Restrictive Covenant) (Appendix A) 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 (Appendix A). 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 and the U.S. Department of Agriculture 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 EPA provided a summary of the alternatives considered in the SFS. STLAA and USDA stated that an excavation remedy would create risks that they could not even calculate, and that monitoring and management of risks created by wildlife would be impossible. STLAA noted that under the ROD-selected remedy, the Site will present no risk to human health or the environment and said that creating new risks by implementing an excavation remedy did not seem advisable. STLAA further stated that an excavation remedy would necessitate FAA review and likely result in objections from airlines as well as the FAA. STLAA was particularly concerned that either excavation alternative would take years to perform.

The EPA asked whether the airport's concerns would be alleviated by excavation of only Area 2 (outside the 10,000-foot range). STLAA's response was no: the entire area is within the Restrictive Covenant and subject to FAA review if "new landfilling operations" were to occur. In particular, STLAA explained that construction of an on-site disposal cell would not qualify as an expansion or change to an existing landfill because the Bridgeton Sanitary Landfill was already in closure mode, but would instead constitute "new operations" at the Site and therefore would trigger FAA review. STLAA stated that it could not predict the changes that any excavation activities would cause to the migratory patterns of birds and could not take the risk that such changes would increase the local bird population. STLAA stated that its 2006 letter, submitted during the public comment period on the ROD for Operable Unit I, still reflected its position.

Notes of this 2010 meeting were provided to the EPA and are included in Appendix A.

By letter dated September 20, 2010 (Appendix A), 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 ("complete rad removal") 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.

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 "complete rad removal" and partial excavation alternatives. The potential action-specific ARARs associated with the ROD-selected remedy and the "complete rad removal" and 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. Subpart A of these UMTRCA regulations contains standards for the control of residual radioactive materials from inactive uranium processing sites. 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 for closure performance standards may potentially be relevant and appropriate to remedial actions for OU-1. Specifically, 40 CFR § 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 CFR § 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 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.

Therefore, the ultimate question is which type of capping system – UMTRCA or solid waste – is the more appropriate for Site conditions. Areas 1 and 2 each consist of over a million yards of MSW – within which exists a smaller amount of MSW mixed with radionuclide-containing material. The fact that the majority of the materials are solid waste, including the RIM itself, suggests that the more appropriate cap design would reflect the solid waste closure criteria. However, the presence of RIM and its unique (relative to the overall MSW) characteristics of emitting gamma radiation and radon, indicate that additional measures, such as those developed for UMTRCA tailing piles, could also be appropriate. The approach included in the ROD-selected remedy reflects the key design components of both sets of regulations. Specifically, the ROD-selected remedy includes a hybrid cover system that is based on the MSW design criteria but incorporates additional measures to address gamma emissions and radon generation, including the projected emissions that will occur as a result of radium ingrowth over time from decay of thorium. By their very nature, MSW landfills require long-term inspection, maintenance and monitoring. To further address longevity considerations and long-term hazards relating to potential disruption of the disposal Site by natural phenomena, the ROD-selected remedy incorporates a concrete debris or a rock material layer to restrict bio-intrusion and erosion into the underlying landfilled materials, to act as a marker layer indicating the presence of human-derived, non-natural materials, and to increase the overall longevity of the landfill cover.

3.1.3.2 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 represent the primary standards for design and implementation of a containment remedy. Specifically, the landfill cover design, gas control measures, maintenance, groundwater monitoring, and corrective action criteria of these regulations are potentially relevant and appropriate.

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. These evaluations will not be repeated in this FFS.

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 excavation and “complete rad removal” 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$_{1/3}$%) and final cover of at least two feet (2’) of compacted clay with a coefficient of permeability of 1 x 10^{-5} cm/sec or less overlaid by at least one foot (1’) of soil capable of sustaining vegetative growth (10 CSR 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 “complete rad removal” 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 33$_{1/3}$%) and final cover of at least two feet (2’) of compacted clay with a coefficient of permeability of 1 x 10^{-5} cm/sec or less overlaid by at least one foot (1’) of soil capable of sustaining vegetative growth (10 CSR 80-3.010(17)(C)(4)).

3.1.3.3 RCRA Subtitle C Regulations

The RCRA Subtitle C requirements relative to 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.

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 CFR § 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 2.5.4, 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. Because the waste materials in Areas 1 and 2 are primarily MSW, there currently is no basis to conclude that these wastes are hazardous or similar to hazardous wastes. Therefore, the RCRA closure requirements would not be relevant. Furthermore, the intent of the RCRA Subtitle C regulations is to minimize migration of liquids through the closed landfill. Requirements to minimize migration of liquids through a closed landfill are also addressed by the RCRA Subtitle D regulations for MSW landfills, which, based on the nature of the materials in Areas 1 and 2, are considered more appropriate requirements than the RCRA Subtitle C regulations. In addition, the primary constituents of concern in Areas 1 and 2 are radionuclides, principally thorium and radium, which are relatively insoluble and therefore relatively immobile as compared to solvents or other types of more mobile constituents addressed by the RCRA Subtitle C regulations. 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. Therefore, the RCRA Subtitle C regulations are not considered to be relevant and appropriate requirements for design and construction of a final landfill cover over Areas 1 and 2.

Furthermore, EPA has indicated that designing closure through the use of a hybrid approach may be more appropriate (EPA, 1989). Hybrid landfill closure is used when residual contamination poses a direct contact threat, but does not pose a groundwater threat. Although EPA has determined that additional evaluations of groundwater conditions will be conducted as part of OU-3, as previously discussed in Sections 2.5.3 and 2.5.4, the groundwater monitoring performed to date has not identified the presence of a plume or contiguous area of groundwater contamination originating from Areas 1 or 2. Hybrid landfill closure entails use of covers, which may be permeable, to address direct contact threat with limited long-term management involving site and cover maintenance and minimal groundwater monitoring coupled with institutional controls (*e.g.*, land-use restrictions or deed notices) as necessary. EPA has directed the FFS consider alternative landfill cover designs. In addition, the landfill cover design included in the ROD-selected remedy is a hybrid MSW cover that has been modified to provide sufficient thickness to protect against gamma radiation and radon emissions.

3.1.4 Additional Requirements Associated with Off-site Disposal

This section discusses additional requirements that would apply to the “complete rad removal” 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 associated with each potential off-site disposal facility. These requirements are described below.

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 CFR § 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 CFR § 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 "complete rad removal" 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 CFR Parts 100 – 178), including specific regulations related to transport of radioactive materials (49 CFR Parts 171 – 180). These include regulations on 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, including 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 related to transport of radioactive materials (10 CFR Part 71).

Requirements established by rail carriers relative to transport of waste materials or radioactive wastes would also be applicable to the “complete rad removal” 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 “complete rad removal” 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 “complete rad removal” 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 “complete rad removal” 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. 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. 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 "complete rad removal" 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.

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 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 (^{238}U, ^{235}U, ^{234}U, ^{234}Th, ^{234m}Pa, ^{231}Th,	<500 ppm / 333 pCi/g	≤ 2000 pCi/g
Depleted Uranium (^{234}Th, ^{234m}Pa)	<500 ppm / 169 pCi/g	≤ 2000 pCi/g
Natural Thorium (^{232}Th, ^{228}Th)	<500 ppm / 110 pCi/g	≤ 2000 pCi/g
^{230}Th in equilibrium with progeny	<0.01 ppm / 200 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 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 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

The Clean Harbors Deer Trail, Colorado facility can only accept materials classified by Colorado Regulations as NORM and TENORM (Appendix C-3). This facility can only accept materials with total activity levels less than 2,000 pCi/g and with total uranium and thorium content less than 500 mg/kg. Ra-226 must be less than 222 pCi/g if it is the only primary radionuclide present. Lead-210 must be less than 666 pCi/g if it is the only primary radionuclide present. In addition, the gamma dose rate must be less than 116 microRoentgens/hour (uR/hr) at the surface of the container. 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

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. 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.

Energy*Solutions*' Radioactive Material License allows receipt and disposal of NORM or NARM. NORM/NARM 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.

The generator or owner must attach to the certification a list of all radiological and non-radiological constituents in the waste and the maximum and average concentrations of such constituents.

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 Chem-Nuclear Systems 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, WA facility would be substantially more expensive than disposal at US Ecology's Grandview, Idaho facility.

3.2 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 CFR § 300.430 (e)(2)(i)]. The remedial action objectives (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:

RAOs for Areas 1 and 2

1. Prevent direct contact with landfill contents, including exposure to external radiation;
2. Minimize infiltration and any resulting contaminant leaching to groundwater;

3. Control surface water runoff of contaminants of concern and minimize erosion; and

4. Control and treat landfill gas emissions including radon.

RAO for the Buffer Zone/Crossroads Property:

5. Prevent direct contact with contaminated surface soils or ensure contaminant levels are low enough to allow for unlimited use and unrestricted exposure.

Because the RI/FS, SFS and RI Addendum do not identify groundwater contamination issues associated with the Site, and because neither the ROD-selected remedy nor the excavation options for OU-1 include groundwater remediation, no groundwater RAO is identified or required at this time. Groundwater will be further evaluated separately as part of the anticipated “OU-3” investigations directed by EPA.

3.2.1 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.

3.2.1.1 ROD-Selected Remedy Cleanup Levels

Because the ROD-selected remedy is a containment remedy, no specific cleanup levels would apply. However, for purposes of defining the extent of the engineered landfill cover that would be installed under the ROD-selected remedy, the EPA criteria for unrestricted use (see discussion below) would be used.

3.2.1.2 “Complete Rad Removal” Alternative

EPA has defined (EPA, 2010a) “complete rad removal” to mean attainment of the risk-based radiological cleanup levels specified in OSWER directives 9200.4-25 and 9200.4-18 (EPA, 1998a and 1997a). These criteria are based on the UMTRCA standards (40 CFR Part 192 Subpart B) for cleanup of so-called “vicinity properties” (as opposed to the actual waste disposal units). Although the 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. 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, 2010b). The standards established pursuant to 40 CFR Part 192 Subpart B are intended to allow for unrestricted use of land relative to radionuclide occurrences. Although removal of all radionuclides above the UMTRCA standards (as modified by the OSWER Directives) would allow for unrestricted (*e.g.*, residential) use of the Site relative to the presence of radionuclides, the Site would still contain MSW and would still be subject to the solid waste regulations requirements including installation of an engineered landfill cover and institutional controls that prohibit residential land use on an MSW landfill.

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 "complete rad removal" alternative, a cleanup level of 54.5 pCi/g was used for uranium based on the approach established by EPA for development of the uranium remediation goals for the St. Louis Downtown Site (SLDS) [EPA, 1998b] and the St. Louis Airport Site (SLAPS) (EPA, 2005a). Additional discussion regarding the approach used for development of the uranium remediation level is presented in the EPA-approved SFS Work Plan (EMSI, 2010) and in Section 2.8.2.1 of the Record of Decision for SLAPS (EPA, 2005a).

Based on these cleanup levels, the so-called "complete rad removal" 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 address radionuclide occurrences would no longer be required. EPA's policies pursuant to CERCLA and the NCP do not require removal of all radionuclides. The radionuclide levels that would remain within Areas 1 and 2 under the "complete rad removal" alternative would allow for unrestricted use of the Site and therefore would be protective of human health for reasonably expected future exposure scenarios.

EPA has defined the "complete rad removal" 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 "complete rad removal" alternative are background-based standards. Determination of background levels is an important part of the development of the soil cleanup levels for the "complete rad removal" 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:

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

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.

Each of these radionuclides is a member of either the U-238 or the Th-232 decay chains. The short-lived members of these chains normally are 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. Examining the results listed above, it can be seen that they 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[16]
- Thorium-230+232 = 7.9 pCi/g

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[16] 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

- Total uranium = 54.5 pCi/g

These cleanup values were used to identify the Site soils that would be included with the scope of the "complete rad removal" alternative and that would otherwise be used to define the extent of any hybrid landfill cover that may be included within the scope of the ROD-selected remedy or the partial excavation alternatives.

A uranium remediation goal of 50 pCi/g is equivalent to a mass-based uranium concentration of 71 mg/kg. EPA's current non-carcinogenic screening level for uranium is 3,500 mg/kg for commercial/industrial uses and 230 mg/kg for residential exposures (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016). Consequently, cleanup of uranium to 50 pCi/g plus background should not pose any non-carcinogenic risks. Therefore, the cleanup level (54.5 pCi/g) derived for the West Lake Landfill OU-1 by use of the same approach used for the SLAPS, which is part of the North St. Louis sites, for potential carcinogenic risks should not present unacceptable non-carcinogenic risks and represents the more conservative cleanup target.

3.2.1.3 Partial Excavation Alternatives Cleanup Levels

EPA directed 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 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.

The 1,000 pCi/g value is based in part on the criterion used in the original 2006 FS to define potential "hot spots." It is also the risk-based level associated with commercial/industrial land use, which is the reasonably anticipated future land use of the Site (Auxier & Associates, 2016b).

EPA did not provide a rationale for the 52.9 pCi/g or the 16-foot depth below the 2005 topographic surface criterion in the SOW (EPA, 2015a).

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 technology when such technology offers 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). To address the two "complete rad removal" alternatives evaluated in the Supplemental Feasibility Study (SFS) (EMSI et al., 2011) 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 has eliminated the "complete rad removal" with on-site disposal alternative from further consideration and 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, 2010), 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 technologies and process options 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 following technologies and process options were added to the technical implementability screening in this FFS to potentially be considered as components of the "complete rad removal" 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 • 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

General Response Action	Remedial Technology	Process Options
		• 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 • 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

General Response Action	Remedial Technology	Process Options
		• 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 “complete rad removal” 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 the ROD-selected remedy and the complete and partial excavation 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 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 scanning 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, as 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

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. An engineered landfill cover consisting of natural materials such as soil, clay and vegetation layers is the primary type of landfill cap considered for OU-1. The description and discussion of this technology were included in the FS (EMSI, 2006).

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 bio-intrusion 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 reduce radon emissions and further restrict precipitation infiltration.

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).

This technology was described in the SFS in conjunction with evaluation of the “complete rad removal” with on-site disposal alternative; however, at the direction of EPA, an alternative consisting of on-site disposal in a new engineered cell is no longer being considered for the Site.

Therefore, technologies that were associated solely with this alternative that were presented, described and evaluated in the SFS are not discussed in this FFS.

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 more 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).

Although the use of sheet piling to stabilize excavation side slopes could potentially reduce the amount of material that may need to be removed, obstructions and uncertain geotechnical properties within the waste mass could greatly impact the implementability of this technology. 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. Application of the sheet pile technology for excavation stabilization is not considered to be implementable or cost effective for Areas 1 and 2.

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, offgas 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.

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. Neither of these radionuclides has been detected in dissolved-phase groundwater at levels above background. 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, which in the case of Areas 1 and 2 have been shown to be in generally unsaturated conditions (EMSI, 2016b and EMSI, 2000). 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, 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.

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 radiologically-impacted soil 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 4-2.

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.

The benefits or impacts of using a shear shredder prior to a trommel screen relative to maximizing separation of radiologically-impacted soil from solid wastes typically is evaluated as part of a pilot test during RD prior to full-scale implementation. 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.

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). For this method, radionuclide-contaminated soil is first excavated and screened to remove large rocks and debris. Large rocks are crushed and placed with soil on a conveyor belt, which carries the soil 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 into contaminated and clean segments. The radioactive materials then receive further treatment and/or disposal. 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 criteria 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 criteria 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, 2016b) 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. Therefore, it is likely this technology will not be effective for the "complete rad removal" or possibly even the 52.9 pCi/g criteria partial excavation alternative. Due to the general correlation between radium and thorium occurrences at higher levels (EMSI, 2016b), this technology may have some application relative to the partial excavation alternative based on the 1,000 pCi/g criteria.

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.

As discussed in Section 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 4-3. Figure 4-3 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 "complete rad removal" 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 4-3).

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. The link to a photo gallery showing the facilities and nearby rail transfer facility is: http://www.americanecology.com/grand_view_photo_gallery.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 the 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 flat bed 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 flat bed 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 the 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 the 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 run-on); 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 remedial design and implemented during the remedial action to ensure that appropriate effective measures are taken to limit run-on, 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 run-on 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 is approximately 200 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. 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 precipitated with the particulates in the storm water and would be removed via gravity settling within a detention or stormwater pond or tanks and filtration to meet direct or indirect (*i.e.*, to a Publically-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[17] or as allowed by State regulations.

4.3.6.2 Bird Nuisance Mitigation

Because the waste materials in Areas 1 and 2 would be regraded as part of the ROD-selected remedy or subjected to excavation under either the partial or “complete rad removal” 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 remedial design process to ensure that appropriate effective measures are taken during excavation to cost-effectively limit bird congregation in order to protect 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

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[17] The design storm represents the maximum rate at which stormwater can be discharged from the Site.

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 ROD-selected remedy and excavated under the partial excavation or "complete rad removal" 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 “complete rad removal” 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	• On-site: New cell
	Cryogenic Barriers	• Subsurface cryogenic barrier
	Vertical Barriers	• 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	• Enclose excavation with temporary structure
	Bird Nuisance Mitigation	• Enclose excavation with temporary structure

General Response Action	Remedial Technology	Process Options
		• Chemical frightening agents or toxicants

Implementability screening comments in addition to those provided on Figure 4-1 for the use of a temporary structure to enclose an excavation for stormwater management or bird nuisance mitigation and the dry soil separation physical treatment process are provided below.

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 was eliminated because the other potential process options would provide adequate stormwater controls or bird nuisance mitigation without the significant disadvantages (summarized below) of using a temporary enclosure. 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 reasonable maximum width of only 160 feet. The width of RIM areas to be excavated, plus layback for overburden, is estimated to range from 250 feet to 1,050 feet. Thus, temporary structures 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. 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 30-40 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. 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 be prohibitive.

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 complete rad removal 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 of this technology cannot be determined without performing a pilot-test. . Furthermore, although a trommel includes an exterior brush (Figure 4-2) 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. Consequently, the potential effectiveness and implementability of this technology relative to segregation of RIM from non-RIM cannot be assessed without performing a pilot test.

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, 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 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 the radiologically-impacted soil fraction of RIM could be separated from the overall matrix of landfilled refuse, debris and fill materials, and unimpacted soil and quarry spoils using the revolving cylindrical sieve trommel technology, then additional dry soil separation 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 “complete rad removal” alternative.

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. The effectiveness of this technology relative to the partial excavation alternative based on the 52.9 pCi/g and 16-ft depth criteria cannot be ascertained from the available information and would require pilot-testing to determine the degree of separation that could be achieved.

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 4-4 based on anticipated effectiveness, implementability, and relative cost to identify applicable technologies that might be used as components of the remedial action alternatives.

Ordinarily in the CERCLA FS process, technologies identified in the technology screening step as being potentially applicable to site characterization results and RAOs are combined to develop remedial alternatives. The remedial alternatives are then screened, if necessary, and subjected to a detailed analysis using nine prescribed evaluation criteria. In the case of this FFS, EPA stipulated the alternatives to be developed and evaluated (EPA, 2015b). Therefore, the step of combining technologies to develop alternatives and screening the alternatives is unnecessary and could result in the elimination of one or more of the alternatives that EPA determined must be evaluated in this FFS.

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 additional technologies or process options were included: short- and long-term monitoring; capping and covers; disposal in an off-site licensed facility; physical/chemical treatment including solidification/stabilization and soil separation; excavation; temporary structure to enclose a material handling area; storm water management; fugitive dust/odor control, bird nuisance mitigation; and truck and truck and rail transportation.

5 REMEDIAL ACTION ALTERNATIVES

This section provides descriptions of the remedial alternatives evaluated in this FFS, including the ROD-selected remedy, the “complete rad removal” alternative, and two partial excavation 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; construction schedules for each alternative; and to 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.

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 FS (EMSI, 2006) and SFS (EMSI et al., 2011).

5.1.1 Remedial Alternatives Evaluated in the FS

A range of remedial alternatives addressing waste materials and contaminated soil present in OU-1 was developed for, and evaluated in, the FS (EMSI, 2006). 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 and is included as Appendix E to this FFS. Based on the nature and extent of the radiological materials present within OU-1, the evaluation concludes that the additional risks involved with a hot spot removal significantly 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:

Areas 1 and 2 Landfill Alternatives

- 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. 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 historic erosion of the landfill berm along the west side of Area 2 and the resultant deposition of radiologically-impacted soil on the surface of the Buffer Zone/Crossroad property (formerly termed the Ford property). The remedial alternatives developed in the FS (EMSI, 2006) to address management of contaminated soil on the Buffer Zone/Crossroad property are as follows:

Buffer Zone/Crossroad Property (former Ford property) Remedial Alternatives

- 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 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 property alternatives relative to the nine criteria specified in the NCP are presented in the 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.

5.1.2 Remedial Alternatives Evaluated in the SFS

In a January 11, 2010, letter (EPA, 2010) and accompanying SOW, EPA requested that the Respondents prepare an SFS to evaluate two complete rad removal alternatives. For purposes of the SFS, EPA identified two "complete rad removal" alternatives that EPA directed be developed and evaluated 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, 2010) 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 SFS (EMSI et al., 2011).

5.1.3 Remedial Alternatives Evaluated in the Final FS

EPA's SOW for the RI Addendum and FFS identifies three partial excavation alternatives and two other remedial alternatives which, in addition to the No Action Alternative, results in the following six remedial alternatives to be evaluated in the FFS:

1. 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 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.

2. 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[18];

3. 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[19];

4. 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[20];

5. 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;[21] and

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[18] 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.

[19] 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 thorium-226 would also lower the negligible risks from these ancillary radionuclides still further.

[20] The SOW indicates 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. However, it is premature to propose an alternative depth at this time. In the event that an alternative depth interval reflective of the actual site data is identified during evaluation of the data during preparation of the RI Addendum and FFS reports, the Respondents will seek concurrence from EPA at that time.

[21] The evaluation performed by Auxier (as set forth in the June 2016 "Risk to Industrial user of Operable Unit 1 prepared by Auxier & Associates, Inc.") identified an industrial-risk-based level of approximately 1,000 pCi/g (after rounding). Alternatives No. 2 and No. 4 are therefore, for all intents and purposes, currently the same alternative.

6. Full Excavation with Offsite 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;

The EPA definition of the "complete rad removal" alternative is based on combined radium and combined thorium activities as specified in OSWER Directive No. 9200-4.18 and 9200-4.25. 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.

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

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 Property 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.

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. 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.[22] 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 displays 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 Property to be consolidated in the area of containment (Areas 1 or 2) prior to placement of fill material or construction of the cover. It is anticipated that construction of the landfill cover will require the toe of the landfill berm to be regraded and extended over the impacted area on the Buffer Zone/Crossroad Property. The precise nature and extent of contaminated soil is uncertain because grading of the Buffer Zone/Crossroad Property occurred after collection of the most recent set of soil sample data.[23] Gamma scans and soil sampling will be used to support the RD

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[22] 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).

[23] Sampling conducted on the Buffer Zone/Crossroad Property in February 2000 (after site soils had been scraped to a depth of approximately 1 to 2 feet) indicated that with the exception of a single sample, all of the samples

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 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. 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 30 years[24], decomposition gas generation is relatively low and expected to decline. 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

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displayed radionuclide levels of less than 5 pCi/g above background. Based on these data, the total extent of the area on the Buffer Zone/Crossroad property that may still contain radionuclides at levels greater than 5 pCi/g above background in February 2000 was estimated to be approximately one acre. For evaluation of remedial alternatives in the FS, it was assumed that soil containing radionuclides at levels above those suitable for unrestricted use remained on the Buffer Zone/Crossroad property.

[24] In light of the passage of time since issuance of the ROD, these areas have now been inactive for an even longer period of time.

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[25] 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, five-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.

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 pursuant to the Missouri Solid Waste Rules;
- 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.

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[25] Operations and Maintenance (O&M) Plan is referred to elsewhere in this report as the OM&M (Operations, Maintenance and Monitoring) Plan.

5.3.1.1 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 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 to regrading 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).

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.

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 in the FFS.

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 run-on 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.

5.3.1.3 Removal of Radiologically-Impacted Soil from the Buffer Zone/Crossroads Property

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 2-14). This design-phase survey would only apply to the Buffer Zone/Crossroads Property and would be performed in accordance with the requirements of 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/Crossroads property are discussed in Section 3.2.1.1 of Appendix G.

Any radiologically contaminated soil on the Buffer Zone/Crossroads Property would be removed and 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. The precise nature and extent of contaminated soil on the Buffer Zone/Crossroads Property is uncertain due to grading activities conducted in these areas after the latest set of samples were obtained. Any soil outside the boundaries of the Site would need to meet remediation goals that support unlimited use and unrestricted exposure and would be subject to verification sampling. Excavation of contaminated material would include dust suppression and monitoring (see Appendix G) to ensure there is no release of fugitive dust.

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 5-1. Figure 5-2 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 x 10^{-5} cm/sec or less; and
- A two-foot thick bio-intrusion/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 6 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 x 10^{-5} cm/sec or less; and 1 foot of soil suitable 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.

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. Therefore, evaluation of the ROD-selected remedy includes both a 2-foot CCL and a 2-foot soil layer that incorporates a GCL (Figure 5-2).

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 updated radium-226 and thorium-230 concentrations and the results of radon flux testing recently completed as part of the construction of the non-combustible cover over portions of Areas 1 and 2 to predict the expected levels of radon, radium and thorium that would result from 1,000 years of thorium and radium decay, radium ingrowth and radon generation.

Measured radon flux values indicate current radium-226 concentrations produce radon-222 emanations that are currently less than 10% of the regulatory limit of 20 pCi/m^2/s, averaged across OU-1 (EMSI, 2016b). Using standard ingrowth equations, it was determined that the average future concentration of radium-226 after 1,000 years of ingrowth would not increase radon-222 emissions above the 20 pCi/m^2/s mark, regardless of cover design. From this it was concluded that a cover over the affected soil is not needed to meet radon-222 criteria. Placing any cover, such as the one required during landfill closure by MDNR, would reduce already acceptable radon-222 emanations further, making the considered designs insensitive to radon-222 radon emission criteria.

Since radon-222 emission criteria would be satisfied by all cap designs, the cap thickness will be governed by surface exposures from gamma radiation penetrating the cap. These calculations were performed on the aged radium-226 inventory using the gamma pathway in EPA's web-based risk calculator for radionuclides[26], and the design specified in the ROD,[27] which 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 was found to provide sufficient protection from surface radiation exposures throughout the 1,000 simulation.

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). Additional evaluations of the cover design may be performed during the RD phase to further verify that the design of the landfill cover complies with the applicable and relevant and appropriate requirements of other environmental regulations. 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 5-2 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 bio-intrusion 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.

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[26] Provided on https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search.

[27] 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.

There are several options for how this material could be managed. Depending upon the relative rates 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). As such, 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 5-3). 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 further protected by the presence of the 500-year levee and supporting flood control system of the Earth City Levee District. In the unlikely event of levee failure during a 500-year flood event, it is possible that flood waters could reach the lowermost approximately two feet of the toe of the landfill cover at the northwestern edge of Area 2. Because the Site is located more than 1.3 miles from the Missouri River, no high energy water flows would be expected if flood waters reached the Site. The flood protection needs of the toe of the landfill would be evaluated in more detail in the RD, and appropriate bank protection methods would be incorporated as necessary (*e.g.*, a rock rip-rap apron). 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. During construction, it is anticipated that:

- 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 off-site 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 and radium, radon-222 and various radon decay products, and potassium-40. 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 landfill gas would be monitored both during and after construction of the ROD-selected remedy. 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 3.1.2 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 offgas 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; however, the additional investigations conducted in 2013 – 2015 did not encounter any leachate or perched water in Area 1 or 2. 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 on-site, and accordingly, the post-closure operations, maintenance and monitoring period would likely 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 and 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 annual post-construction site inspections that would be conducted after remedy construction to verify that the constructed remedy was performing as designed.

Four types of radiological surveys would be conducted to guide the minor cut and fill operations in Areas 1 and 2, 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 would meet design criteria. These methods of remediation control monitoring for the ROD-selected remedy are described in Section 3.2.1 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 for OU-1 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 Five 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 Five Year Review at a minimum of every five years after completion of the Record of Decision for the Site or, if determined by EPA to be necessary, at more frequent intervals. The Five Year review would include an overall statement regarding the protectiveness of the remedy.

5.4 “Complete Rad Removal” Remedial Action Alternative

This section of the FFS describes the RIM volumes to be addressed under the “complete rad removal alternative, RIM excavation procedures and associated activities; short-term, post-construction, and long-term monitoring associated with the “complete rad removal” alternative; and describes the specific components of the “complete rad removal” with off-site disposal alternative. Final grading, capping and closure of Areas 1 and 2 after RIM removal are also described.

Activities associated with the “complete rad removal” 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 RIM 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 radiologically-impacted soil on the Buffer Zone and Crossroad property;
- Excavation of any soil from the Buffer Zone and/or Crossroad property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading, transport, and disposal of the RIM and impacted soil 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.

Per EPA's December 9, 2015 letter and attached SOW (EPA, 2015a), the FFS is to include a "complete rad removal" alternative consisting of excavation of RIM with off-site commercial disposal of the excavated materials. EPA previously indicated (EPA, 2010) 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.

Although this alternative has been termed "complete rad removal," 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 to the degree feasible such that additional engineering and institutional controls would not be required based on the radiological content of these areas. 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.

Several components of this alternative have been addressed above in the ROD-selected remedy and will not be repeated here. The following subsections address excavation, loading and transport of RIM and impacted soil for disposal at an off-site facility.

5.4.1 RIM Volumes for the "Complete Rad Removal" 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 (Appendix B) as follows:

Area 1 RIM (7.9 pCi/g criteria)	46,200 bank cubic yards (bcy)
Area 2 RIM (7.9 pCi/g criteria)	220,000 bcy
Total RIM (7.9 pCi/g criteria)	266,200 bcy

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)	702,500 bcy
Area 2 overburden (7.9 pCi/g criteria)	493,200 bcy
Total overburden (7.9 pCi/g criteria)	1,195,700 bcy

Figures 5-4 and 5-5 display the extent of RIM that would be excavated from Areas 1 and 2 under the "complete rad removal" alternative.

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). 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.

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 included in Section 2.2.5 and is further described in Appendix B.

It should be recognized that the RIM and overburden volume estimates were performed to a feasibility-study level of accuracy, and there is a high degree of uncertainty in these quantities. The levels and distribution of radionuclide activity within the RIM is known to be highly variable due to the inherent heterogeneity of the waste as well as the variable locations where RIM is concentrated. Uncertainty also arises from the limits on the accuracy of the existing site topographic mapping, which is based on aerial photogrammetry without ground control, producing, at best, a topographic surface with a tolerance of approximately one foot. In addition, past subsurface investigations of the Site were focused on providing information on the general nature and extent of occurrences 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 (EMSI et al., 2011). However, the intent of the prior investigations was not to accurately define the three-dimensional extent of the RIM for detailed quantity estimates. Consequently, precise 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, and the relative amounts and distributions of soil and waste materials within the RIM cannot be made at this time. For purposes of this FFS evaluation, the estimated volume of RIM is the single largest uncertainty affecting the estimated costs and schedule for the "complete rad removal" alternative.

5.4.2 RIM Excavation and Associated Activities

This section describes the various activities associated with the "complete rad removal" alternative. Activities associated with regrading and installation of a new landfill cover over Areas 1 and 2 after removal and off-site or on-site disposal of the radioactively-impacted materials in Areas 1 and 2 are described in Section 5.3.5.

5.4.2.1 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 5-6. 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 3.2.2.1 of Appendix G.

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. The excavation would continue across the edge of the suspected RIM zone as guided by the radiation surveyors. It is anticipated that HP technicians could conduct periodic small-scale hand excavations when measurements indicated the presence of RIM just beneath the surface. If the RIM zone was judged to be relatively thin, these hand excavations could be used to attempt to verify the RIM thickness.

If overburden material is present, the excavator would remove the overburden and the survey technicians would screen the material to ensure no RIM was present. If no RIM is present, an additional layer of material would be removed and the area resurveyed. If additional 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 width while the analytical results of soil/waste samples are obtained to determine if all of the RIM above unrestricted use criteria has been removed.

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.

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. Because Th-230 is the controlling radionuclide at the Site, guidance of the excavation activities for the "complete rad removal" alternative can be generally guided by field measurements but ultimately will be directed by the results of laboratory analyses which will increase both the time required for and cost of excavation activities.

The shaded area in Figure 5-6 is a hypothetical scenario that portrays the zone of RIM 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. 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. 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.

5.4.2.2 Material Handling

It has been estimated that approximately 46,200 and 220,000 bank cubic yards of RIM would be excavated from Area 1 and Area 2, respectively, under the "complete rad removal" alternative. In addition, it is estimated that approximately 702,500 and 493,200 bank cubic yards of non-RIM waste overburden would require excavation from Area 1 and Area 2, respectively, to access the RIM waste for the "complete rad removal" alternative. In order to access the underlying RIM waste, this non-RIM overburden material would be removed and temporarily stockpiled at the Site.

Characterization data generated during the RI and supplemental investigation phases of this project (EMSI, 2016b) 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; and
- Final soil cover, possibly including some soil that has been mixed with leached barium-sulfate residues.

The levels and distribution of radionuclide activity within the RIM 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 RIM, the actual volumes and configurations of the RIM, and the relative amounts and distributions of soil and waste materials within the RIM cannot be made at this time. Until actual excavation were to commence and field screening and visual observation begin, the extent and volume of overburden and RIM that would be removed under the "complete rad removal" 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 "complete rad removal" 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 "complete rad removal" alternative. 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, and performing physical separation using the trommel and testing the result 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.

5.4.2.3 Material Stockpiling

As previously noted, excavation of the RIM under the “complete rad removal” alternative would require removal and stockpiling of non-RIM waste materials that overlie the RIM (overburden wastes). For the “complete rad removal” alternative, excavated non-RIM overburden waste would be temporarily stockpiled adjacent to the excavation(s) or elsewhere on-site 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 702,500 and 493,200 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 “complete rad removal” alternative.

For the “complete rad removal” alternative, 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 were 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 “complete rad removal” alternative, it is likely that implementation of the “complete rad removal” alternative would require some stockpiling of materials (non-RIM waste and/or cover construction materials) outside of Areas 1 and 2. Figure 5-3 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 bio-intrusion layer is not included as part of the cover for the “complete rad removal” with off-site disposal alternative. FS-level design projections determined that approximately 1,280,000 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). Potential stockpile areas are shown on Figure 5-3.

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.

5.4.2.4 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 Section 3.2.2.1 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 5.4.2.1 and Appendix G.

5.4.2.5 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 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%) than the 10% estimated in this FFS or substantially more (as much as 20%) than the amount included 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 “complete rad removal” and partial excavation alternatives. Daily cover placed over the RIM excavation areas would mix with and become part of the volume of RIM, therefore increasing the volume and mass of RIM that would be sent for off-site disposal.

It may be possible to place tarps or foam over the non-RIM and RIM excavation areas and non-RIM overburden stockpiles under the “complete rad removal” 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 implementation of a remedial action 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.

5.4.2.6 Removal of Radiologically-Impacted Soil from the Buffer Zone/Crossroad Property

With the exception of the ultimate disposition of such soil, identification, characterization and removal of soil on the Buffer Zone or Crossroad Property 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 5.2.1.2). Under the “complete rad removal” with off-site disposal alternative, any such soil would be disposed off-site.

5.4.2.7 Management of Subsurface Liquids During RIM Excavation

It is not anticipated that groundwater would be encountered during excavation of RIM. Pockets of perched leachate present in the waste mass may be encountered during implementation based on the extent and depths of excavation associated with the “complete rad removal” and partial excavation alternatives. Leachate, if any, 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 for discharge to MSD, and subsequently treated, if and as necessary, prior to discharge to MSD. In the event that this liquid cannot be discharged to MSD, it would be hauled to an offsite disposal facility.

It is not expected that groundwater will be encountered during RIM excavation, based on a comparison of typical measured Site groundwater elevations to the anticipated bottom of the anticipated excavations for Areas 1 and 2.

5.4.2.8 Regulated Materials Management During RIM Excavation

Management of suspected hazardous wastes or RACM encountered during implementation of the "complete rad removal" and partial excavation alternatives would be conducted in the same manner described in Section 5.2.1.8 for the ROD-selected remedy.

5.4.2.9 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 Section 3.2.2.2 of Appendix G.

5.4.3 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 "complete rad removal" alternative would be hauled to one of the off-site disposal facilities described in Section 4.3.7. 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 "complete rad removal" 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 of the offsite disposal facilities with the possible exception of U.S. Ecology's Wayne Disposal facility in Michigan. For all of the offsite disposal facilities, with the possible exception of U.S. Ecology Michigan, RIM would be hauled to the disposal facilities via rail.

As described in Section 4.3.5, 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 bag 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 a lined metal intermodal container with a secured lid and the intermodal container 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.

Loading of the intermodal containers at the Site would occur within an enclosed structure equipped with dust, odor and vapor emission control equipment (Figure 5-7). 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 5-8). Trucks arriving at the Site carrying empty intermodal containers would be first weighed and then would enter one (the “intermodal loading”) side of the building. A liner would be placed in the intermodal container and the truck would pull forward to the center of the building where RIM would be placed in the lined intermodal container 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 “intermodal loading” side 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 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 if 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 intermodal containers of RIM to a truck/rail transloading facility where the intermodal containers would be loaded onto flat rail cars 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 5-7).

For the “complete rad removal” with off-site disposal alternative, determination of the containment method 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 5-8:

- 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 5-8);
- 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 access roads to 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 wetlands 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 to OU-1 Area 1, and parallel tracks to the west of the asphalt plant area[28];
- 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.[29]

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[28] 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.

[29] 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.

- 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.

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, it was decided that for the purposes of FFS evaluations of the “complete rad removal alternative” it would be 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 the off-site disposal facilities described in Section 4.3.7.

5.4.4 Stormwater and Landfill Gas Monitoring and Control

In addition to the surfaces that stormwater could contact under the ROD-selected remedy, stormwater under the “complete rad removal” alternative 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.

Stormwater management for the “complete rad removal” 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 owing to the greater area of disturbance and creation of topographic depressions during construction of the “complete rad removal” alternative and the greater period of stormwater management resulting from the longer duration required for implementation of the “complete rad removal” 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.

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 “complete rad removal” 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 "complete rad removal" 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.

5.4.5 Final Grading and Engineered Landfill Cover

As only the RIM would be removed, 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 as described in Section 5.3.1.4 above with the exception that the final grades would be a minimum of 5% and the final cover installed for the "complete rad removal" alternative would not include the additional two-foot thick rock/rubble biointrusion layer. 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 (10^{-5} cm/sec).

The uppermost one (1) ft soil layer would have to be capable of sustaining 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 found 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 two (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 x 10^{-5} cm/sec or less could be achieved during construction.

5.4.6 Long-Term Operations, Maintenance and Monitoring and Non-Engineered Components

Long-term OM&M activities and the non-engineered components for the "complete rad removal" 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 "complete rad removal" alternative. Because all of the RIM containing radionuclides above levels that would allow for unrestricted use would have been removed from Areas 1 and 2 under the "complete rad removal" 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 would 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 five-year reviews.

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, five-year regulatory reviews, as described in Section 5.2.2.2, should not be required for the "complete rad removal" 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.

5.5 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. This alternative consists of many of the same components as were previously discussed for the "complete rad removal" 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 Crossroad property;
- Excavation of any soil from the Buffer Zone and/or Crossroad property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading, transport, and disposal of the RIM and impacted soil 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 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 "complete rad removal" 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 "complete rad removal" alternative) and the imposition of a maximum depth of excavation for 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 "complete rad removal" alternative, and accordingly, a remedy that (comparatively speaking) may be implemented more readily.

5.5.1 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 (Appendix B) and are as follows:

Area 1 RIM (52.9 pCi/g criteria)	20,800 bank cubic yards (bcy)
Area 2 RIM (52.9 pCi/g criteria)	130,000 bcy
Total RIM (52.9 pCi/g criteria)	150,800 bcy

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)	52,800 bcy
Area 2 overburden (52.9 pCi/g critiera)	198,700 bcy
Total overburden (52.9 pCi/g criteria)	251,500 bcy

Figures 5-9 and 5-10 display the extent of RIM that would be excavated from Areas 1 and 2 under the 52.9 pCi/g partial excavation alternative.

In contrast to the “complete rad removal” 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 would require relocation of the Allied Waste solid waste transfer station building 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), as that excavation would affect the stability of the transfer station (Figure 5-9). As previously discussed in Section 5.4.1 relative to the “complete rad removal” 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.

A discussion of 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 is further described in Appendix B.

As previously discussed in Section 5.4.1 relative to the “complete rad removal” 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 5.4.1 relative to the “complete rad removal” 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.

All other aspects of the 52.9 pCi/g partial excavation alternative would generally be the same as those previously described for the “complete rad removal” alternative, except that because RIM would be left on-site, the enhanced cap included under the ROD-selected remedy (e.g. the biointrusion/marker layer) would also be included as part of 52.9 pCi/g alternative. The 52.9 pCi/g alternative would require a lesser amount of soil material (1,060,000 loose cubic yards) to be purchased and delivered to the Site for construction of this alternative. In addition, because radionuclides above the unrestricted use criteria would still remain at the Site, five-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.

5.6 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 as were previously discussed for the “complete rad removal” 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 property;
- Excavation of any soil from the Buffer Zone and/or Crossroad property that contains radionuclides at levels greater than those that would allow for unrestricted use;
- Loading, transport, and disposal of the RIM and impacted soil 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 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 the “complete rad removal” 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 “complete rad removal” alternative 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 also 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.

5.6.1 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 (Appendix B) and are as follows:

Area 1 RIM (1,000 pCi/g criteria)	7,100 bcy
Area 2 RIM (1,000 pCi/g criteria)	31,100 bcy
Total RIM (1,000 pCi/g criteria)	38,200 bcy

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)	387,000 bcy
Area 2 overburden (1,000 pCi/g critiera)	213,600 bcy
Total overburden (1,000 pCi/g criteria)	600,600 bcy

Figures 5-11 and 5-12 display the extent of RIM that would be excavated from Areas 1 and 2 under the 1,000 pCi/g partial excavation alternative.

Similar to the "complete rad removal" 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 Allied Waste 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 Appendix B.

Similar to the discussion in Section 5.4.1 relative to the "complete rad removal" 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 5.4.1 relative to the "complete rad removal" 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.

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. The 1,000 pCi/g alternative would require the greatest amount of soil material (1,290,000 loose cubic yards) to be purchased and delivered to the Site for construction of this 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 1,000 pCi/g, radionuclides would still remain at the Site at levels above the unrestricted use criteria. Therefore, five-year review evaluations and radon gas monitoring would be required for the 1,000 pCi/g partial excavation alternative.

6 DETAILED ANALYSIS OF ALTERNATIVES

This section provides a detailed analysis of the No Action alternative, the ROD-selected remedy, the “complete rad removal” alternative, and the two partial excavation alternatives developed 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 National Contingency Plan (NCP) (40 CFR § 300.430).

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 5.6.

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).[30]

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[30] 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.

- 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 evaluation 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 adequately justified. Other information, such as advisories, criteria or guidance, is considered during the ARARs analysis as “to be considered” elements (TBCs). The considerations evaluated during 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 Subsection 3.1.

Chemical-specific ARARs:

- Likelihood that the alternative will achieve compliance with chemical-specific ARARs within a reasonable period of time.
- If it appears that compliance with chemical-specific ARARs will not be achieved, then evaluation of whether a waiver is appropriate.

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.

<u>Magnitude of residual risks</u>:

- 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.

Adequacy and reliability of controls:

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.

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 full-scale to treat 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 “complete rad removal” alternative, and the 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). Operation, maintenance, and monitoring (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., five-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 CostWorks First Quarter 2016 digital cost data, site-specific vendor and contractor quotes and discussions, experience with actual costs from similar projects, other historical project costs updated to 2016 costs using the Engineering News Record Construction Cost Index (ENR CCI), and engineering judgment.

As discussed in Section 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 of the FFS have experience performing the type of services that would be necessary for implementation of a “complete rad removal” or partial excavation alternative. In particular, 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. The other two disposal facilities have performed similar services for Formally Utilized Sites Remedial Action Program (FUSRAP) and DOE 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 DOE FUSRAP 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. 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 gondola car 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 were used. For the "complete rad removal" 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, 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, remedial design (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 "complete rad removal" and 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-1.

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 SFS (%)
Soil excavation	15 – 55	55
Off-site disposal	5 – 15	15
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 and the “complete rad removal” and partial excavation alternatives include the following:

- The estimated volume of RIM to be removed under the “complete rad removal” and partial excavation alternatives. As presented in Appendix B of the FFS, the RI data and various interpolation techniques were used to estimate the volume of waste material that might need to be removed, and those estimated volumes then served as the basis for the cost estimates. 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 data quality objectives (DQOs) for the RI were to develop site characterization data, not to estimate volumes of waste material for RD.

- 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 “complete rad removal” 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 Area 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 “complete rad removal” 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 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 4 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 “complete rad removal” 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 are able to accept the RIM at the time of removal and the capacities and waste acceptance criteria of such facilities at the time of remedy implementation[31]; (5) and the overall validity, duration, and reliability of the verbal quotes received from disposal facility representatives.

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, material or supply

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[31] Although potential disposal facilities were contacted during preparation of the SFS and again during preparation of the FFS with regard to available capacity for municipal solid waste mixed with soil containing radionuclides and their specific Waste Acceptance Criteria (WAC), 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 may be implemented.

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 five-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), 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 (February 12, 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 1.5 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 five potential alternative remedies for the Site: (1) No Action alternative; (2) the ROD-Selected Remedy (regrading and enhanced capping); (3) “complete rad removal”; (4) partial excavation of RIM with activity levels above 52.9 pCi/g located within 16 feet of the 2005 topographic surface; and (5) partial excavation of RIM with activity levels greater than 1,000 pCi/g.[32] 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[33] 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. Similarly, no additional institutional controls would be imposed beyond those already in place at the Site, 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. 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. The Site continues to be an active industrial facility to which access is controlled (including fencing and 24-hour security). It is anticipated that the industrial uses currently ongoing at the Site would continue into the future, and it is assumed that the existing fencing and access controls would remain in effect for the No Action alternative. It is also assumed that no monitoring would 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 five-year review would be performed by EPA as part of the implementation of the No Action alternative.

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).

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[32] Initial evaluation of a risk-based criterion reflective of the industrial land use at the Site was previously performed (Auxier & Associates, 2016b) and resulted in a criterion of 1,000 pCi/g. Because this value was the same as the value selected by EPA for one of the partial excavation alternatives (EPA, 2015b), a separate alternative was not developed. EPA has indicated that it would like additional evaluations of the industrial risk-based level to be performed. If such evaluations result in identification of a value other than 1,000 pCi/g, an additional partial excavation alternative may be developed and evaluated in a subsequent draft of the FFS.

[33] Prior actions include installation of the non-combustible cover, fencing and signage on Areas 1 and 2.

6.2.1.1 Overall Protection of Human Health and the Environment

Based on the results of the BRA evaluations (Auxier, 2000 and 2016a), conditions associated with OU-1 do not currently pose an unacceptable risk to on-site workers or the off-site community, assuming the existing institutional controls are maintained, monitored and enforced. The BRA analyses indicated that the potential risks posed to a future groundskeeper[34] working in Areas 1 and 2 could be above the generally accepted risk range 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 other on-site workers, off-site commercial building users, a hypothetical off-site farmer, and off-site residents and the general public were within EPA's accepted risk range. As 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 (Table 3-1). 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 found to be well below the UMTRCA standard and radon NESHAP of 20 pCi/m^2s and the radon standard outside of the Area 1 and 2 disposal areas (see RI Addendum Section 7.1.1.1). Although individual groundwater wells have shown some isolated occurrences of chemical or radiological constituents (*e.g.*, radium) at levels slightly above the UMTRCA groundwater protection standards and the Missouri MCLs, many of these occurrences, including the highest radium activities found in groundwater beneath the Site, were reported in monitoring wells located upgradient of Areas 1 and 2. In addition, the USGS (2014) concluded that 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. Current air monitoring (Auxier and EMSI, 2015a, 2016b and 2016c) and health

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[34] The updated Baseline Risk Assessment (Auxier, 2016a) concluded that a future groundskeeper was the potential receptor with the reasonably-maximum exposure.

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 radiation. Although conditions associated with Areas 1 and 2 currently meet all of these chemical-specific ARARs, without installation and maintenance of additional engineering controls, continued compliance with these standards cannot be ensured.

The No Action alternative is expected to meet all of the location-specific ARARs identified in Section 3.1.2 of this FFS.

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

All current and potential future risks would remain under the No Action alternative. Without monitoring and maintenance of Areas 1 and 2, the No Action alternative would not be effective in meeting the RAOs. As indicated above, future activities such as groundskeeping 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. 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 poses 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 landfill contents and exposure to radiation; (2) minimizing infiltration and any resulting contaminant leaching to groundwater; (3) controlling surface water runoff and erosion and decreasing the potential for erosion and subsequent transport of RIM; and (4) controlling radon and landfill gas emissions from Areas 1 and 2 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 five-year reviews. A periodic (every 5 years) cost of $35,000 is estimated to perform the activities that would be associated with a five-year review. The estimated present worth costs under the 7% discount rate scenario for performance of five-year reviews over periods of 30 years, 200 years and 1,000 years are estimated to be $82,000, $94,000 and $94,000, respectively. Under the 1.5% discount rate scenario, the 30-, 200-, and 1,000-year present worth costs are estimated to be $165,000, $437,000, and $456,000, respectively. Present worth calculations for the No Action alternative are provided in Appendix K-2.

6.2.2 Regrading and Enhanced Capping (ROD-Selected Remedy)

As discussed in Section 5.3, the ROD-selected remedy 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 Crossroads Property.

- Excavation of any soil containing radionuclides above levels that would allow for unrestricted use from the Buffer Zone and/or Crossroads Property 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.

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%. 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 bio-intrusion and erosion, increase the longevity of the landfill cover, and enhance the radon attenuation capability of the cover system. 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 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 one-foot-thick layer of soil capable of sustaining vegetative growth;

- A two-foot-thick infiltration layer of compacted, low-permeability clay soil with a permeability coefficient of 1 x 10^{-5} cm/sec or less; and

- A two-foot-thick bio-intrusion/erosion protection layer consisting of well-graded rock or concrete/asphaltic concrete rubble consisting of pieces up to 8 inches in size.

A geosynthetic clay liner (GCL) could be added to or used as a replacement for the two-foot-thick compacted clay layer (CCL). Because installation of a GCL would require placement of a bedding layer and an overlying protective or drainage layer, it has been assumed for purposes of the FFS that the thickness of the infiltration layer would be two feet with or without inclusion of a GCL.

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 5.3.1.6 and 5.3.1.9, 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 5.3.1.9) 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 five feet (two feet of biointrusion rock/rubble, two feet of clay soil, and one 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 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 a clay layer thickness of two feet, combined with a two-foot thick rock/rubble layer and a one-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 in-growth of radium from decay of thorium.

The potential for direct contact with waste materials would be eliminated by placing a barrier (multi-layer landfill cover including bio-intrusion 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 at the perimeter of the Site meets state standards or other ARARs.[35] 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 x 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.

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-

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[35] After issuance of the ROD in 2008, EPA announced its intention to address groundwater at the Site as part of an entirely separate operable unit (OU-3).

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 3.1.3.2) 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 3.1.3.2.1). 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 B) provide standards for land and buildings contaminated with 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, to address longevity considerations, 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 has often been addressed through placement of a rock armoring layer over the upper surface of the tailings pile capping system. To address longevity considerations for OU-1 and long-term hazards relating to disruption of the disposal site by natural phenomena, the ROD-selected remedy would use a hybridized cover system which incorporates a rock or concrete rubble 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. In particular, 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 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^2s (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, 2016b), radon flux measurements performed in 2016 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 owing 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 3.1.1.4). 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 preventing infiltration 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 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:
>
> 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 3.1.1.3 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 Crossroads Property. 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 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.

6.2.2.2.3 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, 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, 2016b), radon flux measurements performed in 2016 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 in the future, accounting for future radon generation resulting from increased radium levels owing to the decay of thorium over time.

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 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 (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 preventing infiltration of radionuclides to groundwater.

6.2.2.2.5 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against 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[36] and by adhering to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

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[36] 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.

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 reduced 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 long-term 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.

Long-term site management plans and institutional controls would be robust and durable. Long-term groundwater monitoring (as required under the ROD-selected remedy) would be effective in verifying the remedy is performing as required and groundwater is protected. 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 ROD-selected remedy provides long-term effectiveness and permanence relative to the Buffer Zone/Crossroads Property.

6.2.2.3.1 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 ROD-selected remedy has been implemented (Appendix H) are as follows:

- Area 1: <1 x 10^{-7} for year 1 and <1 x 10^{-7} for year 1,000; and
- Area 2: <1 x 10^{-7} for year 1 and <1 x 10^{-6} for year 1,000.

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 EPA’s target risk range of 1 x 10^{-6} to 1 x 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 Property, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.2.3.2 Adequacy and Reliability of Controls

The conceptual design of the engineered cover has been developed to provide protection against all potential exposure pathways. 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 ARARs. 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 does 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, it does not promote stormwater drainage or reduce the potential for infiltration of precipitation. Even with these limitations, infiltration of precipitation has not resulted in discernible leaching of radionuclides or other chemicals to groundwater. Regrading to promote drainage and installation of the engineered landfill cover included in the ROD-selected remedy 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 (SSPA, 2016b) 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. Although a GCL includes synthetic components which may degrade over time, 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 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 five-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) prohibiting residential use (including use as a day care, preschool, or other educational use) and use of groundwater for drinking water. With respect to the parcels of land that comprise OU-1 (including 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).[37] Covenant restrictions cannot be terminated without the written approval of the parcel owners, MDNR, and EPA.

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 five-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).

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.

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[37] 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 prohibiting the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation upon its 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.

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 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 – or a GCL layer if such material is included in the design of the landfill cover – 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. Even with this increased potential for infiltration of precipitation through Areas 1 and 2, the USGS (2014) concluded that 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 would be conducted in the future as part of the OU-3 RI/FS. 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 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 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 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, 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, 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. Further, the conceptual design for the ROD-selected remedy 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 25 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, a tornado is not expected to damage the vegetative layer, and, even if it did, such an impact is not considered to be significant because it could be easily identified. 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 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, regrading of the surface of Areas 1 and 2 to a 2% slope would reduce the velocity of runoff across these areas. 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 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

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)[38] is included in Section 5.7 of the RI Addendum.

Per EPA's SOW, the FFS is to include a discussion of the potential impacts of a subsurface smoldering event (SSE) or other type of subsurface heating event, if one were to occur within (or migrate to) OU-1. 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 addition, the potential for increased release of radionuclides – including via radon and fugitive dust – were further addressed 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. 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).

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, the following conclusions were reached in the SSE Impact Study as part of the initial qualitative evaluation (EMSI, 2014e):

- 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.

- An SSE[39] 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.

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[38] This reaction has previously been called a "subsurface smoldering event" (SSE) or by some as a fire. The current understanding of the nature of the reaction, however, is that it is occurring within saturated landfill materials in the absence of oxygen, which indicates that it is not a result of fire or smoldering (i.e., combustion). Accordingly, current references are to a "subsurface reaction," or SSR, rather than using the prior SSE terminology. Unlike a fire, the SSR has not produced visible smoke or flames.

[39] 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 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 stop when the SSE ends.

- 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.

- 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.

- 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.

- There are no additional ARARs associated with an SSE.

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 SSE 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, 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.

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[40] used to represent Area 1 during a theoretical SSR passing through the area, 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 concludes that the area weighted average radon flux in Area 1 is less than the radon flux standard of 20 pCi/m^{2}s.

The Supplemental Radon Flux Analysis also assessed potential risks to receptors beyond the Site fenceline under modeled conditions.[41] 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 fence line next to the Site office. This is less than the 0.5 pCi/L alternative radon air concentration limit published 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 Site 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 x 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 x 10^{-4} to 1 x 10^{-6} for CERCLA sites. Risks to off-site

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[40] 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.

[41] 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.

residential communities were all projected to be below 1 x 10^{-7}, which is below EPA's acceptable risk range.

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 (if any) 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 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.[42]

Based on the calculated results, the Final Particulate Emission Analysis concluded that even with very conservative (worst-case) assumptions, the highest risk identified in the study – 2 x 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 x 10^{-4} to 1 x 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 x 10^{-7}, far below EPA's acceptable risk range of 10^{-4} to 10^{-6}.

EPA recently asked that the evaluations of potential radon and fugitive dust emissions be updated to include same exposure factors as were used in the recently completed updated Baseline Risk Assessment (Auxier & Associates, 2016a). These evaluations are currently being performed and will be incorporated into the revised draft or final version of this FFS.

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

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[42] The conclusion that dry particulates could become airborne was based in part on several very conservative assumptions about drilling procedures and soil/waste conditions. In particular, 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. These assumptions are in contrast to/not representative of conditions much more likely to occur in such a drilling event, namely: (1) much or all of the soil mixture would be covered or removed promptly in accordance with standard drilling procedures; (2) the mixture would be moist, not dry, when it was first brought to the surface; (3) precipitation would periodically wet the mixture, thereby reducing emissions and promoting the formation of a surface crust; and (4) a sizeable portion of the particulates produced would be too large to be entrained by the wind or ever become respirable.

migrate from the South Quarry portion of the Bridgeton Landfill or otherwise originate in the North Quarry portion of the Bridgeton Landfill. Extensive investigations (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 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). In April 2016, EPA issued an Administrative Settlement Agreement and Order on Consent (ASAOC) requiring Bridgeton Landfill, LLC to install a heat extraction barrier (HEB) in the "neck" area between the South and North Quarry portions of the Bridgeton Landfill, to install additional temperature monitoring probes, and to develop and implement 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. At the time this draft FFS was prepared, evaluation of potential alignments and technologies for implementation of an isolation barrier were still ongoing, and no specific alignment or technology (*e.g.*, physical or heat extraction barrier) has 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 2016, EPA issued an Administrative Settlement Agreement and Order on Consent (ASAOC) to Bridgeton Landfill, LLC that required, among other things, installation of a heat extraction barrier (HEB) in the "neck" area between the North and South Quarry portions of the Bridgeton Landfill (EPA, 2016c). The HEB was installed in the summer of 2016 and began operating in October 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. As discussed in the previous subsection, no adverse impacts or unacceptable risks are expected to result if an SSR or SSE were to extend into Area 1. Therefore, regardless of the location or type of isolation barrier that may be installed, or even if no barrier is installed, no unacceptable risks are expected to occur. Installation of a heat extraction barrier consisting of various heat extraction points (regardless of location) would not have any impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability or cost of the ROD-selected remedy. 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.

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).

E.O. 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?[43]

- 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).

Areas 1 and 2 of the West Lake Landfill were identified on EJSCREEN, and a one-mile radius 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

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[43] 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.

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. 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[44] 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.

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. 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 impracticable. The ROD-selected

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[44] 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.

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 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).[45] Procedures to be used for testing, 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 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. The ROD-selected remedy for the Buffer Zone/Crossroads Property would be effective over the short term and the

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[45] 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.

relatively short duration required to remove the small amount of impacted soil should result in no significant adverse impacts.

The ROD-selected remedy would entail some excavation, handling, loading and transport of RIM within the Site associated with re-contouring to achieve slope requirements, and therefore would 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.

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 less than 1 x 10^{-7}, which is substantially 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 for importing the materials to be used to construct the multilayer landfill cover and during landfill regrading and cover construction are projected to emit 19,000 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 Concerns

As was previously discussed in Section 6.2.1.3.6, 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 incidence of industrial accidents is 2.76 over the life of the project (Appendix H). The projected carcinogenic risk to the maximally-exposed individual (field radiation technician) is estimated to be 9.2×10^{-5} and the projected radiation dose to a remediation worker is 187 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.

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 updated as part of the updated BRA (Auxier, 2016a). The results of that assessment are presented in Section 7 of the BRA (Auxier, 2000) and Appendix B of the updated BRA (Auxier, 2016a). 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 RAO of (1) preventing direct contact with the landfill contents and exposure to external radiation would be met upon installation of an engineered landfill cover. The RAOs of: (2) minimizing infiltration and any resulting contaminant leaching to groundwater; (3) controlling surface water runoff and erosion and decreasing the potential for erosion and subsequent transport of RIM; and (4) controlling radon and landfill gas emissions from Areas 1 and 2 all would be met once construction of the new 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 1.7 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 2.7 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 and 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).

Storm water 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). 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 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 and 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 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 ROD-selected remedy. 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 “complete rad removal” 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.

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 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/Crossroads Property 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-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 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 $67 million. The estimated annual OM&M costs range from $167,000 to $326,000 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 five 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 $64 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 1.5%, the present worth costs would be $70 million. The total non-discounted costs for the ROD-selected remedy over 30 years are projected to be $73 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 $102 million over a 200-year period. The total present-worth costs of the ROD-selected remedy are projected to be $64 million based on a 7% discount rate or $77 million based on a 1.5% 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 $241 million over a 1,000-year period. The present worth costs over a 1,000-year period are projected to be $64 million based on a 7% discount rate or $78 million based on a 1.5% discount rate.

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 volume for the ROD-selected remedy. The added costs for handling, sampling/analysis, shipping, treating, and disposing of mixed waste under the ROD-selected remedy are estimated to range from $240,000 to $450,000 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 uncertainties associated with the nature of such wastes and the required method of treatment. If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher as well.

6.2.3 “Complete Rad Removal” with Off-site Disposal Alternative

This section presents the detailed analysis of the “complete rad removal” alternative. As previously described in Section 5.4, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station, LLC 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 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 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 266,000 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 under this alternative. However, 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 444,000 loose cubic yards (lcy) would be transported off-site for disposal at a permitted disposal facility.

As indicated in Section 5.4.3, 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 West Lake Landfill 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 all of 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 and a final sanitary landfill cover would 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.

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.

6.2.3.1 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.

6.2.3.2 Compliance with ARARs

The “complete rad removal” alternative would comply with the ARARs discussed below.

6.2.3.2.1 UMTRCA

Removal of any soil containing radionuclides from the Buffer Zone and Crossroads 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). 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, 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.

6.2.3.2.2 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.

6.2.3.2.3 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. Because the specific carriers that might be used to transport the wastes under the “complete rad removal” 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.

6.2.3.2.4 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 3.2.3 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. A comparison of RIM activity levels relative to the US Ecology WAC is presented on Table 6-2.

6.2.3.2.5 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 6.2.1.2.1 of this FFS. The only difference between the “complete rad removal” and the ROD-selected remedy would be that regrading Areas 1 and 2 after removal of the RIM under the “complete rad removal” 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.

6.2.3.2.6 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.

6.2.3.2.7 NRC Standards for Protection Against Radiation

The NRC Standards for Protection Against 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 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 “complete rad removal” alternative. In addition, Site health and safety plans would address worker protection consistent with these requirements.

6.2.3.2.8 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 “complete rad removal” alternative would meet these requirements through enforcement of the existing Institutional Controls[46] and adherence to the Well Construction Code requirements for installation of new monitoring wells or abandonment of existing monitoring wells.

6.2.3.2.9 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 one acre or the creation of a storm water point source during construction of the remedy would trigger these requirements. The "complete rad removal" 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 reduce erosion potential as part of the design of the engineered landfill cover.

6.2.3.3 Long-Term Effectiveness and Permanence

Because the "complete rad removal" 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 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.

6.2.3.3.1 Magnitude of residual risk

The calculated lifetime risks from radiological materials that would remain in Areas 1 and 2 after implementation of the "complete rad removal" alternative are as follows:

- Area 1: $<1 \times 10^{-7}$ for year 1 and $<1 \times 10^{-7}$ for year 1,000.

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[46] 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.

- Area 2: $<1 \times 10^{-7}$ for year 1 and $<1 \times 10^{-7}$ for year 1,000.

These calculated risks are attributable to gamma radiation and radon emissions from the radionuclide occurrences that would remain after implementation of the “complete rad removal” 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.

6.2.3.3.2 Adequacy and reliability of controls

Although the “complete rad removal” 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 substantial depth. 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 therefore there are uncertainties regarding land disposal. There also are uncertainties regarding the acceptability of the wastes at some of the facilities, further limiting the number of facilities that could accept the wastes. At this time, only four facilities have been identified that might be able to accept these wastes. See the discussion in Section 3.2.3 for a description of these facilities and their capabilities.

The engineered measures and institutional controls that would be implemented for Areas 1 and 2 under the "complete rad removal" alternative (landfill cover, groundwater and landfill gas monitoring, and institutional controls), are considered to be adequate and reliable. OM&M requirements for the "complete rad removal" 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 "complete rad removal" alternative.

Because the "complete rad removal" 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.

6.2.3.3.3   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 "complete rad removal" 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 6.2.1.3.3 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 ROD-selected remedy, the vegetative layer of the landfill cover to be installed under the “complete rad removal” 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 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. Even with this increased potential for infiltration of precipitation through Areas 1 and 2, the USGS (2014) concluded that 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. 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 “complete rad removal” 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 release of contamination; however, because under the "complete rad removal" alternative it is presumed that all RIM above unrestricted use levels would be removed, 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 "complete rad removal" 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 6.2.1.3.3, the "complete rad removal" alternative is not vulnerable to impacts from a tornado. Specifically, a tornado is not expected to damage the vegetative layer, and even if it did, 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 "complete rad removal" alternative is not considered to be vulnerable to potential impacts from a tornado.

Although the "complete rad removal" 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 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 installed 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.

6.2.3.3.4 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 “complete rad removal” alternative, no radionuclide-related impacts would occur if an SSE or SSR were to occur in Areas 1 or 2. Odor emissions, ground settlement, and other impacts associated with a heating event could potentially still occur under the “complete rad removal” 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 the landfill cover, and reduce odor emissions.

6.2.3.3.5 Effects of an Isolation Barrier

Because it is presumed that all of the radionuclides above unrestricted levels would be removed under the “complete rad removal” alternative, there would be no need for installation of an isolation barrier. If an isolation barrier were installed prior to implementation of a “complete rad removal” alternative, large portions of such a barrier would need to be removed and hence destroyed in order to gain access to RIM located in the subsurface in the vicinity of a barrier.

6.2.3.3.6 Environmental Justice Considerations

As was previously discussed in Section 6.2.1.3.6 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.

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. The “complete rad removal” 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 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/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 “complete rad removal” 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 “complete rad removal” 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 3.2.3) 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.

6.2.3.5 Short-Term Effectiveness

The "complete rad removal" 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).

6.2.3.5.1 Protection of the Community During Remedial Actions

The projected carcinogenic risks that may be posed to off-site residents by this alternative are expected to be less than 1 x 10^{-7}, 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 5.4.3, is currently uncertain), significant additional local truck traffic would occur during the construction period for the "complete rad removal" 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 nearly 29,500 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 extensive 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 "complete rad removal" 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 34.9, meaning that approximately 35 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) 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 “complete rad removal” alternative may expose the community to radioactive waste, methane and radon gas and other contaminants, and 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 “complete rad removal” alternative would contribute significant carbon dioxide equivalent emissions as a result of ongoing vehicle operations associated with remedial work. In particular, approximately 83,000 tons of carbon dioxide equivalent emissions are projected to be emitted to the atmosphere as a result of 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-5).

Because RIM in Areas 1 and 2 would be excavated under this alternative, overburden containing putrescible wastes would be stockpiled and stored and RIM would be loaded into transport containers. During these activities, the nuisance attraction to and congregation by birds at and above the affected areas would be problematic unless effectively controlled. 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 “complete rad removal” 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 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 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[47] 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.

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 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.

6.2.3.5.2 Environmental Justice Concerns

As was previously discussed in Section 6.2.1.5.1 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.

6.2.3.5.3 Protection of Workers During Remedial Actions

The “complete rad removal” 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

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[47] 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).

for each alternative. These include risks from industrial accidents, exposure to carcinogenic substances, and projected radiation exposures. For the “complete rad removal” alternative, the projected incidence of industrial accidents is 17.8 over the life of the project. The projected carcinogenic risk to the maximally exposed individual (radiation field technician) is 2.2 x 10^{-3}, and the projected radiation dose to a remediation worker is 405 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 extensive 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 6.2.2.4 above, the separation of radiologically-impacted soil from solid wastes and construction/ demolition debris may (if feasible) 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.

6.2.3.5.4   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 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 “complete rad removal” 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

Regular monitoring of groundwater quality would be performed at appropriate locations around Areas 1 and 2 to assess the effectiveness of this alternative.

6.2.3.5.6 Time Until Remedial Action Objectives Are Achieved

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. The RAOs related to Areas 1 and 2 would be met once the RIM excavation and construction of the new landfill cover over Areas 1 and 2 were completed. Excavation and off-site disposal of RIM makes achievement of these RAOs post-excavation more certain because the ”complete rad removal” 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 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 were to be performed. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 12.1 years after approval of the RD. Therefore, the remedial action objectives should be achieved within 13.35 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 “complete rad removal” 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 “complete rad removal” 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 of time 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 transport 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 "complete rad removal" alternative would increase.

6.2.3.6 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 adjacent to Areas 1 and 2, grading of the surfaces and installation of upgraded landfill covers over the excavated areas of 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 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 total amount of non-RIM waste required to be removed is estimated to be approximately 1,300,000 bcy, which, based on an expansion factor of 1.5, would result in the need to handle, stockpile and replace 1,950,000 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. 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 269,000 bcy, equivalent to approximately 400,000 lcy. Due to the double-handling (at a minimum) of the overburden material plus the RIM handling, it is anticipated that more than 4,700,000 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 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 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;

- Ability to remove all of the RIM due to the close proximity of some of the deeper RIM in OU-1 Area 1 beneath and adjacent to the above-grade portion of North Quarry part 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/Crossroads Property – 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.

6.2.3.6.1 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 Areas 1 and 2 are 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 found 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 adjacent OU-2 landfill units may prevent or minimize encroachment of excavation slopes into the OU-2 units and therefore prove economical for the “complete rad removal” 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;
- 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 is a primary radionuclide of concern with regard to a “complete rad removal” alternative, even greater reductions in efficiency and increased time may be required for RIM excavation. Thorium-230 cannot be detected using field survey instruments, and therefore 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. All of these activities would undoubtedly impact the rate of RIM excavation and the duration over which excavation areas need to remain open.

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 storm water 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 5.4.3 and as further discussed in Sections 6.2.3.6.5 and 6.2.3.6.6 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 "complete rad removal" 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.

6.2.3.6.2 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 FUSRAP 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. It should be noted, however, that none of these FUSRAP sites involved radiological materials commingled with municipal solid waste and disposed in a landfill setting. 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).

Storm water 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.

6.2.3.6.3 Ease of Undertaking Additional Remedial Actions, if Necessary

It is possible that all of the RIM may not be removed during implementation of the "complete rad removal' 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 "complete rad removal" 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 "complete rad removal" 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.

In the event that monitoring of subsurface landfill gas 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. 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.

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 to be necessary to support implementation of the "complete rad removal" alternative.

6.2.3.6.4 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 5.4.4. These types of monitoring programs have been proven at demonstrating cover effectiveness and are easily implemented.

6.2.3.6.5 Ability to Obtain Approvals from Other Agencies

Implementation of the "complete rad removal" 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 "complete rad removal" 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.

- 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 West Lake Landfill 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, and Energy*Solutions* Clive, UT facility would not be subject to a Waste Compact consent.

6.2.3.6.6 Coordination with Other Agencies

Coordination with many entities would be necessary to implement the “complete rad removal” 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 a larger existing Site 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 and 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 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[48].

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 construction of 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 nighttime 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:

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[48] 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.

- 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 (6.2.3.6), in order to access RIM in Area 1, the Bridgeton Transfer Station LLC 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 “complete rad removal” alternative.

6.2.3.6.7 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 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 3.2.1, 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 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

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 and environmental conditions, as well as to 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/Crossroads Property to unrestricted use levels and to implement the institutional controls and monitoring components of this alternative are also readily available.

6.2.3.6.9 Availability of Prospective Technologies

The “complete rad removal” alternative is based on proven, established, and commonly used technologies. Use of prospective technologies is not currently envisioned to be part of this alternative.

6.2.3.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the “complete rad removal” 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 “complete rad removal” alternative capital cost estimate are provided in Appendix M. The estimated cost to conduct the “complete rad removal” remedy (i.e., design costs, capital costs, and costs for monitoring during the construction period) is $616,000,000 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. The estimated annual OM&M costs range from $167,000 to $326,000 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 “complete rad removal” alternative are projected to be $420 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 1.5%, the present worth costs would be $566 million. The total non-discounted costs for the “complete rad removal” alternative over 30 years are projected to be $6190 million. Present-worth cost estimates were also calculated for 200-years and 1,000-years (Table 6-1), similar to what was done for the other alternatives.

Unit costs associated with transportation by rail and disposal of RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would have added treatment costs in order to meet the Land Disposal Restrictions (LDRs) and Universal Treatment Standards (UTS). Based on discussions with representatives of the disposal facilities during preparation of the SFS (EMSI et al., 2011), the additional costs for treatment at these facilities are estimated to range from $45 to $150 per ton for RCRA metals or $400 to $500 per ton for organics, depending on the type of treatment.

Since the amount of mixed waste that might be excavated along with the RIM is unknown, and because of the RCRA restrictions on waste accumulation amounts and timeframes and limited storage space on-site, it is unclear if volumes would support shipment by rail. As such, the mixed waste would likely be shipped to the off-site disposal facility directly via truck. For truck hauling to the off-site disposal facility, the interior of the semi-trailer would be lined with a disposable polyethylene slip liner and after the waste was loaded the trailer would be covered and the cover securely strapped down. The capacity of each truckload would be 22 tons or 17 cubic yards, depending on the weight of the material. Current trucking costs range from $4.70 to $5.10 per loaded mile. Road mileage from the West Lake Landfill to the US Ecology Wayne Disposal, Michigan; Clean Harbors Deer Trail, Colorado; Energy Solutions Clive, Utah; and US Ecology Grandview, Idaho facilities are 520, 720, 1,340, and 1,580 miles, respectively. Therefore, RCRA or mixed-waste truck transportation costs to an off-site facility could range from $145 to $470 per cubic yard or $110 to $370 per ton, depending on where 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 and RIM for the “complete rad removal” with off-site disposal alternative. The added costs for handling, sampling/analysis, shipping, treating, and disposing of mixed waste for this alternative are estimated to range from $3 to $5.6 million. This cost range primarily results 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. If the volume of mixed waste is higher than the 0.5% of total mass assumption, the added costs would be higher.

6.2.4 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 5.5, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station, LLC 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 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, 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 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 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 151,000 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 249,000 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/Crossroads 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 meet the final closure standards for sanitary landfills and a final sanitary landfill cover would be constructed over Areas 1 and 2. Because waste containing radionuclides above unrestricted use standards would still remain in Areas 1 and 2, this cover would include the additional hybrid components included in the ROD-selected remedy to address the UMTRCA requirements.

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 5.3.1.9) would also be required.

6.2.4.1 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 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 presence of an engineered landfill 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 for the 52.9 Partial Excavation Alternative would be a minimum of five feet (two feet of biointrusion rock/rubble, two feet of clay soil, and one 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 landfill 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 two feet, combined with a two-foot thick rock/rubble layer and a one-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 bio-intrusion 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 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.

6.2.4.2 Compliance with ARARs

Insofar as the 52.9 Partial Excavation Alternative includes excavation and off-site disposal of a large portion of the RIM and regrading of the remaining solid wastes and installation of a new landfill cover over Areas 1 and 2, the Missouri solid waste rules for sanitary landfills would 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 consistent with the cover requirements for a solid waste landfill without a liner. Because all of the RIM above unrestricted use levels would not be removed from Areas 1 and 2, the UMTRCA standards would be relevant and appropriate for

Areas 1 and 2. Therefore, the landfill cover under this alternative would also include the 2-foot-thick rock biointrusion layer. Sections 6.2.2.2.1 and 6.2.2.2.2 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 NESHAPs, the Safe Drinking Water Act, Missouri Radiation Regulations for Protection Against Ionizing Radiation, the Missouri Well Construction Code, and the Missouri Storm Water Regulations. Sections 6.2.2.2.3 through 6.2.2.2.8 contain full discussions of these regulatory requirements. These requirements would be met or achieved using the same methods as previously described in Sections 6.2.3.2.3 through 6.2.3.2.8 with respect to the "complete rad removal" alternative.

6.2.4.3 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, and 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 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 moving the contamination from the Buffer Zone/Crossroads Property 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/Crossroads Property.

6.2.4.3.1 Magnitude of residual risk

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: <1 x 10^{-7} for year 1 and <1 x 10^{-7} for year 1,000.
- Area 2: <1 x 10^{-7} for year 1 and <1 x 10^{-7} for year 1,000.

The calculated risk levels are below EPA's target risk range of 1 x 10^{-6} to 1 x 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 cap at 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/Crossroads Property, residual risks posed by the remaining radionuclide-impacted material on these properties, if any, should be indistinguishable from variations in background levels.

6.2.4.3.2 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 ARARs. 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.

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 five-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 five-year reviews.

6.2.4.3.3 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 the 2-foot-thick rock/rubble biointrusion layer along with the 2-foot-thick low-permeability and 1-foot thick vegetative layers as previously described for the ROD-selected remedy (Sections 5.3.1.4 and 6.2.2). This engineered landfill cover would be classified as 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 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 both alternatives. These effects were previously discussed in Section 6.2.2.3.3 for the ROD-selected remedy and therefore will not be repeated again here. The results of those evaluations (as discussed in Section 6.2.2.3.3) 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 landfill 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.

The low-permeability layer (CCL) could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include desiccation of the CCL, with a resultant increase in permeability that in turn could lead to increased precipitation infiltration. 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 without generation of currently identifiable impacts to underlying groundwater quality[49]. 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 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. 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 and 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 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 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

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[49] EPA has indicated that additional evaluations of groundwater will be conducted in the future as part of the OU-3 RI/FS.

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 and 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 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.

6.2.4.3.4 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. However, as discussed for the ROD-selected remedy, even if such an event were to occur, the radon emission rate would still be less than the standard established by the radon NESHAP. Additionally, if such a release were to occur, risks at or beyond the fence line are expected to be below the acceptable risk levels established by EPA.

6.2.4.3.5 Effects of an Isolation Barrier

As discussed in the previous subsection, no adverse impacts or unacceptable risks are expected to result if an SSR or SSE were to extend into Area 1. Therefore, regardless of the location or type of isolation barrier that may be installed, or even if no barrier is installed, no unacceptable risks are expected to occur. Installation of a heat extraction barrier consisting of various heat extraction points, regardless of location, would not have any impact on the protectiveness, long-term effectiveness, short-term effectiveness, implementability or cost of the 52.9 Partial Excavation Alternative. 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 potential 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.

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.

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. Although a portion of the RIM would be removed, the 52.9 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 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. 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 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 6.2.2.4 contains a full discussion of the procedures, protocols and concerns associated with the off-site shipment of hazardous wastes or mixed wastes.

6.2.4.5 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).

6.2.4.5.1 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 1 x 10^{-7}. 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 10.6, meaning that approximately 11 transportation-related accidents are project 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 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 43,000 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-3).

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 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 increased accumulation of precipitation[50] 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.

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

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[50] 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).

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 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.

6.2.4.5.2 Environmental Justice Concerns

As was previously discussed in Section 6.2.2.5.1 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.

6.2.4.5.3 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 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 52.9 Partial Excavation Alternative, the projected incidence of industrial accidents is 8.5 over the life of the project. The projected carcinogenic risk to the maximally exposed individual is 1.18 x 10^{-3} and the projected radiation dose to a remediation worker is 720 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.

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 BRA (Auxier, 2000) and the updated BRA (Auxier, 2016a), 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.

6.2.4.5.5 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.

6.2.4.5.6 Time Until Remedial Action Objectives Are Achieved

The RAO of (1) preventing exposure to radionuclides or waste at concentrations above ARARs or risk levels would be met immediately upon completion of construction of a new engineered landfill cover. The RAOs of: (2) minimizing infiltration and any resulting contaminant leaching to groundwater; (3) controlling surface water runoff and erosion and decreasing the potential for erosion and subsequent transport of RIM; and (4) controlling radon and landfill gas emissions from Areas 1 and 2 would also be met once construction of the new 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.

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 were to be performed. The RAOs would be achieved upon completion of construction which is estimated to be finished within approximately 4.6 years after approval of the RD. Therefore, the remedial action objectives should be achieved within 5.9 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 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.

6.2.4.6 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 the areas of 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 part 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 350,000 bcy, which, based on an expansion factor of 1.5, would result in the need to handle, stockpile and replace 525,000 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 151,000 bcy, equivalent to 226,000 lcy. Due to the double-handling (at a minimum) of the overburden material plus the RIM handling, it is anticipated that more than 1,100,000 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 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 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/Crossroads Property – 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.

6.2.4.6.1 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, located as they are within an overall 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 is a primary radionuclide of concern relative to any excavation alternative that may be considered for the Site, even greater reductions in efficiency and increased time may be required for RIM excavation. Thorium-230 cannot be detected using field survey instruments, and therefore 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. All of these activities would undoubtedly impact the rate of RIM excavation and the duration over which excavation areas need to remain open.

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 storm water 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 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 6.2.3.6.5 and 6.2.3.6.6 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.

6.2.4.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material has been performed at number of FUSRAP facilities and is a reliable technology. It should be noted, however, that none of these FUSRAP sites involved radiological materials commingled with municipal solid waste and disposed in a landfill setting. 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.

6.2.4.6.3   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.

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.

6.2.4.6.4 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 5.4.4. 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 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 “complete rad removal” 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.

- 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 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 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.

6.2.4.6.6 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 and 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 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[51].

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;

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[51] 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 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 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 (6.2.3.6), 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.

6.2.4.6.7 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, 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 3.2.1, 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 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.

6.2.4.6.8 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 and environmental conditions, as well as to 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 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 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) 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/Crossroads Property above 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 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.

6.2.4.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the 52.9 Partial Excavation Alternative are included in Appendix K-5 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 $313,000,000 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 $159,000 to $326,000 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 five 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 $265 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 1.5%, the present worth costs would be $305 million. The total non-discounted costs for the 52.9 Partial Excavation Alternative over 30 years are projected to be $318 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 $348 million over a 200-year period. The total present-worth costs of the 52.9 Partial Excavation Alternative are projected to be $265 million based on a 7% discount rate or $312 million based on a 1.5% discount rate, respectively, over a 200-year period. The total non-discounted costs of the 52.9 Partial Excavation Alternative are projected to be $487 million over a 1,000-year period. The present-worth costs over a 1,000-year period are projected to be $265 million based on a 7% discount rate or $312 million based on a 1.5% discount rate.

Unit costs associated with transportation by rail and disposal of RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would have added treatment costs in order to meet the LDRs and UTS. Based on discussions with representatives of the disposal facilities during preparation of the SFS (EMSI et al., 2011), the additional costs for treatment at their facilities are estimated to range from $45 to $150 per ton for RCRA metals or $400 to $500 per ton for organics, depending on the type of treatment.

Since the amount of mixed waste, if any, that might be excavated along with the RIM is unknown, and because of the RCRA restrictions on waste accumulation amounts and timeframes and limited storage space on-site, it is unclear if volumes would support shipment by rail. As such, the mixed waste would likely be shipped to the off-site disposal facility directly via truck. For truck hauling to the off-site disposal facility, the interior of the semi-trailer would be lined with a disposable polyethylene slip liner and, after the waste was loaded the trailer, would be covered and the cover securely strapped down. The capacity of each truckload would be 22 tons or 17 cubic yards, depending on the weight of the material. Current trucking costs range from $4.70 to $5.10 per loaded mile. Road mileage from the West Lake Landfill to the US Ecology Wayne Disposal, Michigan, Clean Harbors Deer Trail, Colorado; Energy Solutions Clive, Utah; and US Ecology Grandview, Idaho facilities are 520, 720, 1,340, and 1,580 miles, respectively. Therefore, RCRA or mixed-waste truck transportation costs to an off-site facility could range from $145 to $470 per cubic yard or $110 to $370 per ton, depending on where 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 and RIM for the 52.9 Partial Excavation Alternative. The added costs for handling, sampling/analysis, shipping, treating, and disposing of mixed waste for this alternative are estimated to range from $950,000 to $1.8 million. The range of costs primarily results 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. 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 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 5.6, this alternative consists of the following components:

- Removal of the asphalt plant and relocation of the Bridgeton Transfer Station, LLC 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 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 or 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 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 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 38,200 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 63,100 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/Crossroads Property 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 meet the final closure standards for sanitary landfills and a final sanitary landfill cover would be constructed over Areas 1 and 2. Because waste containing radionuclides above unrestricted use standards would still remain in Areas 1 and 2, this cover would include the additional hybrid components included in the ROD-selected remedy to address the UMTRCA requirements.

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 5.3.1.9) and enforcement of the institutional controls (Section 5.3.2.1) would also be required.

6.2.5.1 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 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 presence of an engineered landfill 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 for the 1,000 Partial Excavation Alternative would be a minimum of five feet (two feet of biointrusion rock/rubble, two feet of clay soil, and one 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 landfill cover acts 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 two feet, combined with a two-foot-thick rock/rubble layer and a one-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 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 bio-intrusion 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.

6.2.5.2 Compliance with ARARs

Insofar as the 1,000 Partial Excavation Alternative includes excavation and off-site disposal of a large portion of the RIM, regrading of the remaining solid wastes, and installation of a new landfill cover over Areas 1 and 2, the Missouri solid waste rules for sanitary landfills would 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 consistent with the cover requirements for a solid waste landfill without a liner would be installed. These actions would result in this alternative meeting the MDNR solid waste rules. Because some RIM above unrestricted use levels would remain in Areas 1 and 2, the UMTRCA standards for gamma and radon emissions in 40 CFR 192.02 are potentially relevant and appropriate for Areas 1 and 2. Therefore, the landfill cover under this alternative would also include the 2-foot thick rock biointrusion layer and the cover would be designed to meet the radiation exposure and radon emission requirements of UMTRCA. Sections 6.2.2.2.1 and 6.2.2.2.2 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 NESHAPs, the Safe Drinking Water Act, the NRC Standards for Protection Against Radiation, the Missouri Well Construction Code, the Missouri Storm Water Regulations, and the Clean Water Act (for stormwater runoff). These requirements would be met or achieved using the same methods as previously described in Sections 6.2.3.2.3 through 6.2.3.2.8 with respect to the “complete rad removal” alternative.

6.2.5.3 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 long-term 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, and 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 moving the contamination from the Buffer Zone/Crossroads Property to either Areas 1 or 2, the remedy would provide long-term effectiveness and permanence relative to the Buffer Zone/Crossroads Property.

6.2.5.3.1 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: $<1 \times 10^{-7}$ for year 1 and $<1 \times 10^{-7}$ for year 1,000.
- Area 2: $<1 \times 10^{-7}$ for year 1 and $<1 \times 10^{-7}$ for year 1,000.

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 cap at 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/Crossroads Property, residual risks posed by the remaining radionuclide-impacted soil on these properties, if any, should be indistinguishable from variations in background levels.

6.2.5.3.2 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 ARARs. 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.

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 five-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 five-year reviews.

6.2.5.3.3 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 rock/rubble biointrusion layer along with the 2-foot-thick low permeability and 1-foot-thick vegetative layers as previously described for the ROD-selected remedy (Sections 5.3.1.4 and 6.2.2). 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 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 will not be fully repeated here. The results of those evaluations (as discussed in Section 6.2.2.3.3) with regard to the landfill cover system for the 1,000 Partial Excavation Alternative are summarized below.

Similar to the ROD-selected remedy, the vegetative layer of the landfill 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 voracity 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 desiccation of the CCL, with a resultant increase in permeability that could lead to increased precipitation infiltration. Such impacts are not considered to be significant because Areas 1 and 2 have existed for over 40 years with essentially flat (no grade) surfaces and minimal cover material, thereby maximizing precipitation infiltration without generation of currently identifiable impacts to underlying groundwater quality[52]. 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 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. 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, and therefore 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 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 relative to 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 and 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

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[52] EPA has indicated that additional evaluations of groundwater will be conducted in the future as part of the OU-3 RI/FS.

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 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 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 should be included as part of the ongoing inspection and maintenance program.

6.2.5.3.4 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. However, as discussed for the ROD-selected remedy, even if such an event were to occur, the radon emission rate would still be less than the standard established by the radon NESHAP. Additionally, if such a release were to occur, risks at or beyond the fence line are expected to be below the acceptable risk levels established by EPA.

6.2.5.3.5 Effects of an Isolation Barrier

As discussed in the previous subsection, no adverse impacts or unacceptable risks are expected to result if an SSR or SSE were to extend into in Area 1. Therefore, regardless of the location or type of isolation barrier that may be installed, or even if no barrier is installed, no unacceptable risks are expected to occur. Installation of a heat extraction barrier consisting of various heat extraction points would not have any 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 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 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 that it is designed before the RIM removal and regrading occurs.

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.

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. 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/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 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.

6.2.5.5 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).

6.2.5.5.1 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 1 x 10^{-7} (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 16.6, meaning that approximately 17 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 as a result of ongoing, vehicle operations associated with remedial work. In particular, approximately 53,000 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 multilayer landfill cover for Areas 1 and 2 (Appendix I, Table I-4).

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 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.

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.

6.2.5.5.2 Environmental Justice Concerns

As was previously discussed in Section 6.2.2.5.1 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.

6.2.5.5.3 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 11.7 over the life of the project. The projected carcinogenic risk to the reasonably maximally exposed individual, a radiation technician, is 2.37×10^{-3}, which exceeds EPA’s generally accepted risk range of 10^{-4} to 10^{-6}. The projected radiation dose to a remediation worker is 867 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.

6.2.5.5.4 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.

6.2.5.5.5 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.

6.2.5.5.6 Time Until Remedial Action Objectives are Achieved

The RAO of (1) preventing exposure to radionuclides or waste at concentrations above ARARs or risk levels would be met immediately upon construction of a new engineered landfill cover. The RAOs of: (2) minimizing infiltration and any resulting contaminant leaching to groundwater; (3) controlling surface water runoff and erosion and decreasing the potential for erosion and subsequent transport of RIM; and (4) controlling radon and landfill gas emissions from Areas 1 and 2 would also be met once construction of the new 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.

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 were to be performed. The RAOs would be achieved upon completion of construction, which is estimated to be finished within approximately 7.7 years after approval of the RD. Therefore, the remedial action objectives should be achieved within 9 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 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 schedule, the time required to complete construction and consequently the costs for the 1,000 Partial Excavation Alternative would increase.

6.2.5.6 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 the areas of 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 part 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 787,000 bcy, which – based on an expansion factor of 1.5 – would result in the need to handle, stockpile and replace approximately 1,200,000 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 while waiting for final placement and capping. Similarly, the total volume of RIM that would be excavated under this alternative is estimated to be 38,200 bcy, which is equivalent to 57,300 lcy. Accounting for the excavation and handling of overburden, side slope cut material, and RIM, a total of approximately 3.4 million cubic yards 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 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 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 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 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; 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. 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/Crossroads Property – 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.

6.2.5.6.1 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 an overall 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 is a primary radionuclide of concern relative to any excavation alternative that may be considered for the Site, even greater reductions in efficiency and increased time may be required for RIM excavation. Thorium-230 cannot be detected using field survey instruments, and therefore 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 RIM has been removed from a particular area would also be subjected to off-site laboratory analyses and data validation. All of these activities would undoubtedly impact the rate of RIM excavation and the duration over which excavation areas need to remain open.

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 6.2.3.6.5 and 6.2.3.6.6 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 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 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.

6.2.5.6.2 Reliability of the Technology

Excavation and off-site disposal of radioactively-impacted material has been performed at FUSRAP facilities and is generally a reliable technology. It should be noted, however, that none of these FUSRAP sites involved radiological materials commingled with municipal solid waste and disposed in a landfill setting. 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.

6.2.5.6.3 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 dependent 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 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.

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.

6.2.5.6.4 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 5.4.4. These types of monitoring programs are easily implemented and have been proven to be successful at demonstrating cover effectiveness in landfill settings.

6.2.5.6.5 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 with regard 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. It may be necessary to work directly with the FAA and the Airport Authority 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.

- 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 were 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.

6.2.5.6.6 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 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 and 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 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[53].

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 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 the adjacent property owners and businesses (for example, the Crossroads Property/AAA Trailer) would also be necessary to:

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[53] 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.

- 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 (6.2.3.6), 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.

6.2.5.6.7 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 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 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 3.2.1, 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 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.

6.2.5.6.8 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 and environmental conditions, as well as to 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 to remove the designated portion of the RIM and to construct the engineered landfill cover over Areas 1 and 2 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 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/Crossroads Property above 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 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.

6.2.5.7 Cost

Estimated capital, annual OM&M, and 30-year present worth costs for the 1,000 Partial Excavation Alternative are included in Appendix K-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 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 $361,000,000 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 $167,000 to $326,000 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 five 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 $275 million over a 30-year period based on a discount rate of 7%. Based on the current OMB rate of 1.5%, the present worth costs would be $342 million. The total non-discounted costs for the 1,000 Partial Excavation Alternative over 30 years are projected to be $365 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 $395 million over a 200-year period. The total present-worth costs of the 1,000 Partial Excavation Alternative are projected to be $276 million based on a 7% discount rate or $349 million based on a 1.5% discount rate, respectively, over a 200-year period. The total non-discounted costs of the 1,000 Partial Excavation Alternative are projected to be $534 million over a 1,000-year period. The present-worth costs over a 1,000-year period are projected to be $276 million based on a 7% discount rate or $350 million based on a 1.5% discount rate.

Unit costs associated with transportation by rail and disposal of RCRA soil, RCRA soil with radionuclide material, RCRA debris, and RCRA debris with radionuclide material would have added treatment costs in order to meet the LDRs and UTS. Based on discussions with representatives of the disposal facilities during preparation of the SFS (EMSI et al., 2011), the additional costs for treatment at their facilities are estimated to range from $45 to $150 per ton for RCRA metals or $400 to $500 per ton for organics, depending on the type of treatment.

Since the amount of mixed waste that might be excavated along with the RIM is unknown, and because of the RCRA restrictions on waste accumulation amounts and timeframes and limited storage space on-site, it is unclear if volumes would support shipment by rail. As such, the mixed waste would likely be shipped to the off-site disposal facility directly via truck. For truck hauling to the off-site disposal facility, the interior of the semi-trailer would be lined with a disposable polyethylene slip liner and after the waste was loaded the trailer would be covered and the cover securely strapped down. The capacity of each truckload would be 22 tons or 17 cubic yards, depending on the weight of the material. Current trucking costs range from $4.70 to $5.10 per loaded mile. Road mileage from the West Lake Landfill to the US Ecology Wayne Disposal, MI, Clean Harbors Deer Trail, Colorado; Energy Solutions Clive, Utah; and US Ecology Grandview, Idaho facilities are 520, 720, 1,340, and 1,580 miles, respectively. Therefore, RCRA or mixed-waste truck transportation costs to an off-site facility could range from $145 to $470 per cubic yard or $110 to $370 per ton, depending on where 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 and RIM for the 1,000 Partial Excavation Alternative. The added costs for handling, sampling/analysis, shipping, treating, and disposing of mixed waste for this alternative are estimated to range from $1.6 to $3 million. The range of costs primarily results 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. 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 “complete rad removal,” and the partial excavation alternatives evaluated 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.

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, 2016a), conditions associated with OU-1 do not currently pose an unacceptable risk to on-site workers or the off-site community as long as the existing institutional controls are maintained, monitored and enforced and Areas 1 and 2 are monitored and maintained. These analyses indicated that the potential risks posed to a future groundskeeper working in Areas 1 and 2 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 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, long-term surveillance and maintenance, and institutional controls on land and resource use. Installation of a new multi-layer landfill cover under the ROD-selected remedy and two partial excavation alternatives, and excavation of RIM under the “complete rad removal” and partial excavation alternatives, would all serve to 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 multi-layer landfill cover over Areas 1 and 2 is included as part of all of the remedial alternatives. This 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 fugitive dust. Installation of a cover over Areas 1 and 2 also would greatly reduce the potential for infiltration of precipitation and thus the potential for leaching of contaminants from wastes into groundwater.

Long-term maintenance of the cover 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 “complete rad removal” alternative.

7.1.2 Compliance with ARARs

An alternative must comply with 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, 3-2, and 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 potentially applicable 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 (Buffer Zone and Crossroad Property), as modified by the EPA OSWER Directives regarding use of these standards at Superfund sites; Nuclear Regulatory Commission (NRC) radiation protection standards; the maximum concentrations for groundwater protection under the UMTRCA standards; and the Missouri maximum contaminant levels (MCLs).

7.1.2.2 Location-Specific ARARs

All of the alternatives (including the No Action alternative) would meet the location-specific ARARs found in the Missouri solid waste regulations standards for landfills located within the 100-year floodplain or within 10,000 feet of an airport runway. 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 located outside of the 500-year floodplain.

The Missouri Solid Waste Management regulations 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 the landfill is designed and operated such that it does not pose a bird hazard to aircraft. Portions of the Site are located within 10,000 feet of the end of the westernmost runway at Lambert-St. Louis International Airport; however, none of the alternatives evaluated in this FFS entail construction of new disposal cells or new solid waste disposal activities. 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 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. Such a plan would also be of interest to the FAA and the Airport Authority. 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).

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 remedial alternatives would meet the Missouri closure and post-closure standards of the solid waste regulations, the NRC radiation protection standards, and the noise protection standards during implementation of a remedial action and closure of Areas 1 and 2.

Design of the final cover for Areas 1 and 2 under the ROD-selected remedy and the partial excavation alternatives would meet the design standards for landfill covers established by the Missouri solid waste management regulations and the substantive relevant and appropriate requirements of the UMTRCA regulations. Although design of the final cover for these alternatives would primarily be based on the design standards of the solid waste regulations, additional components would be included to address the presence of radionuclides and the requirements of the UMTRCA regulations. Specifically, the design of the final cover would need to be thick enough to shield against gamma radiation and attenuate radon emissions under both current and future conditions (including projected ingrowth of radium from thorium decay over time). A rock layer within the landfill cover would be included to address the longevity criteria of the UMTRCA standards. Under the “complete rad removal” alternative, all of 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 final cover system for this alternative is based solely on the design standards of the solid waste regulations.

The off-site disposal component of the partial excavation and the “complete rad removal” 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.

7.2 Primary Balancing Criteria

The five NCP primary balancing criteria are: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility and 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 four alternatives (*i.e.*, ROD-selected remedy, “complete rad removal’”, and the 52.9 and 1,000 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.

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 groundskeeper working in Areas 1 and 2 could pose a risk above the generally accepted risk range used by EPA in CERCLA actions (Auxier, 2016a) if no remedial action is taken at the Site. None of the remedial alternatives pose significant radiological or chemical exposure-related risks to on-site workers or the general public. The long-term risks associated with each of the alternatives are essentially the same, and the residual cancer risks posed to a potential future groundskeeper at the Site under all four remedial alternatives are below EPA's target risk range of 1 x 10^{-6} to 1 x 10^{-4}. Projected radiation doses after 1,000 years of radium ingrowth for all four remedial alternatives are far below the limit of 100 mrem per year established by NRC for the general public. The estimated long-term risks associated with each alternative are listed on Table 7-1. Detailed information regarding the estimated potential long-term risks and estimated radiation doses relative to a future on-site groundskeeper associated with each remedial alternative is provided as part of the assessment of risks included as Appendix H.

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 control waste materials that remain on-site. The primary engineering measures included in the ROD-selected remedy and the partial excavation alternatives are the construction, inspection and maintenance of multilayer engineered landfill cover systems over Areas 1 and 2 that are designed to reduce potential exposures to gamma radiation and reduce radon emissions, including increased levels of gamma radiation and radon emissions occurring after 1,000 years of radioactive decay of thorium. The "complete rad removal" and partial excavation alternatives include excavation and off-site disposal of at least a portion of the RIM. In addition, the partial excavation alternatives include construction, inspection and maintenance of multilayer engineered landfill cover systems over Areas 1 and 2 designed to reduce potential exposures to gamma radiation and reduce radon emissions, including increased levels of gamma radiation and radon emissions occurring after 1,000 years of radioactive decay. The "complete rad removal" alternative entails removal and off-site disposal of all RIM containing radionuclides at levels above those that would allow for unrestricted use. Therefore, this alternative would not need to address potential gamma exposures or radon emissions and would not include the rock/rubble layer that would be part of the landfill cover system included under the ROD-selected remedy and the partial excavation alternatives.

Although the RIM and other wastes have been present in Areas 1 and 2 for many decades without grading to promote runoff or an engineered landfill cover to minimize infiltration and leachate production, the USGS (2014) concluded that 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. All of the remedial alternatives rely on the construction, inspection and maintenance of multilayer covers to prevent or reduce the potential for infiltration of precipitation and resultant leaching to groundwater. The "complete rad removal" alternative (as well as the partial excavation alternatives) includes removal of at least some of the RIM from the Site, thus providing a corresponding additional level of effectiveness and permanence relative to potential leaching of radionuclides to groundwater.

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 design of the cover systems for the ROD-selected remedy and the partial excavation alternatives has 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 of the landfill cover by precipitation, disruption of the landfill cover by possible intrusion by woody vegetation, or potential human actions that could affect the cover system would necessitate regular and ongoing inspections and maintenance (O&M) 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.

7.2.1.1 Climate Change Considerations

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 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 and voracity 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 layer included as part of the landfill cover for all of the remedial alternatives could be damaged by periods of extended extreme temperatures or prolonged drought. Potential impacts could include drying out of the low-permeability materials (CCL or

GCL) with a resultant increase in permeability, which could lead to increased infiltration of precipitation. Such potential impacts are not considered to be significant because the landfill has existed for over 40 years with minimal cover material and essentially flat (no grade) surfaces with low spots that collect and pond water, thereby maximizing precipitation infiltration. Even with this increased potential for infiltration of precipitation through Areas 1 and 2, the USGS (2014) concluded that 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. However, EPA has indicated that additional evaluations of groundwater will be conducted in the future as part of the OU-3 RI/FS. Drying of the low-permeability layer could also result in an increase in radon emissions for all of the alternatives except for the “complete rad removal” alternative; however, even without significant cover material, the radon emissions from the surfaces of Areas 1 and 2 are far below the UMTRCA and NESHAP standards (see Section 2.3.1 of this FFS and Section 7.1.1.1 of the RI Addendum) and are projected to remain below these standards in the future (Appendix F). Therefore, even if drying of the low-permeability layer was 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, the potential for any impacts could be anticipated and readily identified in advance of any such occurrence and 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 for the ROD-selected remedy and the two 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. Since the landfill cover under the “complete rad removal” 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 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 expect 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 area of the Site. As previously discussed in Section 2.1.6, recent updates to the flood insurance rate map (FIRM) 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 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 is protected by the engineered levee and stormwater and flood control systems installed to protect the Earth City Industrial Park. Further, the conceptual design for the ROD-selected remedy includes construction of a perimeter (starter) berm along the toe of the entire northern boundary of Area 2, which would result in placement of approximately 25 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 and the other alternatives are not expected to be vulnerable to flooding.

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 and concluded that none of the alternatives are vulnerable to such impacts. Specifically, a tornado is not expected to damage the vegetative layer, and 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 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.

7.2.1.2 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). This evaluation reached the following conclusions:

- 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.

- 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.

- 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 temperature and would quickly reach an equilibrium at a lower rate reflective of the rate of radon emanation.

- In the unlikely event that an increased subsurface temperature were to occur in West Lake Area 1 or 2, it would not result in any additional long-term risks to people or the environment.

- Any short-term risks associated with increased subsurface temperatures would result from the temporary increase in radon gas coming from the surface of Areas 1 and 2 if no cover is installed, or if the cover was not properly maintained.

- 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.

Based on the foregoing conclusions, the only potential impact that may occur as a result of a subsurface heating event would be a temporary, localized increase in radon emissions. Because it is expected that all of the RIM above unrestricted levels would be removed under the “complete rad removal” alternative, any potential short-term increase in radon emissions as a result of a heating event would only be associated with the two partial excavation alternatives and the ROD-selected remedy.

Quantitative evaluations of the potential magnitude of an increase in radon emissions were performed on behalf of the Respondents in 2014 (EMSI et al., 2014e). Quantitative evaluations of potential increases in radon emissions were performed as part of evaluations of a potential thermal isolation barrier on behalf of Bridgeton Landfill, LLC and Rock Road Industries in 2014, 2015 and 2016 (EMSI et al., 2014, EMSI, 2015f, and Auxier and EMSI, 2016d). Three potential conditions associated with radon emissions under elevated temperatures and occurrence of a heating event in Area 1 were examined:

- 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, 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 fence line would be below the acceptable risk levels established by EPA.

The potential for a hypothetical release of particulate matter containing radionuclides was also evaluated on behalf of Bridgeton Landfill, LLC and Rock Road Industries in 2016 (Auxier and EMSI, 2016e). This evaluation concluded that even with very conservative (worst-case) assumptions, the projected air concentrations at the closest occupied structure, the closest boundary fence, and at the two closest communities produced risks on the order of 10^{-8}, far below EPA's acceptable risk range of 10^{-4} to 10^{-6}.

7.2.1.3 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.

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). For the RIM interspersed within portions of the solid waste in Areas 1 and 2, the 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. 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.

Accordingly, under all of the alternatives, no treatment processes would be employed on-site or at an off-site disposal facility for soil or debris containing only RIM. Therefore, there would not be any reduction in toxicity, mobility, or volume through treatment for RIM under any alternative.

The potential exists to reduce the volume of materials handled as RIM (but not the overall total volume of waste materials in Areas 1 and 2) through use of ex-situ physical separation processes to separate impacted soil from solid wastes such as hand-picking of large, bulky items, shredding and physical sorting with various fixed, vibrating, or rotating screens. For example, 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. While not a “treatment” process, this physical separation process could potentially be employed to reduce the volume of excavated RIM that would be transported to an off-site disposal facility under the “complete rad removal” or the partial excavation alternatives. Because such processes have not been applied to a solid waste matrix that contains radiologically-impacted materials, no data exist regarding the potential effectiveness, implementability or cost of such technologies in this context. Therefore, though the potential exists as part of the “complete rad removal” or 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 in order to evaluate the reduction in volume of RIM, as well as the effectiveness, implementability, and cost of the technology. Additional evaluation would 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.

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 LDR program and 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.

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 “complete rad removal” 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 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 that are less than 10^{-7}, which is 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 less than 0.0001, far 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 “complete rad removal” and partial excavation alternatives, with the “complete rad removal” alternative posing the greatest risk. These risks arise largely from the much greater number of truck trips associated with off-site disposal, resulting in greater traffic congestion on St. Charles Rock Road and other nearby highways, as well as the associated potential for traffic accidents and fatalities, greater greenhouse gas emissions, and greater noise impacts. The projected incidence of transportation-related accidents (Table 7-1) is 34.9 for the “complete rad removal” alternative, compared to 16.6 for the 1,000 pCi/g partial excavation alternative, 10.6 for the 52.9 pCi/g partial excavation alternative, and 0.61 for the ROD-selected remedy, respectively[54]. The off-site disposal components of the complete and partial excavation

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[54] 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 “complete rad removal” or partial excavation alternatives may be reduced; however, even if the trains were only

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. Projected carbon dioxide equivalent (greenhouse gas) emissions are also substantially greater for the "complete rad removal" alternative, at 83,000 tons of carbon dioxide equivalent emissions, compared to 43,000 tons and 53,000 tons for the 52.9 and 1,000 partial excavation alternatives, respectively, and 19,000 tons for the ROD-selected remedy (Table 7-1).

In contrast to the ROD-selected remedy, which only includes regrading of existing landfill surfaces, the "complete rad removal" and partial excavation alternatives require excavation of large portions of Areas 1 and 2. Excavation of RIM from Areas 1 and 2 would require removal of (1) the existing landfill cover; (2) non-RIM overburden over Areas 1 and 2; (3) RIM above cleanup levels in Areas 1 and 2; and (4) portions of adjacent areas of landfill at OU-2. The "complete rad removal" and 1,000 pCi/g partial excavation alternatives also would require removal, temporary relocation and subsequent replacement of a large amount of the above-ground portion of the North Quarry part of the Bridgeton Landfill that overlies the southwestern portion of Area 1. Excavation, handling, stockpiling and replacement of overburden is likely to result in generation of significant amounts of odor. The total amount of waste material to be relocated as part of the regrading process under the ROD-selected remedy is estimated to be approximately 130,000 bank cubic yards (bcy). In contrast, the total volume of waste that would need to be excavated under the "complete rad removal" alternative is estimated to be nearly 1,600,000 bcy, much of which would be associated with younger, and therefore more putrescible, wastes contained in the above-grade portion of the North Quarry part of the Bridgeton Landfill. Similarly, the 1,000 pCi/g partial excavation alternative would require removal of approximately 820,000 bcy of waste, while the 52.9 pCi/g partial excavation alternative would require removal of approximately 500,000 bcy. Both of these partial excavation alternatives also require removal of significant portions of North Quarry waste. 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.

The above volume estimates do not account for the additional handling associated with temporary stockpiling or subsequent replacement of the overburden material, and therefore the actual volumes of waste being handled under the three 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 re-grade 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[55] in depressions created

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transferred at night, an at-grade rail crossing would still represent a significant safety issue for traffic on St. Charles Rock Road.

[55] 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).

during waste excavation could result in infiltration of precipitation runoff through the underlying waste materials, which in turn could result in leaching of VOCs or other 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 "complete rad removal" 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 and infiltration of precipitation. Stormwater best management practices, 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 6.2.1.5.1, 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.

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 "compete rad removal" and partial excavation alternatives are higher than those associated with the ROD-selected remedy (Table 7-1). Workers involved with remedy implementation are assumed to 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 2.4×10^{-3} for the 1,000 partial excavation alternative to a low of 9.2×10^{-5} for the ROD-selected remedy (see Table 7-1 and Appendix H). The total effective dose equivalent (TEDE) to remediation workers are projected to be approximately 867 mrem/year for the 1,000 partial excavation alternative, 720 mrem/per year for the 52.9 partial excavation alternative, 405 mrem per year for the "complete rad removal" alternative, and 187 mrem/year for the ROD-selected remedy; however, the TEDEs associated with all of the alternatives are projected to be less than 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 range from a high of 17.8 for the "complete rad removal" alternative to a low of 2.8 for the ROD-selected remedy (Table 7-1).

For all of the alternatives, workers would be instructed and trained in safe work practices, work practices at hazardous waste 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 RIM 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 re-grading 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[56]. 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). The ROD-selected remedy would achieve the RAOs in the shortest amount of time, while the "complete excavation alternative" would take the longest time to achieve RAOs.

- Approximately 2.7 years for the ROD-selected remedy,

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[56] 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 5.9 years for the 52.9 pCi/g partial excavation alternative, and
- Approximately 9 years for the 1,000 pCi/g partial excavation alternative, and
- Approximately 13.4 years for the "complete rad removal" 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 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 "complete rad removal" 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 is a primary radionuclide of concern relative to the "complete rad removal" and partial excavation alternatives, significant reductions in efficiency and increased time may be required for RIM excavation, as compared with the ROD-selected remedy. Thorium-230 cannot be detected using field survey instruments, so 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. All of these activities would undoubtedly impact the rate of RIM excavation and the duration over which excavation areas need to remain open.

For the ROD-selected remedy and the partial excavation alternatives, measurements of gamma radiation levels and radon flux would be made on and around Areas 1 and 2 after construction is complete 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 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 and partial excavation alternatives; however, these are the same types of measures that would be used to address the solid waste materials remaining in Areas 1 and 2 under the “complete rad removal” alternative, with certain enhancements to address the presence of RIM.

Unlike the ROD-selected remedy, the estimated schedules for construction of the “complete rad removal” 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 less. To the extent that the swell factor is greater than what has been assumed during preparation of this FFS, the schedules for completion of construction – and consequently, the costs and risks associated with the “complete rad removal” and partial excavation alternatives – would increase. The swell factor does not apply to the ROD-selected remedy and therefore would not increase the costs and risks associated with that remedial alternative.

The projected construction schedule and the cost estimate for the “complete rad removal” 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 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 and risks for the “complete rad removal” or partial excavation alternatives – would increase.

Similarly, the schedule, costs and risks for the “complete rad removal” 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; similarly, it is unlikely that the number assumed could be greater. Consequently, the actual duration required for construction of the “complete rad removal” and partial excavation alternatives could be greater than that assumed in this FFS, resulting in increased time to complete, costs and risks.

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.

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 sites. Monitoring of landfill cover surfaces, landfill gas, radon, groundwater, and surface water are proven methods for demonstrating the long-term effectiveness of a covered landfill and are easily implemented.

All of the alternatives include re-grading and contouring the existing overburden and waste materials in Areas 1 and 2 in order to achieve final grades. Re-compaction of the re-graded materials will be required 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 compaction of the existing waste materials, depending upon the nature, age, and amount of prior degradation of the materials. 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.

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.

The proximity of the landfill mass to the property boundaries and adjacent properties constrains the potential methods that can be utilized to re-grade Areas 1 and 2. Specifically, the lack of space along the margins of Areas 1 and 2 dictates that re-grading of these areas to achieve the desired slopes 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. Even so, the amount of waste relocation that may need to be performed for the ROD-selected remedy is still anticipated to be considerably less than the amount of overburden excavation and waste movement that would be required for the “complete rad removal” or partial excavation alternatives, as these alternatives entail removal and stockpiling of substantial amounts of overburden, removal of substantial amounts of RIM, and replacement of the overburden material.

Uncertainty exists concerning the ability to remove all of the RIM under the “complete rad removal” and partial excavation alternatives due to the depth of the RIM in some areas and 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.

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;
- 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 “complete rad removal” 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 “complete rad removal” and partial excavation alternatives include the considerations listed below. The ROD-selected remedy would not pose such implementability concerns because it does not involve the 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 nighttime 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.[57]

- 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.

Management and discharge of any leachate 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 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 the Crossroads Property, 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

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 four 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;

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[57] 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.

- Excavation of RIM under the "complete rad removal" 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 four 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 FS 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 facilities currently are anticipated to have 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 "complete rad removal" 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 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 "complete rad removal" or partial excavation alternative were to be selected, the facilities identified in Section 3.2.3 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.

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 “complete rad removal” alternative, followed by the 1,000 pCi/g partial excavation alternative and the 52.9 pCi/g partial excavation alternative, with the lowest costs associated with the ROD-selected remedy as the second lowest (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 $67 million, with estimated annual OM&M costs ranging from $167,000 to $326,000.

- Capital costs for construction of the 52.9 pCi/g partial excavation alternative are estimated to be $313 million with estimated annual operations, maintenance and monitoring costs of $167,000 to $326,000.

- Capital costs for construction of the 1,000 pCi/g partial excavation alternative are projected to be $361 million with estimated annual operations, maintenance and monitoring costs of $167,000 to $326,000.

- Implementation of the “complete rad removal” with off-site disposal alternative would result in incurrence of the highest total estimated capital cost at $616 million, with estimated annual operations, maintenance and monitoring costs of $167,000 to $326,000.

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 five-year reviews are conducted).

Based on a 7% discount rate, the 30-year present worth costs of the alternatives are estimated to be:

- $63 million for the ROD-selected remedy,

- $265 million for the 52.9 pCi/g partial excavation alternative,

- $275 million for the 1,000 pCi/g partial excavation alternative, and
- $421 million for the "complete rad removal" alternative.

Based on the Office of Management and Budget's current value (2016 value issued in December 2015) of 1.5% for the 30-year discount rate, the 30-year present worth costs of the alternatives are estimated to be:

- $70 million for the ROD-selected remedy,
- $305 million for the 52.9 pCi/g partial excavation alternative,
- $342 million for the 1,000 pCi/g partial excavation alternative, and
- $567 million for the "complete rad removal" alternative.

Finally, the total non-discounted costs over the same 30-year period are estimated to be:

- $72 million for the ROD-selected remedy,
- $318 million for the 52.9 pCi/g partial excavation alternative,
- $365 million for the 1,000 pCi/g partial excavation alternative, and
- $620 million for the "complete rad removal" alternative.

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%), and landfill 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 (7) the associated management techniques, and 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 “complete rad removal” and partial excavation alternatives. There also are uncertainties regarding the specification and cost of the rock that would be used for the bio-intrusion layer included in the ROD-selected remedy and the partial excavation alternatives, 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 is not expected to have the potential for significant cost growth after construction begins because it is a demonstrated technology with fewer uncertainties in cost-determining factors. In contrast, the “complete rad removal” 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 different 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 “complete rad removal” 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 Areas 1 and 2 to 5% slopes upon completion of the waste excavation activities.

The nature of the activities and the longer duration required for implementation of the “complete rad removal” and, to a lesser extent, partial excavation alternatives, significantly increases the potential for occurrence of cost increases over time.

7.3 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.

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TABLES

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole 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 (1995)																		
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 (2013)/Phase 1B (2014)																		
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
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

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Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
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
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

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													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
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
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

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
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	No						-	-	NA	-	-	-
2-2	1068876.813	515926.163	475.200	4,354	32	443.2	No						-	-	NA	-	-	-
5-3	1068986.832	516093.839	474.400	336,937	29.5	444.9	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	No						-	-	NA	-	-	-
12-5	1069087.130	516641.299	478.900	3,864	14	464.9	No						-	-	NA	-	-	-
13-3	1069232.054	516662.275	472.600	3,607	16.5	456.1	No						-	-	NA	-	-	-
13-6	1069093.452	516723.784	475.900	3,902	24.5	451.4	No						-	-	NA	-	-	-
14-2	1069250.965	516701.546	474.600	4,008	27.5	447.1	No						-	-	NA	-	-	-
14-4	1069179.619	516743.234	474.400	3,888	9	465.4	No						-	-	NA	-	-	-
14-5	1069122.899	516777.908	472.900	3,454	13.5	459.4	No						-	-	NA	-	-	-
14-7	1069027.735	516848.642	473.300	3,637	31.5	441.8	No						-	-	NA	-	-	-
15-2	1069281.151	516768.917	476.500	5,184	26	450.5	Yes	22	454.5	27	449.5	5.0	-	-	NA	-	X	-
16-3	1069267.110	516837.299	470.700	4,118	20	450.7	No						-	-	NA	-	-	-
16-6	1069155.378	516938.746	477.100	3,841	14	463.1	No						-	-	NA	-	-	-
1C-6	1068688.971	515936.009	469.200	53,732	22.5	446.7	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	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	-
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	-	-	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
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	No						-	NA	NA	NA	NA	NA
1D-2	1068999.089	515778.193	468.382	5,142	5.9	462.5	No						-	NA	NA	NA	NA	NA
1D-3	1068972.272	515874.232	472.064	390,720	27.4	444.7	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	No						-	NA	NA	NA	NA	NA
1D-5	1068649.773	516043.497	487.632	143,724	55.1	432.5	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	No						-	NA	NA	NA	NA	NA
1D-7	1068647.213	516155.853	512.790	775,560	82.8	430.0	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	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	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	No						-	NA	NA	NA	NA	NA
1D-11	1068732.965	516319.191	522.966	5,970	1.8	521.2	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	No						-	NA	NA	NA	NA	NA
1D-13	1068807.791	516405.192	520.176	7,980	36.4	483.8	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	No						-	NA	NA	NA	NA	NA
1D-15	1068600.173	516194.976	516.672	16,194	89.6	427.1	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	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	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	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	-
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						-	-	-	-	-	-

Table 2-1: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 1

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
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 Characterization (2015)																		
AC-1a	1069120.740	516017.324	466.725	824,868	10.5	456.2	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	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	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	No						-	-	-	-	-	-
AC-5	1069483.755	516657.795	451.372	4,656	12.5	438.9	No						-	-	-	-	-	-
AC-6	1069420.320	516222.713	464.254	4,857	26.0	438.3	No						-	-	-	-	-	-
AC-7	1069315.677	516025.425	461.529	24,727	2.5	459.0	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	No						-	-	X	-	-	-
WL-106A-CT	1069300.779	516090.264	463.803	27,546	4.5	459.3	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	Yes	2	465.4	6	461.4	4.0	-	X	-	-	-	-

amsl = above mean sea level   cpm = counts per minute

Notes: 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

Table 2-2: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 2

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
NRC (1981)																		
PVC-4	1070516.46	514691.78	469.91	1,290,000	1	468.91	Yes	0	469.91	5.5	464.41	5.5	X	NA	NA	X	NA	X
PVC-4	1070516.46	514691.78	469.91	14,000	11.5	458.41	Yes	11	458.91	13	456.91	2	X	NA	NA	-	NA	NA
PVC-5	1070548.99	514548.01	464.99	15,000	5.5	459.49	Yes	1	463.99	7	457.99	6	X	NA	NA	-	NA	NA
PVC-5	1070548.99	514548.01	464.99	14,000	11.5	453.49	Yes	9.5	455.49	14.5	450.49	5	X	NA	NA	-	NA	NA
PVC-6	1070626.94	514760.76	466.08	367,000	11	455.08	Yes	0	466.08	16	450.08	16	X	NA	NA	X	NA	-
PVC-6	1070626.94	514760.76	466.08	23,000	20.5	445.58	Yes	19	447.08	22.5	443.58	3.5	X	NA	NA	NA	NA	NA
PVC-7	1070484.08	514749.72	470.99	1,386,000	2	468.99	Yes	0	470.99	7	463.99	7	X	NA	NA	NA	NA	NA
PVC-7	1070484.08	514749.72	470.99	22,000	19.5	451.49	Yes	17	453.99	22	448.99	5	X	NA	NA	NA	NA	NA
PVC-8	1070343.56	514871.72	471.41	24,000	0.5	470.91	Yes	0	471.41	1.5	469.91	1.5	X	NA	NA	-	NA	NA
PVC-9	1070386.31	515127.48	470.92	22,000	5	465.92	Yes	1	469.92	6.5	464.42	5.5	X	NA	NA	X	NA	-
PVC-10	1069916.35	514518.86	473.75	752,000	3	470.75	Yes	0	473.75	7	466.75	7	X	NA	NA	X	NA	NA
PVC-10	1069916.35	514518.86	473.75	152,000	9.5	464.25	Yes	7	466.75	13	460.75	6	X	NA	NA	X	NA	X
PVC-11B	1069844.18	514456.61	475.87	2,144,000	3	472.87	Yes	0	475.87	10.5	465.37	10.5	X	NA	NA	X	NA	X
PVC-12	1070528.68	515176.76	468.32	58,000	2.5	465.82	Yes	0.5	467.82	5.5	462.82	5	X	NA	NA	NA	NA	NA
PVC-13	1070515.37	514386.08	464.45	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	NA	NA	NA
PVC-18	1070300.94	514677.19	470.72	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	NA	NA
PVC-19	1070599.18	514961.49	469.55	332,000	8	461.55	Yes	6	463.55	10.5	459.05	4.5	X	NA	NA	X	NA	-
PVC-20	1070750.51	514806.92	466.65	127,000	1.5	465.15	Yes	0	466.65	4	462.65	4	X	NA	NA	X	NA	NA
PVC-33	1070857.78	514810.78	466.31	10,000	2.5	463.81	Yes	1.5	464.81	3.5	462.81	2	X	NA	NA	NA	NA	NA
PVC-34	1070742.95	514647.99	463.31	22,000	1	462.31	Yes	0	463.31	3	460.31	3	X	NA	NA	NA	NA	NA
PVC-35	1070722.28	515029.87	467.11	745,000	4	463.11	Yes	0.5	466.61	8	459.11	7.5	X	NA	NA	NA	NA	NA
PVC-39	1070540.52	515388.6	466.67	14,000	2.5	464.17	Yes	1.5	465.17	4	462.67	2.5	X	NA	NA	NA	NA	NA
PVC-40	1070639.64	515256.1	467.09	120,000	2.5	464.59	Yes	0.5	466.59	5	462.09	4.5	X	NA	NA	NA	NA	NA
PVC-40	1070639.64	515256.1	467.09	46,000	7	460.09	Yes	6	461.09	9	458.09	3	X	NA	NA	NA	NA	NA
NRC-2	1069760.3	514524.439	482.25	11,000	16	466.25	Yes	15	467.25	18	464.25	3	X	NA	NA	NA	NA	NA
NRC-3	1070125.45	514647.91	476	> 50,000	0	476	Yes	0	476	3	473	3	X	NA	NA	NA	NA	NA
NRC-16	1069680.96	514630.204	485.5	> 50,000	11	474.5	Yes	0	485.5	19 +	< 466.5	19 +	X	NA	NA	NA	NA	NA
NRC-17	1069551.8	514684.924	487.5	3,000	20	467.5	Yes	20	467.5	21	466.5	1	X	NA	NA	NA	NA	NA
NRC-21	1069806.61	514696.505	474	14,000	0	474	Yes	0	474	2	472	2	X	NA	NA	NA	NA	NA
NRC-21	1069806.61	514696.505	474	> 50,000	6	468	Yes	5	469	12	462	7	X	NA	NA	NA	NA	NA
NRC-21	1069806.61	514696.505	474	10,000	15	459	Yes	14	460	16	458	2	X	NA	NA	NA	NA	NA
NRC-22	1069582.39	514524.142	486.5	13,000	1	485.5	Yes	0	486.5	2	484.5	2	X	NA	NA	NA	NA	NA
NRC-22	1069582.39	514524.142	486.5	9,000	15	471.5	Yes	8	478.5	17	469.5	9	X	NA	NA	NA	NA	NA
NRC-22	1069582.39	514524.142	486.5	> 50,000	23	463.5	Yes	18	468.5	25 +	< 461.5	7 +	X	NA	NA	NA	NA	NA
NRC-30	1069518.48	514458.816	482.25	1,200	15	467.25	No	None	None	None	None	None	-	NA	NA	NA	NA	NA
NRC-31	1069476.62	514588.473	491	1,500	4	487	No	None	None	None	None	None	-	NA	NA	NA	NA	NA
NRC-32	1069898.79	514796.564	473	> 50,000	1	472	Yes	0	473	2	471	2	X	NA	NA	NA	NA	NA
McLaren/Hart RI (1995)																		
WL-207	1070743.05	514299.87	444.5	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-208	1070141.19	514752.42	474.8	12,000	No peak	None	Yes	0	474.8	10	464.8	10	-	NA	NA	-	X	-
WL-209	1070492.55	514686.34	467.4	744,000	0	467.4	Yes	0	467.4	11	456.4	11	X	NA	NA	X	X	X
WL-209	1070492.55	514686.34	467.4	6,000	No peak	None	Yes	24	443.4	26	441.4	2	-	NA	NA	-	X	-
WL-210	1069775.15	514811.55	477.8	509,000	0	477.8	Yes	0	477.8	16.5	461.3	16.5	X	NA	NA	X	X	X
WL-210	1069775.15	514811.55	477.8	88,000	47.5	430.3	Yes	39	438.8	49.5	428.3	10.5	X	NA	NA	-	X	-
WL-211	1070046.08	514684.07	475.3	330,000	0.75	474.55	Yes	0	475.3	13	462.3	13	X	NA	NA	X	X	-
WL-212	1070025.86	514973.26	472.9	6,000	No peak	None	Yes	8	464.9	12	460.9	4	-	NA	NA	-	X	-
WL-213	1070223.38	514947.61	472.3	6,000	No peak	None	Yes	0	472.3	6	466.3	6	-	NA	NA	-	X	-
WL-214	1070206.86	515241.19	468.5	6,000	No peak	None	Yes	4	464.5	6	462.5	2	-	NA	NA	-	X	-
WL-214	1070206.86	515241.19	468.5	6,000	No peak	None	Yes	24	444.5	26	442.5	2	-	NA	NA	-	X	-
WL-215	1070432.01	515259.72	470	Not logged	NA	NA	No	NA	NA	NA	NA	NA	NA	NA	NA	-	-	-
WL-216A	1069836.29	514936.08	477.4	24,000	3.5	473.9	Yes	0	477.4	10	467.4	10	X	NA	NA	X	X	-
WL-216B	1069827.87	514931.35	477.5	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-216C	1069819.16	514925.06	477.6	48,000	3.5	474.1	Yes	0	477.6	8	469.6	8	X	NA	NA	NA	NA	NA
WL-217	1069961.3	515082.21	474.7	6,000	No peak	None	Yes	9	465.7	11	463.7	2	-	NA	NA	-	X	-
WL-218	1069462.69	514839.09	489.7	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-219	1069142.47	514545.63	496.7	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-220	1069258.11	514733.38	503.9	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-221	1070567.35	514459.37	462.3	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-222	1070799.38	514618.74	457.8	6,000	No peak	None	Yes	0	457.8	7	450.8	7	-	NA	NA	-	X	-

Table 2-2: Summary of Occurrences of Radiologically-Impacted Material (RIM) in Area 2

Boring	Northing	Easting	Ground Surface Elevation (ft amsl)	Maximum Gamma Value (cpm)	Depth to Maximum Gamma (ft)	Elevation of Maximum Gamma (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					
													Downhole Gamma	Core Gamma	Core Alpha	Radium	Thorium	Uranium
WL-223	1070745.71	514734.14	462.2	15,000	4	458.2	Yes	1	461.2	7.5	454.7	6.5	X	NA	NA	-	X	-
WL-224	1070485.74	515601.73	468.4	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-225	1070576.93	515632.66	468.2	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-226	1070536.03	514992.1	467.5	370,000	10.5	457	Yes	0	467.5	22	445.5	22	X	NA	NA	-	X	-
WL-227	1070685.99	515258.39	462	8,000	No peak	None	Yes	4	458	6	456	2	-	NA	NA	-	X	-
WL-228	1071044.35	514724.16	441.6	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-229	1069329.26	514268.59	448.5	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-230	1070716.09	515139.66	463.3	10,000	1.5	461.8	Yes	0	463.3	6	457.3	6	X	NA	NA	-	X	-
WL-231	1070850.73	515007.27	464.8	29,000	5.5	459.3	Yes	3	461.8	11	453.8	8	X	NA	NA	-	X	-
WL-233	1069542.4	514609.19	489.2	90,000	22	467.2	Yes	17	472.2	31	458.2	14	X	NA	NA	-	X	-
WL-234	1069757.62	514428.12	480	1,104,000	7	473	Yes	0	480	21	459	21	X	NA	NA	X	X	X
WL-235	1069615.23	514418.87	481.1	6,000	No peak	None	Yes	0	481.1	1	480.1	1	-	NA	NA	-	X	-
WL-235	1069615.23	514418.87	481.1	20,000	22.5	458.6	Yes	20.5	460.6	24.5	456.6	4	X	NA	NA	-	-	-
WL-236	1069399.29	514384.13	484.3	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-237	1070069.42	515161.88	473.9	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	NA	NA	NA
WL-238	1070705.96	514916.28	466.2	130,000	6	460.2	Yes	1	465.2	10.5	455.7	9.5	X	NA	NA	NA	NA	NA
WL-239	1070921.77	514829.72	458.9	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	-	-	-
WL-240	1070320.97	515315.69	468.5	6,000	No peak	None	No	None	None	None	None	None	-	NA	NA	NA	NA	NA
WL-241	1070319.84	515100.73	469.6	46,000	5.5	464.1	Yes	1	468.6	9.5	460.1	8.5	X	NA	NA	X	X	-
WL-242	1070836.39	515098.99	NA	Not logged	NA	NA	Yes	0	NA	3	NA	3	NA	NA	NA	-	X	-
WL-243	1070860.46	515113.42	NA	Not logged	NA	NA	Yes	0	NA	2	NA	2	NA	NA	NA	-	X	-
WL-244	1070946.92	515215.29	NA	Not logged	NA	NA	Yes	0	NA	1	NA	1	NA	NA	NA	-	X	-
WL-245	1070976.4	515093.24	NA	Not logged	NA	NA	No	None	None	None	None	None	NA	NA	NA	-	-	-
WL-246	1071018.3	515193.17	NA	Not logged	NA	NA	No	None	None	None	None	None	NA	NA	NA	-	-	-
Area 2 - Additional Characterization (2015)																		
AC-8	1069429.27	514606.086	490.616	3,917	51	439.616	No	None	None	None	None	None	-	-	-	-	-	-
AC-9	1069593.07	514302.64	469.194	3,785	31	438.194	No	None	None	None	None	None	-	-	-	-	-	-
AC-10	1070422.82	514642.616	467.676	3,423	3	464.676	Yes	11	456.676	14	453.676	3	-	-	-	-	X	-
AC-11	1070423.22	514437.378	462.965	3,413	2	460.965	No	NA	NA	NA	NA	NA	-	-	-	-	-	-
AC-12	1070680.1	514526.364	459.587	3,577	2.5	457.087	Yes	1	458.587	5	454.587	4	X	X	-	-	X	-
AC-13	1070614.43	514865.994	468.089	500,239	18	450.089	Yes	14	454.089	24	444.089	10	X	X	X	X	X	-
AC-14	1070798.35	515338.175	457.834	3,847	22	435.834	No	None	None	None	None	None	-	-	-	-	-	-
AC-15	1070703.03	515525.938	457.237	3,803	11.5	445.737	No	None	None	None	None	None	-	-	-	-	-	-
AC-16	1070482.01	515440.258	468.212	443,815	18	450.212	Yes	10	458.212	30	438.212	20	X	X	X	X	X	X
AC-17	1070259.66	515183.215	471.311	3,519	9	462.311	No	None	None	None	None	None	-	-	-	-	-	-
AC-18	1070438.51	514922.137	469.529	259,236	2	467.529	Yes	0	469.529	15	454.529	15	X	X	X	X	X	X
AC-19	1069959.2	514772.616	477.185	214,732	2.5	474.685	Yes	0	477.185	14	463.185	14	X	X	X	X	X	X
AC-20	1069664.02	514960.169	488.976	402,171	21.5	467.476	Yes	19	469.976	29	459.976	10	X	X	X	X	X	X
AC-21	1069642.25	514760.309	477.569	272,024	10.5	467.069	Yes	8	469.569	33	444.569	25	X	X	X	X	X	X
AC-21A	1069646.97	514754.423	477.393	338,865	12	465.393	Yes	6	471.393	17	460.393	11	X	X	X	X	X	X
AC-22	1069738.46	514617.507	483.275	45,675	18	465.275	Yes	16	467.275	20	463.275	4	X	X	X	X	X	-
AC-23	1069568.41	514618.063	486.548	200,376	22	464.548	Yes	17	469.548	29	457.548	12	X	X	X	X	X	X
AC-24	1069783.77	514810.651	477.384	470,901	2	475.384	Yes	0	477.384	17	460.384	17	X	X	X	X	X	X
AC-24	1069783.77	514810.651	477.384	40,193	44.5	432.884	Yes	42.5	434.884	46	431.384	3.5	X	-	-	NA	NA	NA
AC-25	1069622.81	514420.771	479.445	19,802	21	458.445	Yes	20	459.445	22.5	456.945	2.5	X	-	-	NA	NA	NA
AC-26A	1069548.81	515122.279	473.186	15,245	3.5	469.686	Yes	2.5	470.686	6	467.186	3.5	X	X	X	X	X	-
AC-26A	1069548.81	515122.279	473.186	4,134	36	437.186	Yes	36	437.186	39	434.186	3	-	-	-	-	X	-
Cotter (2015)																		
WL-209-CT	1070488.51	514687.354	467.546	488,730	1.5	466.046	Yes	0	467.546	12	455.546	12	X	X	X	X	X	X
WL-234-CT	1069762.44	514435.675	480.017	894,913	9	471.017	Yes	1	479.017	22	458.017	21	X	X	X	X	X	X

Notes:
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

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D, A1 Additional Borings, and Cotter Borings)

DRAFT

Sample Designation	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	CSU^{1}	CV	MDA	Result	Final Q	CSU^{1}	CV	MDA				Result	Final Q	CSU^{1}	CV	MDA	Result	Final Q	CSU^{1}	CV	MDA				Result	Final Q	CSU^{1}	CV	MDA	Result	Final Q	CSU^{1}	CV	MDA	Result	Final Q	CSU^{1}	CV	MDA			
McLaren/Hart RI Data																																															
WL-101	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	20	20	pCi/g	0.91		0.19		0.35	1.08	U			1.08	1.45	*	Less than Criteria	1.63		0.57		0.23	1.45		0.53		0.19	3.08		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	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	15	15	pCi/g	0.98		0.23		0.35	1.07	U			1.07	1.52	*	Less than Criteria	1.68		0.58		0.3	1.64		0.56		0.2	3.32		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	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	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	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	20	20	pCi/g	0.39		0.19		0.34	0.92	U			0.92	0.85	*	Less than Criteria	1.26		0.47		0.21	0.77		0.35		0.14	2.03		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-105	10	10	pCi/g	40.8		2.1		0.6	1.59	U			1.59	41.6	*	Exceeds Criteria	522		95		0.09	4.34		2.62		1.36	526		Exceeds Criteria	6.64		1.23		0.16	3.95		0.73		1.97	6.94		1.28		0.14	17.53		Less than Criteria
WL-105	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-106	0	0	pCi/g	906		37		2	5.86	U			5.86	909	*	Exceeds Criteria	9,700		1,800		11.8	35.2				11.2	9,735		Exceeds Criteria	105		22		3	75.5		8.5		8.7	105		22		2	286		Exceeds Criteria
WL-106	5	5	pCi/g	18.8		1.3		0.4	1.42				1.07	20.2		Exceeds Criteria	731		135		0.21	3.22				0.2	734		Exceeds Criteria	11.5		4.8		4.0	2.10		0.43		1.12	6.69		3.5		2.73	20.3		Less than Criteria
WL-106 DUP (F)	5	5	pCi/g	128		6		1.0	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		1.7		3.4	26.4		10.1		17.2	54.3	*	Exceeds Criteria
WL-106	25	25	pCi/g	1.26		0.25		0.4	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	2.7		0.53		0.06	0.78	U			0.78	2.89		0.56		0.06	6.0	*	Less than Criteria
WL-106 DUP (F)	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	1.9		0.42		0.18	1.14	U			1.14	2.08		0.45		0.17	4.6	*	Less than Criteria
WL-107	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	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-107 DUP (L)	51	51	pCi/g	0.42		0.2		0.38	1.11	U			1.11	0.98	*	Less than Criteria	0.67		0.33		0.23	0.22		0.17		0.13	0.89		Less than Criteria	0.34		0.19		0.08	0.63	U			0.63	0.59		0.25		0.08	1.25	*	Less than Criteria
WL-108	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-109	5	5	pCi/g	0.90		0.21		0.31	1.18		0.4		0.62	2.08		Less than Criteria	0.67		0.3		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-109	50	50	pCi/g	0.95		0.21		0.30	1.36		0.48		0.71	2.31		Less than Criteria	1.1		0.36		0.2	0.58		0.25		0.21	1.7		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-109 DUP (L)	50	50	pCi/g	1.36		0.37		0.56	1.51	U			1.51	2.12	*	Less than Criteria	2.43		0.71		0.26	1.13				0.12	3.56		Less than Criteria	0.83		0.32		0.11	1.28	U			1.28	1.13		0.39		0.12	2.60	*	Less than Criteria
WL-110	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	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		0.4		0.20	0.74	U			0.74	1.14		0.39		0.23	2.68	*	Less than Criteria
WL-111	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	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 DUP (L)	5	5	pCi/g	0.91		0.23		0.41	1.36	U			1.36	1.59	*	Less than Criteria																															
WL-111	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-111 DUP (L)	51	51	pCi/g	0.51		0.22		0.35	1.01	U			1.01	1.02	*	Less than Criteria																															
WL-112	0	0	pCi/g	1.32		0.24		0.41	1.18	U			1.18	1.91	*	Less than Criteria	2.67		0.76		0.25	0.84		0.34		0.19	3.51		Less than 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	5	5	pCi/g	4.66		0.46		0.42	1.20	U			1.20	5.26	*	Less than Criteria	84.4		15.8		1.9	0.66	U	0.81		1.56	84.7	*	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	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		0.3	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	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 DUP (F)	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	10	10	pCi/g	1.53		0.15		0.12	0.98		0.22		0.24	2.51		Less than Criteria	2.21		0.52		0.13	0.08		0.07		0.08	2.29		Less than 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	0	0	pCi/g	109		5		0.9	2.50	U			2.50	110	*	Exceeds Criteria	7,850		1,470		0.92	18.1		4.6		0.78	7,868		Exceeds Criteria	154		40		1.0	17.6		2.1		3.0	147		38		0.9	319		Exceeds Criteria
WL-114	5	5	pCi/g	2.59		0.17		0.06	0.39		0.12		0.16	2.98		Less than Criteria	23.2		4.9		0.4	0.25	U	0.22		0.26	23.3	*	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 DUP (L)	5	5	pCi/g	2.54		0.14		0.07	0.46		0.12		0.15	3.00		Less than Criteria																															
WL-114	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		0.2	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-114 DUP (L)	15	15	pCi/g	0.97		0.08		0.07	1.08		0.17		0.15	2.05		Less than Criteria																															
WL-115	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	40	40	pCi/g	0.58		0.05		0.05	0.69		0.1		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	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	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 DUP (F)	5	5	pCi/g	1.18		0.13		0.13	1.0		0.2		0.28	2.2		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	10	10	pCi/g	1.00		0.07		0.05	0.76		0.11		0.11	1.76		Less than Criteria	0.36		0.2		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	10	10	pCi/g	3.15		0.19		0.07	0.64		0.14		0.16	3.79		Less than Criteria	36.58		7.4		0.13	1		0.35		0.12	38		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	25	25	pCi/g	0.62		0.06		0.05	0.64		0.12		0.12	1.26		Less than Criteria	0.7		0.28		0.15	0.2		0.14		0.12	0.9		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	5	5	pCi/g	18.4		1		0.3	0.73	U			0.73	18.8	*	Exceeds Criteria	425		87		2.5	10.3		3.5		2.22	435		Exceeds Criteria	15.6		3.6		0.2	2.40		0.37		1.41	17.8		4.1		0.2	35.8		Less than Criteria
WL-118	10	10	pCi/g	1.31		0.1		0.05	0.49		0.09		0.14	1.80		Less than Criteria	7.19		1.88		0.2	0.35		0.23		0.2	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	5	5	pCi/g	0.89		0.07		0.06	0.73		0.12		0.12	1.62		Less than Criteria	0.6		0.28		0.22	0.26		0.17		0.13	0.9		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	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 DUP (L)	50	50	pCi/g	0.48		0.05		0.06	0.44		0.1		0.12	0.92		Less than Criteria																															
WL-119 DUP (F)	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	0.1		0.08		0.09	0.3		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	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	50	50	pCi/g	0.92		0.1		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 DUP (F)	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	0	0	pCi/g	7.28	U			7.28	2.14	U			2.14	Non-detect	*	Non-detect	1.57		0.36		0.1	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	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		0.1	2.95		Less than Criteria	0.94		0.26		0.1						0.87		0.25		0.09	1.81		Less than Criteria
WL-123	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	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		0.3		0.07	3.32		Less than Criteria	1.5		0.34		0.06						1.02		0.26		0.06	2.5		Less than Criteria
Phase 1C data (and Cotter samples from Core of Phase 1C borings)																																															
FEEBRI14-5.012-013	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	0.805		0.227	0.013	0.054	0.123		0.091	0.006	0.077	0.866		0.237	0.004	0.054	1.793		Less than Criteria
FEEBRI14-5.060-061	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	0.981		0.253	0.010	0.075	0.093		0.081	0.001	0.093	0.864		0.234	0.001	0.075	1.938		Less than Criteria
FEEBRIS 12-5.002-003	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	0.535		0.183	0.013	0.057	0.051	U	0.067	0.001	0.102	0.604		0.197	0.002	0.082	1.189	*	Less than Criteria
FEEBRIS 12-5.012-013	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	0.670		0.207	0.015	0.064	0.100		0.087	0.001	0.100	0.763		0.223	0.004	0.056	1.532		Less than Criteria
FEEBRIS 13-3.019-020	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	0.951		0.259	0.036	0.103	0.178		0.112	0.006	0.080	0.916		0.251	0.018	0.089	2.045		Less than Criteria
FEEBRIS 13-3.029-030	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	0.717		0.214	0.013	0.056	0.044	U	0.057	0.006	0.079	0.885		0.243	0.006	0.063	1.646	*	Less than Criteria
FEEBRIS 14-2.019-020	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	0.748		0.204	0.017	0.064	0.095		0.073	0.003	0.058	0.796		0.211	0.003	0.047	1.639		Less than Criteria
FEEBRIS 14-2.029-031	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	1.032		0.276	0.039	0.109	0.034	U	0.060	0.015	0.108	1.019		0.271	0.011	0.078	2.085	*	Less than Criteria
FEEBRIS 14-4.005-006	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	1.077		0.250	0.030	0.082	0.117		0.083	0.012	0.082	0.729		0.195	0.008	0.059	1.923		Less than Criteria
FEEBRIS 14-4.028-029	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	0.945		0.234	0.029	0.083	0.077		0.066	0.005	0.065	1.232		0.275	0.014	0.072	2.254		Less than Criteria
FEEBRIS 14-7.013-014	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	1.068		0.265	0.012	0.052	0.102		0.081	0.005	0.073	1.012		0.256	0.006	0.059	2.183		Less than Criteria
FEEBRIS 14-7.039-040	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	0.864		0.224	0.011	0.048	0.071		0.069	0.001	0.085	0.828		0.219	0.001	0.069	1.763		Less than Criteria
FEEBRIS 15-2.024-025	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	115.62		23.75	0.02	0.09	1.84		0.46	0.14	0.10	117.5		Exceeds Criteria	0.980		0.260	0.035	0.100	0.059	U	0.073	0.019	0.112	0.930		0.249	0.006	0.063	1.969	*	Less than Criteria
FEEBRIS 15-2.043-044	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	0.727		0.195	0.024	0.074	0.017	U	0.037	0.008	0.073	0.817		0.208	0.008	0.059	1.561	*	Less than Criteria
FEEBRIS 16-3.006-007	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	0.692		0.218	0.021	0.081	0.053	U	0.070	0.001	0.106	0.751		0.227	0.006	0.068	1.497	*	Less than Criteria
FEEBRIS 16-3.011-012	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	0.900		0.235	0.026	0.082	0.139		0.093	0.007	0.077	1.054		0.258	0.013	0.075	2.093		Less than Criteria
FEEBRIS 16-3.011-012D	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	0.851		0.229	0.022	0.077	0.160		0.100	0.005	0.072	0.979		0.248	0.003	0.051	1.991		Less than Criteria
FEEBRIS 16-6.006-007	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	0.00	0.06	1.23		0.35	0.13	0.06	2.90		Less than Criteria	1.110		0.260	0.011	0.046	0.046	U	0.055	0.009	0.077	1.022		0.247	0.009	0.062	2.178	*	Less than Criteria
FEEBRIS 16-6.021-022	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	0.584		0.206	0.038	0.112	0.106		0.092	0.007	0.090	0.591		0.210	0.048	0.136	1.281		Less than Criteria
FEEBRIS01-2.008-009	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	0.469		0.157	0.013	0.055	0.043	U	0.056	0.001	0.085	0.435		0.149	0.003	0.048	0.946	*	Less than Criteria
FEEBRIS01-2.018-019	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	0.400		0.138	0.016	0.059	0.053	U	0.058	0.010	0.077	0.412		0.139	0.005	0.050	0.866	*	Less than Criteria
FEEBRIS01-2.020-021	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	0.458		0.158	0.012	0.051	0.007	U	0.031	0.007	0.078	0.396		0.145	0.003	0.050	0.862	*	Less than Criteria
FEEBRIS01-2.022-023	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	0.149		0.080	0.016	0.059	0.004	U	0.025	0.008	0.068	0.062	U	0.056	0.018	0.072	0.215	*	Less than Criteria
FEEBRIS01-2.023-024	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	0.441		0.174	0.018	0.074	0.095		0.092	0.001	0.114	0.355		0.156	0.015	0.092	0.891		Less than Criteria
FEEBRIS01-2.024-025	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	0.756		0.226	0.014	0.059	0.136		0.098	0.004	0.072	1.195		0.300	0.009	0.073	2.087		Less than Criteria
FEEBRIS01-2.028-029	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	0.726		0.222	0.014	0.060	0.088		0.085	0.001	0.106	0.571		0.194	0.014	0.085	1.385		Less than Criteria
FEEBRIS01-2.033-034	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	0.499		0.151	0.013	0.051	0.022	U	0.034	0.003	0.050	0.298		0.112	0.003	0.040	0.819	*	Less than Criteria

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D, A1 Additional Borings, and Cotter Borings)

DRAFT

Sample Designation	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	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA				Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA				Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA			
FEEBRIS01-2.038-039	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	0.314		0.126	0.012	0.049	0.070		0.064	0.003	0.060	0.264		0.115	0.005	0.056	0.648		Less than Criteria
FEEBRIS01-2.038-039D	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	0.303		0.122	0.011	0.047	0.163		0.097	0.005	0.067	0.321		0.126	0.007	0.059	0.786		Less than Criteria
FEEBRIS01-2.039-040	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	416.66	OJ	123.32	0.05	0.80	5.23	OJ	2.46	0.81	0.72	421.9		Exceeds Criteria	3.555		0.668	0.015	0.064	0.337		0.164	0.004	0.079	3.843		0.708	0.007	0.073	7.736		Less than Criteria
FEEBRIS01-2.040-041	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	0.173		0.091	0.011	0.049	0.067	U	0.064	0.005	0.069	0.205		0.100	0.005	0.055	0.444	*	Less than Criteria
FEEBRIS02-2.005-006	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	0.985		0.245	0.012	0.049	0.101		0.081	0.001	0.087	0.865		0.227	0.001	0.070	1.952		Less than Criteria
FEEBRIS02-2.019-020	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	0.360		0.121	0.009	0.038	0.009	U	0.022	0.002	0.047	0.306		0.111	0.001	0.054	0.676	*	Less than Criteria
FEEBRIS02-2.020-021	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	0.325		0.126	0.015	0.058	0.068		0.066	0.001	0.081	0.338		0.128	0.003	0.046	0.731		Less than Criteria
FEEBRIS02-2.021-022	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	0.911		0.237	0.018	0.068	0.070	U	0.066	0.005	0.071	0.766		0.213	0.006	0.058	1.747	*	Less than Criteria
FEEBRIS02-2.022-023	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	0.386		0.125	0.013	0.050	0.058	U	0.054	0.007	0.062	0.414		0.130	0.004	0.042	0.859	*	Less than Criteria
FEEBRIS02-2.022-023D	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	0.458		0.156	0.026	0.081	0.053	U	0.063	0.014	0.092	0.434		0.149	0.007	0.059	0.946	*	Less than Criteria
FEEBRIS02-2.031-032GP	31	32	pCi/g	13.77	J	1.28	0.25	0.52	0.79	UJ	0.58	0.47	0.98	14.56	*	Exceeds Criteria	205.53		43.37	0.01	0.04	1.39		0.33	0.04	0.04	206.9		Exceeds Criteria	0.818		0.170	0.008	0.030	0.034		0.031	0.002	0.030	0.706		0.154	0.004	0.030	1.558		Less than Criteria
FEEBRIS02-3.034-035GP	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	16.79		3.42	0.01	0.04	0.26		0.09	0.04	0.04	17.04		Exceeds Criteria	0.494		0.117	0.009	0.031	0.043		0.034	0.002	0.031	0.445		0.111	0.021	0.050	0.982		Less than Criteria
FEEBRIS02-3.035-036GP	35	36	pCi/g	21.08	J	2.06	0.49	1.02	0.45	UJ	0.78	0.59	1.25	21.53	*	Exceeds Criteria	281.62		53.20	0.00	0.03	2.60		0.49	0.03	0.02	284.2		Exceeds Criteria	1.597		0.263	0.005	0.020	0.166		0.066	0.003	0.032	1.627		0.266	0.003	0.026	3.390		Less than Criteria
FEEBRIS05-3.025-026	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	0.457		0.145	0.020	0.064	0.096		0.073	0.011	0.076	0.402		0.133	0.008	0.055	0.955		Less than Criteria
FEEBRIS05-3.025-026D	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	88.92		18.01	0.00	0.07	0.82		0.25	0.07	0.06	89.7		Exceeds Criteria	0.649		0.173	0.013	0.050	0.060	U	0.057	0.009	0.070	0.707		0.183	0.011	0.059	1.416	*	Less than Criteria
FEEBRIS05-3.028-029	28	29	pCi/g	1,487.21	J	121.47	5.09	10.21	19.82	QJ	6.41	5.36	10.81	1,507		Exceeds Criteria	25,825	QJ	7,538	1.45	17.70	202.82	QJ	78.56	15.40	15.53	26,028		Exceeds Criteria	428.669	J	73.202	1.299	5.593	22.867	QJ	12.502	0.355	6.900	431.061	J	73.499	0.154	8.002	882.597		Exceeds Criteria
FEEBRIS05-3.029-030	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	97.72	0.25	1.12	6.76	QJ	2.48	1.51	0.92	450		Exceeds Criteria	2.863		0.501	0.017	0.063	0.187		0.104	0.007	0.073	2.510		0.456	0.038	0.102	5.560		Less than Criteria
FEEBRIS05-3.029-030D	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	0.623		0.200	0.018	0.072	0.068	U	0.075	0.001	0.101	0.557		0.189	0.018	0.090	1.248	*	Less than Criteria
FEEBRIS05-3.033-034	33	34	pCi/g	32.62	J	2.44	0.46	0.93	1.96	J	0.43	0.44	0.90	34.58		Exceeds Criteria	1,815	QJ	559	0.54	4.54	14.41	QJ	8.16	3.69	4.00	1,829		Exceeds Criteria	12.391		1.902	0.015	0.065	0.704	O	0.247	0.004	0.080	11.949		1.841	0.007	0.074	25.044		Less than Criteria
FEEBRIS08-1.028-029	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	0.861		0.236	0.015	0.062	0.109		0.084	0.003	0.067	0.911		0.243	0.004	0.054	1.882		Less than Criteria
FEEBRIS08-1.040-041	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	0.839		0.234	0.019	0.074	0.078		0.071	0.003	0.067	0.998		0.259	0.004	0.054	1.915		Less than Criteria
FEEBRIS08-1.044-045	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	77.76		16.93	0.01	0.06	0.48		0.19	0.08	0.06	78.2		Exceeds Criteria	0.568		0.170	0.012	0.052	0.089		0.070	0.005	0.064	0.469		0.152	0.005	0.051	1.126		Less than Criteria
FEEBRIS08-1B.028-029GP	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	0.352		0.108	0.010	0.039	0.055		0.045	0.004	0.044	0.370		0.111	0.007	0.041	0.776		Less than Criteria
FEEBRIS08-1B.028-029GP-D	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	10.39	Q	2.65	0.01	0.07	0.19		0.11	0.07	0.07	10.6		Exceeds Criteria	0.415		0.105	0.006	0.025	0.046		0.036	0.001	0.039	0.430		0.107	0.002	0.022	0.890		Less than Criteria
FEEBRIS08-1B.029-030GP	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	0.744		0.169	0.007	0.028	0.056		0.043	0.002	0.034	0.501		0.131	0.003	0.032	1.301		Less than Criteria
FEEBRIS1-2.023-024GP	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	0.527		0.125	0.013	0.038	0.043		0.035	0.003	0.035	0.373		0.100	0.004	0.030	0.943		Less than Criteria
FEEBRIS1-2.028-029GP	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	0.224		0.077	0.009	0.033	0.013	U	0.020	0.002	0.030	0.162		0.064	0.002	0.024	0.399	*	Less than Criteria
FEEBRIS13-6.021-022	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	0.913		0.240	0.012	0.052	0.108		0.087	0.001	0.093	1.096		0.269	0.004	0.052	2.116		Less than Criteria
FEEBRIS13-6.021-022D	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	0.996		0.271	0.012	0.085	0.102		0.086	0.004	0.073	1.006		0.272	0.002	0.085	2.105		Less than Criteria
FEEBRIS13-6.039-040	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	0.808		0.316	0.026	0.109	0.086	U	0.112	0.011	0.155	1.044		0.370	0.003	0.157	1.939	*	Less than Criteria
FEEBRIS1C-12.048-049GP	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	0.535		0.137	0.010	0.038	0.012	U	0.023	0.004	0.043	0.555		0.140	0.003	0.032	1.102	*	Less than Criteria
FEEBRIS1C-12.049-050GP	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	0.612		0.132	0.006	0.024	0.061		0.040	0.001	0.026	0.479		0.113	0.001	0.021	1.152		Less than Criteria
FEEBRIS1C-12B.053-054GP	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	0.621		0.152	0.018	0.051	0.033	U	0.037	0.007	0.052	0.723		0.167	0.009	0.044	1.377	*	Less than Criteria
FEEBRIS1C-12B.054-055GP	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	0.523		0.125	0.015	0.042	0.043		0.036	0.004	0.038	0.608		0.137	0.005	0.033	1.174		Less than Criteria
FEEBRIS1C-12C.055-056GP	55	56	pCi/g	31.01	J	2.47	0.51	1.04	1.25	UJ	0.67	0.60	1.23	32.25	*	Exceeds Criteria	398.76		91.99	0.00	0.04	2.19		0.55	0.06	0.04	401.0		Exceeds Criteria	1.826		0.340	0.018	0.054	0.223		0.096	0.001	0.056	1.924		0.354	0.026	0.069	3.972		Less than Criteria
FEEBRIS1C-2RA.028-029GP	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	0.467		0.125	0.014	0.045	0.047		0.039	0.002	0.034	0.589		0.145	0.010	0.045	1.103		Less than Criteria
FEEBRIS1C-4R.046-047GP	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	0.880		0.256	0.019	0.074	0.032	U	0.055	0.001	0.097	0.905		0.260	0.008	0.068	1.817	*	Less than Criteria
FEEBRIS1C-4RB.046-047GP	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	0.547		0.196	0.016	0.068	0.035	U	0.060	0.001	0.105	0.584		0.205	0.009	0.074	1.166	*	Less than Criteria
FEEBRIS1C-6TI.022-023GP	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	0.603		0.130	0.008	0.029	0.052		0.036	0.002	0.029	0.535		0.120	0.002	0.023	1.190		Less than Criteria
FEEBRISIC-6.019-020	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	1.263		0.297	0.019	0.071	0.101		0.082	0.008	0.082	1.030		0.260	0.012	0.075	2.394		Less than Criteria
FEEBRISIC-6.024-025	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	51.01		10.82	0.01	0.07	1.43		0.40	0.09	0.09	52.4		Exceeds Criteria	1.462		0.356	0.018	0.073	0.170		0.119	0.001	0.113	1.489		0.359	0.004	0.064	3.120		Less than Criteria
FEEBRISIC-6.025-026	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	239.82		52.04	0.01	0.09	1.09		0.33	0.09	0.07	240.9		Exceeds Criteria	1.078		0.266	0.020	0.072	0.099		0.079	0.005	0.071	1.037		0.262	0.049	0.117	2.214		Less than Criteria
FEEBRISIC-6.026-027	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	201.96		39.97	0.00	0.05	0.88		0.25	0.06	0.07	202.8		Exceeds Criteria	1.150		0.272	0.013	0.056	0.041	U	0.049	0.003	0.060	1.120		0.267	0.007	0.061	2.310	*	Less than Criteria
FEEBRISWL-119.001-002	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	0.608		0.203	0.024	0.086	0.015	U	0.035	0.004	0.074	0.864		0.250	0.014	0.086	1.486	*	Less than Criteria
FEEBRISWL119.005-006	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	1.019		0.270	0.028	0.091	0.179		0.114	0.008	0.089	0.957		0.258	0.006	0.066	2.155		Less than Criteria
FEEBRISWL-119.009-010	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	0.762		0.209	0.013	0.055	0.029	U	0.049	0.001	0.086	0.806		0.216	0.003	0.048	1.597	*	Less than Criteria
FEEBRISWL-119.009-010D	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	0.578		0.172	0.012	0.051	0.011	U	0.026	0.003	0.054	0.485		0.155	0.001	0.063	1.074	*	Less than Criteria
FEEBRISWL-119.020-021	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	0.306		0.121	0.009	0.065	0.027	U	0.046	0.001	0.081	0.474		0.153	0.005	0.052	0.807	*	Less than Criteria
FEEBRISWL-119.034-035GP	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	0.600		0.164	0.011	0.043	0.025	U	0.035	0.005	0.054	0.577		0.160	0.001	0.049	1.203	*	Less than Criteria
FEEBRISWL-119.040-041	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	0.218		0.107	0.014	0.059	0.091		0.080	0.001	0.091	0.121		0.078	0.004	0.051	0.430		Less than Criteria
FEEBRISWL-119.041-042	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	0.421		0.145	0.016	0.062	0.110		0.082	0.010	0.081	0.477		0.155	0.005	0.052	1.009		Less than Criteria
FEEBRISWL119.051-052	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	0.408		0.140	0.013	0.052	0.062	U	0.059	0.005	0.064	0.419		0.142	0.003	0.045	0.890	*	Less than Criteria
FEEBRISWL-119B.038-039GP	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	0.356		0.099	0.006	0.024	0.027	U	0.028	0.001	0.029	0.349		0.098	0.001	0.034	0.732	*	Less than Criteria
FEEBRISWL-119C.043-044GP	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	0.480		0.118	0.005	0.023	0.020	U	0.024	0.001	0.029	0.527		0.125	0.003	0.029	1.026	*	Less than Criteria
FEEBRISWL-119C.045-046GP	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	0.477		0.114	0.009	0.032	0.038		0.033	0.000	0.038	0.377		0.098	0.001	0.021	0.892		Less than Criteria
Phase 1D data (and Cotter samples from Core of Phase 1D borings)																																															
FEEBRIS1D-01.007-009	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	0.441	J-	0.163	0.032		0.039	J	0.054	0.007		0.367	J	0.145	0.014		0.85		Less than Criteria
FEEBRIS1D-01.024-027	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	0.869	J-	0.219	0.007		0.080	J	0.070	0.001		0.774	J	0.204	0.001		1.72		Less than Criteria
FEEBRIS1D-02.020-023	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	0.314	J-	0.135	0.008		0.047	J	0.057	0.003		0.288	J	0.128	0.005		0.65		Less than Criteria
FEEBRIS1D-02.027-030	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	0.250	J-	0.136	0.010		0.078	J	0.085	0.007		0.371	J	0.166	0.007		0.70		Less than Criteria
FEEBRIS1D-02.036-037	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	0.252	J-	0.111	0.003		0.043	J	0.056	0.001		0.295	J	0.121	0.005		0.59		Less than Criteria
FEEBRIS1D-03.028-029	28	29	pCi/g	188.12	J+	14.14	20.89	3.24	2.14	U	3.05	2.33	4.76	190.26	*	Exceeds Criteria	615.58	J+	127.85	0.08	0.09	4.07		0.92	0.01	0.0636	620		Exceeds Criteria	9.356		1.518	0.007		0.727		0.249	0.012		9.272		1.505	0.001		19.36		Less than Criteria
FEEBRIS1D-03.041-043	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	0.220	J	0.109	0.008		0.000	UJ	0.043	0.001		0.276	J	0.124	0.001		0.50	*	Less than Criteria
FEEBRIS1D-03.041-043 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	0.146	J	0.103	0.002		0.040	J	0.068	0.001		0.057	J	0.065	0.009		0.24		Less than Criteria
FEEBRIS1D-4.061-062	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	2.832		1.260	0.058		0.323	J	0.549	0.009		2.776		1.255	0.098		5.93		Less than Criteria
FEEBRIS1D-4.064-065	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	1.418		0.617	0.048		0.375		0.364	0.004		1.785		0.696	0.035		3.58		Less than Criteria
FEEBRIS1D-5.051-052	51	52	pCi/g	53.91		4.27	7.67	0.75	1.35		0.65	0.70	1.45	55.25		Exceeds Criteria	216.29	J	42.31	0.06	0.05	1.94	J	0.45	0.01	0.06	218		Exceeds Criteria	0.230		0.135	0.042		0.136		0.107	0.011		0.179		0.129	0.062		0.54		Less than Criteria
FEEBRIS1D-5.063-064	63	64	pCi/g	1.06	U	0.18	1.18	0.21	0.84		0.22	0.22	0.471	1.90	*	Less than Criteria	0.45		0.19	0.07	0.09	0.19	J	0.11	0.01	0.09	0.65		Less than Criteria	0.273	J	0.175	0.016		0.059	J	0.072	0.015		0.263	J	0.147	0.007		0.59		Less than Criteria
FEEBRIS1D-6.080-081	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	2.235		0.447	0.001		0.114		0.092	0.001		2.195		0.441	0.019		4.54		Less than Criteria
FEEBRIS1D-6.085-086	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	0.171	J	0.119	0.018		0.019	J	0.046	0.004		0.307	J	0.157	0.011		0.50		Less than Criteria
FEEBRIS1D-7.084-085	84	85	pCi/g	3,630.35		242.46	104.91	11.74	31.85		9.45	8.29	16.66	3,662.19		Exceeds Criteria	16,702.67		3,436.82	20.91	23.01	178.26		53.11	8.73	22.59	16,881		Exceeds Criteria	372.91		166.87	9.887		40.91	J	69.74	1.086		222.72		126.43	9.376		636.5		Exceeds Criteria
FEEBRIS1D-7.093-094	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	18.03		4.29	0.10	0.10	0.38		0.19	0.02	0.12	18.40		Exceeds Criteria	0.164		0.099	0.001		0.051	J	0.067	0.001		0.216		0.111	0.003		0.43		Less than Criteria
FEEBRIS1D-8.075-076	75	76	pCi/g	4.54		0.47	1.77	0.40	0.94		0.27	0.24	0.50	5.48		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	0.659	UJ	0.476	0.244		0.259	UJ	0.376	0.086		0.585	UJ	0.681	0.391		Non-detect	*	Non-detect
FEEBRIS1D-8.090-091	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	0.116	0.75	J	0.25	0.01	0.07	1.74		Less than Criteria	0.899	J	0.520	0.031		0.248	J	0.301	0.017		0.825	J	0.496	0.029		1.97		Less than Criteria
FEEBRIS1D-09.078-079	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	0.064	J-	0.057	0.007		0.055	J	0.057	0.003		0.040	J	0.046	0.007		0.16		Less than Criteria
FEEBRIS1D-09.088-089	88	89	pCi/g	40.20	J	9.94	4.59	1.05	3.58	U	2.31	0.49	4.24	43.78	*	Exceeds Criteria	905.57	J+	180.92	0.24	0.289	3.76	J	1.08	0.10	0.376	909.3		Exceeds Criteria	3.407	J-	0.989	0.068		0.619	UJ	0.430	0.111		3.229	J	0.961	0.102		7.25	*	Less than Criteria
FEEBRIS1D-09.099-100	99	100	pCi/g	0.66	U	0.10	1.25	0.166	0.48		0.13	0.21	0.29	1.14	*	Less than Criteria	3.41	J+	0.82	0.07	0.08	0.19	J	0.11	0.01	0.08	3.60		Less than Criteria	0.276	J-	0.142	0.036		0.127	J	0.101	0.006		0.275	J	0.126	0.012		0.68		Less than Criteria
FEEBRIS1D-10.046-049	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	0.209	J	0.130	0.005		0.063	J+	0.082	0.008		0.458	J	0.198	0.005		0.73		Less than Criteria
FEEBRIS1D-10.074-076	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	0.376		0.160	0.024		0.155	J+	0.110	0.008		0.332		0.156	0.051		0.86		Less than Criteria
FEEBRIS1D-11.085-086	85	86	pCi/g	24.40	J+	1.86	2.84	0.55	1.10		0.44	0.39	0.80	25.50		Exceeds Criteria	119.05	J+	24.07	0.06	0.07	1.35		0.34	0.00	0.05	120.4		Exceeds Criteria	1.485		0.330	0.001		0.074	J	0.072	0.001		1.412		0.318	0.007		2.97		Less than Criteria
FEEBRIS1D-11.087-088	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	0.859		0.243	0.019		0.065	J	0.074	0.014		0.736		0.223	0.032		1.66		Less than Criteria
FEEBRIS1D-12.061-062	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	0.107	J	0.077	0.004		0.014	J	0.033	0.003		0.077	J	0.066	0.006		0.20		Less than Criteria
FEEBRIS1D-12.074-075	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	0.230		0.112	0.010		0.028	J	0.043	0.003		0.212	J	0.115	0.039		0.47		Less than Criteria
FEEBRIS1D-13.085-086	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	0.300	J-	0.175	0.015		0.059	J	0.101	0.002		0.275	J	0.167	0.014		0.63		Less than Criteria
FEEBRIS1D-13.093-094	93	94	pCi/g	4.22		0.37	1.48	0.28	0.46	J	0.21	0.20	0.358	4.68		Less than Criteria	4.27	J+	0.97	0.11	0.07	0.26	J	0.15	0.01	0.06	4.54		Less than Criteria	2.772	J-	0.584	0.016		0.313	J	0.180	0.008		3.630	J	0.707	0.063		6.71		Less than Criteria
FEEBRIS1D-14.054-056	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	0.215	J-	0.104	0.003		0.012	J	0.030	0.003		0.094	J	0.068	0.003		0.32		Less than Criteria
FEEBRIS1D-14.082-084	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	0.397	J-	0.179	0.008		0.022	J	0.065	0.020		0.410	J	0.183	0.011		0.83		Less than Criteria
FEEBRIS1D-15.077-080	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	0.144	J	0.089	0.010		-0.005	U	0.032	0.005		0.078	J	0.067	0.012		0.22	*	Less than Criteria
FEEBRIS1D-15.085-086	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	30.86	J+	6.16	0.05	0.05	0.31	J	0.12	0.01	0.06	31.17		Exceeds Criteria	0.462		0.158	0.007		0.036	J	0.050	0.007		0.477		0.161	0.001		0.98		Less than Criteria
FEEBRIS1D-16.050-051	50	51	pCi/g	33.46		2.76	5.55	0.84	0.98		0.65	0.74	1.52	34.44		Exceeds Criteria	971.46	J	198.37	0.06	0.05	6.45	J	1.31	0.01	0.07	977.92		Exceeds Criteria	5.034	J	1.003	0.047		0.303	J	0.191	0.039		4.773	J	0.961	0.063		10.11		Less than Criteria

Table 2-3: Area 1 Combined Radium, Thorium, and Uranium Results (RI Borings, Phases 1C and 1D, A1 Additional Borings, and Cotter Borings)

	Upper Sample Depth	Lower Sample Depth		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
Sample Designation	(feet)	(feet)	Units	Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA				Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA				Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA			
FEEBRIS1D-16.059-061	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	0.101	J	0.078	0.011		0.119	J	0.095	0.001		0.176	J	0.100	0.003		0.40		Less than Criteria
FEEBRIS1D-16.059-061 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	0.077		0.069	0.009		0.032	J	0.048	0.003		0.288	J	0.131	0.006		0.40		Less than Criteria
FEEBRIS1D-17.030-031	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	0.140	J-	0.089	0.001		0.029	J	0.044	0.003		0.127	J	0.084	0.001		0.30		Less than Criteria
FEEBRIS1D-17.033-036	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	0.852	J-	0.337	0.018		0.037	J	0.102	0.002		0.471	J	0.242	0.007		1.36		Less than Criteria
FEEBRIS1D-18.013-014	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	0.420	J-	0.161	0.008		0.048	J	0.058	0.003		0.206	J	0.111	0.001		0.67		Less than Criteria
FEEBRIS1D-18.038-041	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	0.07	0.05	J	0.06	0.00	0.06	6.03		Less than Criteria	0.222	J-	0.115	0.006		0.049	J	0.060	0.003		0.108	J	0.080	0.006		0.38		Less than Criteria
FEEBRIS1D-18.044-046	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	0.311	J-	0.186	0.012		0.120	J	0.131	0.011		0.283	J	0.177	0.011		0.71		Less than Criteria
FEEBRIS1D-19.061-063	61	63	pCi/g	1.17	U	0.32	2.31	0.429	1.23		0.50	0.46	0.973	2.40	*	Less than Criteria	1.08	J	0.35	0.09	0.08	0.54	J	0.22	0.01	0.09	1.62		Less than Criteria	0.471	J	0.189	0.008		0.164	J+	0.112	0.011		0.551	J	0.207	0.010		1.19		Less than Criteria
FEEBRIS1D-19.061-063 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	0.657	J	0.211	0.004		0.191	J+	0.118	0.003		0.578	J	0.197	0.008		1.43		Less than Criteria
FEEBRIS1D-20.080-081	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	1.920	J	0.828	0.128		0.140	UJ	0.400	0.205		0.934	J	0.593	0.165		3.00	*	Less than Criteria
FEEBRIS1D-20.080-081 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	2.100		0.789	0.018		0.475		0.397	0.016		1.040		0.536	0.016		3.62		Less than Criteria
FEEBRIS1D-20.089-090	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	3.364		1.552	0.100		0.336	J	0.571	0.067		3.975		1.701	0.123		7.68		Less than Criteria
Area 1 Additional Borings																																															
FEEBRISAC-1.010-011	10	11	pCi/g	4,926.29		342.65	139.45	28.69	14.76	U	20.68	15.54	31.25	4,941	*	Exceeds Criteria	7,908	J+	1,823	8.73	11.06	257.04		69.58	5.04	15.70	8,165		Exceeds Criteria	183.118		41.377	3.478	8.110	30.504	J+	15.955	0.232	11.431	206.199	J+	44.871	0.531	9.227	419.8		Exceeds Criteria
FEEBRISAC-1.030-031	30	31	pCi/g	49.46		3.87	5.65	0.99	0.98	J	0.77	0.57	1.17	50.4		Exceeds Criteria	1,946		436.40	0.10	0.11	10.16		2.21	0.00	0.06	1,956		Exceeds Criteria	5.584		0.873	0.010	0.047	0.279		0.121	0.003	0.051	5.512		0.863	0.003	0.041	11.37		Less than Criteria
FEEBRISAC-2B.010-012	10	12	pCi/g	8.95		0.83	2.16	0.38	0.56	J	0.32	0.39	0.80	9.5		Exceeds Criteria	472.18		110.55	0.08	0.09	2.91		0.74	0.01	0.08	475.08		Exceeds Criteria	1.831		0.366	0.008	0.043	0.085	J	0.068	0.004	0.061	1.908		0.377	0.002	0.062	3.82		Less than Criteria
FEEBRISAC-2B.023-026	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	0.618		0.173	0.011	0.051	0.034	J	0.041	0.002	0.050	0.604		0.171	0.008	0.055	1.26		Less than Criteria
FEEBRISAC-3.005-006	5	6	pCi/g	2,599.36		183.37	112.63	20.25	6.28	U	15.98	12.01	24.24	2,606	*	Exceeds Criteria	17,784	J+	3,962	8.73	11.27	514.88		120.66	2.57	12.02	18,299		Exceeds Criteria	128.951	J	30.573	2.996	6.941	17.672	J+	10.862	0.425	6.810	140.251	J+	32.240	1.134	6.911	286.9		Exceeds Criteria
FEEBRISAC-3.044-045	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	0.326	J+	0.133	0.031	0.072	0.049	J	0.059	0.010	0.084	0.343		0.135	0.008	0.057	0.72		Less than Criteria
FEEBRISAC-4B.013-014	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	0.327	J	0.115	0.015	0.056	0.064	J	0.053	0.002	0.045	0.217	J	0.091	0.005	0.042	0.61		Less than Criteria
FEEBRISAC-4B.032-033	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	0.472	J	0.137	0.012	0.049	-0.003	UJ	0.021	0.004	0.049	0.448	J	0.132	0.006	0.043	0.92	*	Less than Criteria
FEEBRISAC-4B.032-033 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	0.566	J	0.152	0.008	0.039	0.112	J	0.070	0.001	0.061	0.521	J	0.145	0.006	0.043	1.20		Less than Criteria
FEEBRISAC-5.011-012	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	0.801	J	0.200	0.012	0.053	0.054	J	0.052	0.004	0.055	0.849	J	0.207	0.003	0.039	1.70		Less than Criteria
FEEBRISAC-5.025-026	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	0.476	J	0.145	0.041	0.086	0.080	J	0.061	0.005	0.056	0.659	J	0.171	0.007	0.049	1.22		Less than Criteria
FEEBRISAC-6.013-016	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	0.672	J	0.175	0.009	0.042	0.033	J	0.043	0.001	0.066	0.662	J	0.173	0.003	0.037	1.37		Less than Criteria
FEEBRISAC-6.023-026	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	0.406	J	0.134	0.014	0.056	0.079	J	0.061	0.002	0.048	0.495	J	0.149	0.003	0.039	0.98		Less than Criteria
FEEBRISAC-7.022-023	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	0.829	J	0.195	0.011	0.048	0.069	J	0.055	0.004	0.050	0.803	J	0.191	0.004	0.040	1.70		Less than Criteria
FEEBRISAC-7.032-033	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	0.392	J	0.121	0.010	0.045	0.036	J	0.039	0.003	0.047	0.477	J	0.135	0.007	0.045	0.91		Less than Criteria
Cotter Borings																																															
WL102CTA.002-003	2	3	pCi/g	1.03		0.147	0.0289	0.073	0.137	U	0.25	0.196	0.422	1.17	*	Less than criteria	5.81	J+	0.423	0.007	0.023	0.826	J	0.159	0.01	0.0371	6.64		Less than criteria	0.636		0.167	0.0085	0.0329	0.0495	J	0.055	0.015	0.0709	0.58		0.159	0.0085	0.033	1.27		Less than criteria
WL-102-CT-A	4	5	pCi/g	0.581	J+	0.269	0.34	0.143	0.122	UJ	0.433	0.758	0.346	0.703	*	Less than criteria	4.43	J+	0.378	0.05	0.013	0.577		0.136	0.04	0.0104	5.01		Less than criteria	0.507		0.145	0.0311	0.008	0.0209	U	0.037	0.0669	0.0141	0.49		0.143	0.0588	0.014	1.02	*	Less than criteria
WL-102-CT-A DUP	4	5	pCi/g	6.75	J+	0.577	0.258	0.111	0.054	UJ	0.24	0.417	0.193	6.80	*	Less than criteria	1.82	J+	0.235	0.054	0.016	0.681		0.144	0.05	0.0138	2.50		Less than criteria	0.535		0.153	0.0328	0.0085	0.011	U	0.028	0.0619	0.0106	0.534		0.153	0.0327	0.008	1.08	*	Less than criteria
WL102CTA.022-023	22	23	pCi/g	1.41		0.19	0.0332	0.085	1.11		0.317	0.194	0.418	2.52		Less than criteria	1.75	J+	0.236	0.007	0.024	1.23		0.198	0.01	0.0444	2.98		Less than criteria	1.01		0.202	0.0078	0.0458	0.05	J	0.05	0.0097	0.0375	1.05		0.206	0.00779	0.046	2.11		Less than criteria
WL106ACT.004-006	4	6	pCi/g	18		0.611	0.0289	0.073	0.767		0.286	0.185	0.401	19		Exceeds criteria	401	J+	3.58	0.012	0.048	1.14		0.19	0.01	0.0238	402		Exceeds criteria	11.3	J	0.82	0.0116	0.0448	0.687	J	0.226	0.0144	0.0557	12.2	J	0.852	0.0116	0.045	24.2		Less than criteria
WL-106A-CT	10	12	pCi/g	9.64	J+	0.685	0.28	0.123	0.271	UJ	0.308	0.506	0.234	9.91	*	Exceeds criteria	165	J+	2.6	0.073	0.021	0.831	J	0.184	0.05	0.0093	166		Exceeds criteria	3.94		0.408	0.06	0.0142	0.242		0.115	0.0746	0.0176	4.67		0.443	0.0316	0.008	8.85		Less than criteria
WL-114-CT	7	8	pCi/g	0.981	J+	0.225	0.18	0.074	0.739		0.343	0.508	0.236	1.720		Less than criteria	4.78	J+	0.404	0.041	0.008	0.885		0.175	0.06	0.0157	5.67		Less than criteria	0.722		0.176	0.0686	0.0184	0.0239	U	0.038	0.0601	0.0102	0.779		0.182	0.055	0.012	1.525	*	Less than criteria
WL114CT.032-033	32	33	pCi/g	0.458		0.104	0.0324	0.08	0.512		0.25	0.167	0.365	0.970		Less than criteria	0.635	J+	0.138	0.015	0.053	0.47		0.118	0.01	0.0357	1.11		Less than criteria	0.432		0.137	0.0084	0.0494	0.0135	J	0.027	0.0105	0.0405	0.319		0.119	0.0146	0.062	0.765		Less than criteria
Cotter Samples from Core of Non-Cotter Borings																																															
1-2-CT	39	40	pCi/g	0.72	J+	0.222	0.244	0.105	0.506	UJ	0.34	0.532	0.247	1.23	*	Less than criteria	0.855	J+	0.164	0.044	0.01	0.348		0.104	0.03	0.0048	1.203		Less than criteria	0.394		0.133	0.0706	0.0189	0.0136	U	0.027	0.0407	0.0105	0.408		0.134	0.062	0.015	0.816	*	Less than criteria
1C-6-CT	25	27	pCi/g	26.7	J+	1.16	0.209	0.086	0.293	U	0.327	0.537	0.247	27.0	*	Exceeds criteria	2,450	J+	95.6	2.79	1.18	2.78	U	3.21	2.78	1.17	2,453	*	Exceeds criteria	2.09		0.29	0.0457	0.0078	0.0578	U	0.056	0.0649	0.0137	1.81		0.27	0.0612	0.016	3.96	*	Less than criteria
1D-16-CT	46	47	pCi/g	2.74	J+	0.369	0.258	0.113	0.324	U	0.284	0.456	0.21	3.06	*	Less than criteria	1.84	J+	0.235	0.022	0.007	0.854		0.16	0.04	0.0069	2.69		Less than criteria	0.685		0.166	0.0519	0.011	0.0303	U	0.044	0.0707	0.0167	0.551		0.149	0.0609	0.016	1.266	*	Less than criteria
1D-7-CT	83	84	pCi/g	1200	J+	9.25	0.286	0.116	4.94	J	0.485	0.361	0.166	1,205		Exceeds criteria	678,000	J+	15,300	475	109	847	J	538	256	108	678,847		Exceeds criteria	21.3		1.02	0.0555	0.0095	0.758		0.214	0.0455	0.0118	14.6		0.843	0.0365	0.009	36.7		Less than criteria
5-3-CT-A	28	30	pCi/g	33.7	J+	1.23	0.19	0.079	0.574	J	0.352	0.546	0.255	34.3		Exceeds criteria	3,660	J+	143	7.71	1.76	7.17	U	6.99	9.12	2.48	3,667	*	Exceeds criteria	6.1		0.537	0.0871	0.0259	0.335		0.141	0.0668	0.0114	5.51		0.51	0.08	0.022	11.9		Less than criteria
5-3-CT-B	33	34	pCi/g	73.9	J+	1.8	0.197	0.082	0.397	U	0.297	0.47	0.217	74.3	*	Exceeds criteria	2,310	J+	158	8.12	3.42	0.449	U	6.25	17.7	4.81	2,310	*	Exceeds criteria	12.3		0.796	0.101	0.0315	0.668		0.207	0.0727	0.0124	12.1		0.789	0.101	0.031	25.1		Less than criteria

Notes: NDE = gamma log not deep enough.   No Log = no log from RI investigation exists.   * Indicates that result for one of the two isotopes was non-detect   Final Q = final qualifier   CSU[1] = combined standard uncertainty (+/- sigma for McLaren/Hart samples)   CV = critical value

🟨 indicates that combined value is 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 McLaren/Hart RI Soil Boring Data:

In calculated 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".

In calculated 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".

Table 2-4: Area 2 Combined Radium, Thorium, and Uranium Results (RI Borings, A2 Additional Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Batch ID	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	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA				Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA				Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA	Result	Final Q	CSU[1]	CV	MDA			
McLaren/Hart RI Data																																																
WL-207	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	0.8		0.37		0.22	1.27	U			1.27	0.66		0.33		0.20	2.10	*	Less than criteria
WL-207 DUP (L)	5	5		pCi/g	0.68		0.18		0.24	0.97	U			0.97	1.17	*	Less than criteria	1.12		0.88		0.88	1.92		1.16		0.59	3.04		Less than criteria	0.85		0.38		0.23	0.58	U			0.58	0.89		0.39		0.21	2.03	*	Less than criteria
WL-207	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	5	5		pCi/g	3.26		0.32		0.37	0.68		0.46		0.66	3.94		Less than criteria	123		23		0.10	1.43		0.42		0.08	124.4		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 DUP (L)	5	5		pCi/g	3.40		0.34		0.38	1.03	U			1.03	3.92	*	Less than criteria	94.9		17		0.23	0.82		0.32		0.14	95.7		Exceeds criteria	2.27		0.65		0.19	1.04	U			1.04	2.82		0.76		0.13	5.61	*	Less than criteria
WL-208	9	9		pCi/g	1.35		0.23		0.25	0.74	U			0.74	1.72	*	Less than criteria	10.07		2		0.07	0.36		0.16		0.07	10.43		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	0	0		pCi/g	3,720		142		10	21.34	U			21.34	3,731	*	Exceeds criteria	29,240		5,290		0.10	127		23		0.09	29,367		Exceeds criteria	575		180		0.7	263		33		33	294		92		0.7	1,132		Exceeds criteria
WL-209	5	5		pCi/g	2,970		123		7	16.34	U			16.34	2,978	*	Exceeds criteria	38,280		7,750		40.2	138		60		32.2	38,418		Exceeds criteria	335		57		0.19	74.8		22.9		23.8	249		43		0.14	659		Exceeds criteria
WL-209 DUP (F)	5	5		pCi/g	3,140		116		5	16.7		9.3		11.3	3,157		Exceeds criteria	32,680		6,420		29.0	180		65		20.2	32,860		Exceeds criteria	527		87		0.20	62.6		25.4		13.4	287		47		0.15	877		Exceeds criteria
WL-209	25	25		pCi/g	0.85		0.18		0.29	0.92	U			0.92	1.31	*	Less than criteria	26.9		5.4		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 DUP (F)	25	25		pCi/g	0.62		0.2		0.27	0.85	U			0.85	1.05	*	Less than criteria	12.85		3.7		0.72	0.39	U	0.53		0.84	13.05	*	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	0	0		pCi/g	2,280		89		4	9.55	U			9.55	2,285	*	Exceeds criteria	18,190		3,510		15.1	59.2		23.2		17.5	18,249		Exceeds criteria	216		67		0.7	182		22		14	134		42		0.6	532		Exceeds criteria
WL-210	5	5		pCi/g	520		26		3	6.72	U			6.72	523	*	Exceeds criteria	12,400		2,140		0.14	106		19		0.06	12,506		Exceeds criteria	145		25		0.18	10.12	U			10.12	65.5		11.2		0.12	216	*	Exceeds criteria
WL-210 DUP (F)	5	5		pCi/g	458		20		2	4.66	U			4.66	460	*	Exceeds criteria	15,610		2,700		0.11	120		21		0.06	15,730		Exceeds criteria	267		46		0.17	27.2		11.9		5.4	128		22		0.14	422		Exceeds criteria
WL-210	40	40		pCi/g	0.68		0.18		0.31	0.83	U			0.83	1.10	*	Less than criteria	18.2		3.3		0.12	0.37		0.17		0.08	18.6		Exceeds 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 DUP (F)	40	40		pCi/g	1.66		0.4		0.59	1.45	U			1.45	2.39	*	Less than criteria	10.8		2.2		0.1	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	5	5		pCi/g	8.52		0.58		0.33	1.15	U			1.15	9.10	*	Exceeds criteria	66.11		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	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	5	5		pCi/g	1.26		0.4		0.46	1.16	U			1.16	1.84	*	Less than criteria	5.73		1.2		0.10	0.29		0.14		0.08	6.02		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	10	10		pCi/g	1.77		0.24		0.28	0.90	U			0.90	2.22	*	Less than criteria	116		20		0.23	0.9		0.29		0.13	117		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	0	0		pCi/g	1.00		0.26		0.37	0.90	U			0.90	1.45	*	Less than criteria	24.2		4.7		0.2	1.11		0.41		0.20	25.3		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	5	5		pCi/g	1.26		0.23		0.27	0.92	U			0.92	1.72	*	Less than criteria	17.29		3.4		0.16	0.89		0.3		0.15	18.18		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	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	5	5		pCi/g	0.95		0.18		0.22	0.81	U			0.81	1.36	*	Less than criteria	44.4		7.8		0.21	0.41		0.2		0.14	44.8		Exceeds criteria	1.09		0.36		0.12	0.52	U			0.52	0.81		0.3		0.09	2.16	*	Less than criteria
WL-214	25	25		pCi/g	0.52	U			0.52	0.89	U			0.89	Non-detect	*	Non-detect	12.8		2.5		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	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	5	5		pCi/g	88.4		5.2		0.9	2.21	U			2.21	89.5	*	Exceeds criteria	1,131				0.93	3.05		1.45		0.81	1,134		Exceeds criteria	12.5		4.0		1.90	3.07	U			3.07	11.4		3.8		2.20	25.4	*	Less than criteria
WL-216	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		0.1	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	5	5		pCi/g	0.60		0.21		0.31	0.81	U			0.81	1.01	*	Less than criteria	0.96		0.3		0.13	0.38	U	0.16		0.06	1.15	*	Less than criteria	0.45		0.2		0.08	0.53	U			0.53	0.51		0.21		0.08	1.23	*	Less than criteria
WL-217	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	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	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		0.3		0.12	1.86		Less than criteria	0.73		0.28		0.12	0.84	U			0.84	0.81		0.3		0.12	1.96	*	Less than criteria
WL-218	40	40		pCi/g	0.68		0.23		0.43	1.16	U			1.16	1.26	*	Less than criteria	7.27		1.51		0.1	0.58		0.25		0.09	7.85		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	5	5		pCi/g	1.12		0.26		0.33	1.17		0.59		0.77	2.29		Less than criteria	1.07		0.4		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	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		0.2		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	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	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		0.1	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	5	5		pCi/g	0.75		0.2		0.34	1.12	U			1.12	1.31	*	Less than criteria	4.28		0.94		0.24	0.7		0.28		0.24	5.0		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	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		0.1	0.79	U			0.79	0.50		0.21		0.11	1.42	*	Less than criteria
WL-222	0	0		pCi/g	2.94		0.59		0.53	1.75	U			1.75	3.82	*	Less than criteria	131		25		0.19	1.31		0.40		0.2	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	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	1.3		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	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	1.0		0.3		0.15	1.9		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	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		0.3		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	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		0.1	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	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		0.5		0.68	0.71	U			0.71	0.63		0.41		0.40	1.74	*	Less than criteria
WL-224	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	5	5		pCi/g	1.07		0.27		0.40	1.18	U			1.18	1.66	*	Less than criteria	2.84		1.44		1.32	1.76		1.07		0.62	4.60		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	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	10	10		pCi/g	1.4		0.27		0.34	0.95		0.46		0.82	2.4		Less than criteria	14.1		4		1.1	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	20	20		pCi/g	3.26		0.44		0.40	1.12	U			1.12	3.82	*	Less than criteria	173		31		1.0	0.69	U	0.68		0.85	173	*	Exceeds criteria	6.02		2.2		1.31	0.87	U			0.87	6.32		2.24		0.91	12.78	*	Less than criteria
WL-227	5	5		pCi/g	1.32		0.22		0.29	1.35		0.43		0.73	2.67		Less than criteria	20.4		4.7		0.9	0.5	U	0.52		0.53	20.7	*	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	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	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		1.3	3.60	*	Less than criteria
WL-228	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	0.6	U	0.46		0.74	0.75	U			0.75	0.26	U	0.39		0.78	Non-detect	*	Non-detect
WL-229	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		0.6		0.39	2.59	*	Less than criteria
WL-229	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	5	5		pCi/g	1.67		0.26		0.34	1.16	U			1.16	2.25	*	Less than criteria	26.8		6.4		1.3	0.51	U	0.63		0.87	27.1	*	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	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	0.1	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	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	0.1		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	5	5		pCi/g	4.06		0.37		0.28	1.02	U			1.02	4.57	*	Less than criteria	94.5		17.4		1.0	1.11		0.85		0.83	95.6		Exceeds criteria	6.97		2.76		2.14	0.73	U			0.73	3.86		2.03		2.18	11.20	*	Less than criteria
WL-231	10	10		pCi/g	1.37		0.24		0.40	0.75	U			0.75	1.75	*	Less than criteria	10.2		3.0		1.4	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	27	27		pCi/g	4.44		0.46		0.38	1.11	U			1.11	5.00	*	Less than criteria	427		80		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	30	30		pCi/g	0.79		0.20		0.41	1.05	U			1.05	1.32	*	Less than criteria	9.93		2.72		0.9	0.82		0.64		0.49	10.75		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	10	10		pCi/g	3,060		116		4	14.5		7.9		10.3	3,075		Exceeds criteria	57,300		19,300		238	148	U	173		240	57,374	*	Exceeds criteria	128		39		5	774		150		12	138		42		5.0	1,040		Exceeds criteria
WL-234 DUP (F)	10	10		pCi/g	1,260		49		3	6.62	U			6.62	1,263	*	Exceeds criteria	12,000		3,670		116	58.1	U	84.6		98.7	12,029	*	Exceeds criteria	45.4		9.7		0.5	97.6		11.2		7.9	60.7		12.4		1.1	204		Exceeds criteria
WL-234	20	20		pCi/g	0.66	U			0.66	1.25	U			1.25	Non-detect	*	Non-detect	16.2		3.2		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 DUP (F)	20	20		pCi/g	1.18		0.26		0.39	1.23	U			1.23	1.80	*	Less than criteria	11.3		2.2		0.5	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	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		0.4		0.37	2.02	*	Less than criteria
WL-235	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		0.5		0.50	3.20	*	Less than criteria
WL-235	30	30		pCi/g	1.09		0.25		0.43	0.93	U			0.93	1.56	*	Less than criteria	3.15		1.43		1.0	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	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	35	35		pCi/g	1.01		0.24		0.35	1.23	U			1.23	1.63	*	Less than criteria	4.9		1.33		1.01	0.9	U	0.63		1.02	5.4	*	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	5	5		pCi/g	0.96		0.11		0.10	1.13		0.19		0.17	2.09		Less than criteria	0.5		0.2		0.12	0.26		0.13		0.07	0.8		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	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	5	5		pCi/g	12.9		0.54		0.1	0.24	U			0.24	13.0	*	Exceeds criteria	343		66		0.11	3.84		0.9		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	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	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	U	0		0.34	8.63	*	Exceeds criteria	1.83		0.5		0.17						1.63		0.46		0.13	3.46		Less than criteria
WL-242	2	2		pCi/g	2.42		0.45		0.59	1.57	U			1.57	3.21	*	Less than criteria	21.3		5.3		1.11	0.52	U	0.58		0.75	21.6	*	Exceeds criteria	1.35		0.43		0.1						0.75		0.3		0.1	2.10		Less than criteria
WL-243	0	0		pCi/g	4.78		0.44		0.33	1.13		0.54		0.84	5.91		Less than criteria	265		50		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	0	0		pCi/g	1.54		0.22		0.33	1.05	U			1.05	2.07	*	Less than criteria	20.8		4.1		0.71	0.78		0.68		0.65	21.6		Exceeds criteria	0.88		0.3		0.12						1.35		0.4		0.09	2.23		Less than criteria
WL-245	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		0.2		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	0	0		pCi/g	1.04		0.26		0.37	1.07	U			1.07	1.58	*	Less than criteria	2.91		0.82		0.3	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)																																																
FEEBRISAC-8.024-026	24	26	15-12062	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
FEEBRISAC-8.035-036	35	36	15-12062	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
FEEBRISAC-9.025-028	25	28	15-12034	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	0.01	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
FEEBRISAC-9.025-028 FD	25	28	15-12034	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	0.02	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
FEEBRISAC-9.032-033	32	33	15-12034	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	0.01	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
FEEBRISAC-10.012-013	12	13	15-12063	pCi/g	1.66		0.22	1.17	0.23	0.48		0.21	0.17	0.37	2.15		Less than criteria	12.19	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
FEEBRISAC-10.026-028	26	28	15-12063	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
FEEBRISAC-11.008-009	8	9	15-12064	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
FEEBRISAC-11.017-019	17	19	15-12064	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
FEEBRISAC-12.002-004	2	4	15-12064	pCi/g	2.85		0.28	1.19	0.19	0.36		0.16	0.17	0.35	3.21		Less than criteria	43.95	J	10.91	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
FEEBRISAC-12.010-011	10	11	15-12064	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
FEEBRISAC-13.020-022	20	22	15-12062	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+	20.72	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
FEEBRISAC-13.031-033	31	33	15-12062	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
FEEBRISAC-14.013-014	13	14	15-12064	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	0.47	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
FEEBRISAC-14.025-026	25	26	15-12064	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
FEEBRISAC-15.026-027	26	27	15-12064	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
FEEBRISAC-15.032-034	32	34	15-12064	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
FEEBRISAC-15.032-034 FD	32	34	15-12064	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
FEEBRISAC-16.019-020	19	20	15-12064	pCi/g	554		39.48	20.98	4.76	13.81		2.52	2.57	5.18	568		Exceeds criteria	8,710		1,811	6.23	7.84	43.68		17.25	2.11	9.28	8,753		Exceeds criteria	310	J+	53.7	5.25	9.90	29.7	J	13.4	0.93	7.87	266	J	47.9	4.21	10.4	606		Exceeds criteria
FEEBRISAC-16.022-023	22	23	15-12064	pCi/g	358		23.76	13.03	1.71	8.01		1.40	1.35	2.71	366		Exceeds criteria	5,166	J	1,048	6.75	6.74	30.48	J	14.03	2.93	10.25	5,197		Exceeds criteria	294	J+	55.6	2.74	5.90	14.8	J	10.5	0.93	9.16	248	J	49.0	0.73	5.88	557		Exceeds criteria
FEEBRISAC-16.022-023 FD	22	23	15-12064	pCi/g	317		24.70	25.03	4.34	10.62		3.50	4.32	8.28	327		Exceeds criteria	12,250	J	2,514	7.26	7.52	68.71	J	22.88	1.93	9.12	12,319		Exceeds criteria	442	J+	72.6	3.07	7.06	24.7	J	12.9	0.18	9.26	432	J	71.2	1.07	6.54	899		Exceeds criteria
FEEBRISAC-16.029-030	29	30	15-12064	pCi/g	1.17		0.19	1.16	0.26	0.97		0.21	0.17	0.35	2.14		Less than criteria	15.91	J	3.84	0.08	0.08	1.07	J	0.34	0.02	0.09	16.98		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
FEEBRISAC-17.008-010	8	10	15-12064	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
FEEBRISAC-17.032-033	32	33	15-12062	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

Table 2-4: Area 2 Combined Radium, Thorium, and Uranium Results (RI Borings, A2 Additional Borings, and Cotter Borings)

DRAFT

Sample Designation	Upper Sample Depth (feet)	Lower Sample Depth (feet)	Batch ID	Units	Radium-226					Radium-228					Combined Radium 226 + 228		Combined Radium relative to 7.9 pCi/g Unrestricted Use Criteria
					Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA			
FEEBRISAC-18.002-005	2	5	15-12062	pCi/g	206	J	13.96	12.52	2.17	8.16		1.44	1.50	3.03	215		Exceeds criteria
FEEBRISAC-18.002-005 FD	2	5	15-12062	pCi/g	333	J	22.18	17.29	1.66	9.19		1.62	1.30	2.62	343		Exceeds criteria
FEEBRISAC-18.010-011	10	11	15-12062	pCi/g	184		14.82	19.11	2.97	6.53		2.39	2.06	4.17	190		Exceeds criteria
FEEBRISAC-19.005-006	5	6	15-12063	pCi/g	1,005		66.26	19.31	2.47	8.07		1.99	1.70	3.41	1,013		Exceeds criteria
FEEBRISAC-19.036-037	36	37	15-12062	pCi/g	1.20		0.18	1.13	0.24	1.17		0.21	0.19	0.41	2.37		Less than criteria
FEEBRISAC-20.023-024	23	24	15-12063	pCi/g	580		38.54	18.16	3.74	8.43		1.74	2.00	4.02	588		Exceeds criteria
FEEBRISAC-20.047-049	47	49	15-12063	pCi/g	1.33		0.20	1.05	0.25	1.55		0.25	0.19	0.40	2.88		Less than criteria
FEEBRISAC-20.047-049 FD	47	49	15-12063	pCi/g	1.40	U	0.37	2.67	0.46	1.56		0.44	0.40	0.86	2.95	*	Less than criteria
FEEBRISAC-21.012-013	12	13	15-12106	pCi/g	272		18.78	27.10	3.26	8.48		2.28	2.37	4.82	280		Exceeds criteria
FEEBRISAC-21.030-032	30	32	15-12062	pCi/g	1.11	U	0.32	2.34	0.44	0.75		0.35	0.50	1.04	1.86	*	Less than criteria
FEEBRISAC-21.040-042	40	42	15-12062	pCi/g	0.80	U	0.12	1.07	0.18	0.49		0.18	0.16	0.35	1.29	*	Less than criteria
FEEBRISAC-21A.013-014	13	14	15-12106	pCi/g	376		30.43	51.89	7.58	6.84	J	6.11	4.74	9.69	383		Exceeds criteria
FEEBRISAC-21A.047-048	47	48	15-12106	pCi/g	1.55		0.20	1.07	0.20	1.01		0.21	0.17	0.36	2.55		Less than criteria
FEEBRISAC-22.018-019	18	19	15-12064	pCi/g	14.77		1.17	2.89	0.40	0.58	J	0.36	0.30	0.63	15.36		Exceeds criteria
FEEBRISAC-22.041-042	41	42	15-12064	pCi/g	1.26	U	0.36	1.87	0.63	1.65		0.55	0.51	1.09	2.90	*	Less than criteria
FEEBRISAC-23.023-024	23	24	15-12063	pCi/g	344		24.34	22.56	3.52	1.51	U	3.11	2.34	4.74	346	*	Exceeds criteria
FEEBRISAC-23.067-068	67	68	15-12063	pCi/g	0.47	U	0.10	0.61	0.15	0.38		0.12	0.14	0.29	0.84	*	Less than criteria
FEEBRISAC-24.004-005	4	5	15-12063	pCi/g	1,188		78.28	21.06	3.17	9.53		2.22	1.87	3.75	1,198		Exceeds criteria
FEEBRISAC-24.014-015	14	15	15-12063	pCi/g	56.22		4.19	7.60	1.50	29.12		2.34	1.83	3.70	85.35		Exceeds criteria
FEEBRISAC-24.039-041	39	41	15-12063	pCi/g	1.08	U	0.26	2.46	0.39	1.11		0.44	0.37	0.79	2.19	*	Less than criteria
FEEBRISAC-24.047-048	47	48	15-12063	pCi/g	0.51	U	0.26	1.74	0.39	0.60		0.29	0.23	0.52	1.11	*	Less than criteria
FEEBRISAC-25.037-038	37	38	15-12062	pCi/g	1.25	U	0.20	1.53	0.28	1.50		0.27	0.19	0.41	2.75	*	Less than criteria
FEEBRISAC-25.043-045	43	45	15-12062	pCi/g	1.27	U	0.21	1.74	0.24	1.19		0.29	0.23	0.50	2.46	*	Less than criteria
FEEBRISAC-26A.004-005	4	5	15-12106	pCi/g	12.48		1.48	4.14	0.74	0.94	J	0.62	0.52	1.09	13.42		Exceeds criteria
FEEBRISAC-26A.037-038	37	38	15-12106	pCi/g	2.41		0.28	1.38	0.26	1.40		0.30	0.26	0.54	3.81		Less than criteria
Cotter Borings																	
WL-209-CT	1	3	160156091	pCi/g	882	J+	4.87	0.151	0.066	5.48	J	0.486	0.347	0.16	887		Exceeds criteria
WL-209-CT DUP	1	3	160156091	pCi/g	855	J+	4.86	0.136	0.057	4.57	J	0.453	0.349	0.161	860		Exceeds criteria
WL209CT.009-010	9	10	160-16191-1	pCi/g	460	J	3.84	0.08	0.185	45	J	1.37	0.193	0.416	505		Exceeds criteria
WL209CT.021-023	21	23	160-16191-1	pCi/g	0.756	J	0.137	0.047	0.11	0.23	J	0.239	0.18	0.39	0.99		Less than criteria
WL209CT.021-023 FD	21	23	160-16191-1	pCi/g	0.59		0.118	0.037	0.088	0.418	J	0.227	0.154	0.337	1.01		Less than criteria
WL209CT.026-027	26	27	160-16191-1	pCi/g	0.493	J	0.116	0.046	0.107	0.546	J	0.241	0.157	0.344	1.039		Less than criteria
WL-234-CT	8	10	160156071	pCi/g	1,040	J+	8.62	0.257	0.102	3.82	J	0.456	0.399	0.184	1,044		Exceeds criteria
WL-234-CT DUP	8	10	160156071	pCi/g	757	J+	7	0.24	0.096	1.92	J	0.346	0.376	0.173	759		Exceeds criteria
WL234CT.018-019	18	19	160-16191-1	pCi/g	110	J	1.6	0.05	0.117	0.633	J	0.251	0.159	0.348	111		Exceeds criteria
WL234CT.044-045	44	45	160-16191-1	pCi/g	0.992		0.149	0.034	0.084	0.39	J	0.221	0.15	0.33	1.38		Less than criteria
Cotter Samples from Core of Non-Cotter Borings																	
WL-210-CT (AC-24)	4	5	160156091	pCi/g	633	J+	4.06	0.122	0.051	1.5	J	0.314	0.374	0.173	635		Exceeds criteria
AC24-WL210CT.045-046	45	46	160-16191-1	pCi/g	0.489		0.107	0.031	0.078	0.248	J	0.221	0.162	0.355	0.737		Less than criteria
AC25-WL235CT.021-022	21	22	160-16191-1	pCi/g	0.994		0.156	0.043	0.102	0.674		0.271	0.168	0.372	1.668		Less than criteria

Sample Designation	Thorium-230					Thorium-232					Combined Thorium 230 + 232		Combined Thorium relative to 7.9 pCi/g Unrestricted Use Criteria
	Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA			
FEEBRISAC-18.002-005	1,752	J+	368	7.28	7.73	22.98	J+	11.52	0.34	5.38	1,775		Exceeds criteria
FEEBRISAC-18.002-005 FD	2,167	J+	449	6.71	6.65	31.21	J+	13.66	0.55	6.05	2,199		Exceeds criteria
FEEBRISAC-18.010-011	3,414	J+	743	7.26	7.18	22.48	J+	12.60	3.61	11.46	3,436		Exceeds criteria
FEEBRISAC-19.005-006	976	J+	201	5.63	5.29	9.76	J+	6.73	0.29	4.61	986		Exceeds criteria
FEEBRISAC-19.036-037	1.39	J+	0.38	0.06	0.06	1.07	J+	0.30	0.01	0.05	2.46		Less than criteria
FEEBRISAC-20.023-024	6,737	J+	1,397	7.63	8.09	40.44	J+	16.57	1.51	8.50	6,777		Exceeds criteria
FEEBRISAC-20.047-049	1.54	J+	0.38	0.04	0.04	1.06	J+	0.27	0.01	0.04	2.60		Less than criteria
FEEBRISAC-20.047-049 FD	1.32	J+	0.34	0.05	0.05	1.20	J+	0.30	0.02	0.07	2.52		Less than criteria
FEEBRISAC-21.012-013	3491	J+	788	6.81	10.58	136.70		41.32	0.87	8.75	3,628		Exceeds criteria
FEEBRISAC-21.030-032	22.62	J+	4.71	0.12	0.10	1.17	J+	0.39	0.01	0.10	23.79		Exceeds criteria
FEEBRISAC-21.040-042	5.61	J+	1.21	0.04	0.04	0.53	J+	0.16	0.00	0.05	6.14		Less than criteria
FEEBRISAC-21A.013-014	4,112	J+	908	7.61	9.60	101.67	J	32.57	2.37	11.09	4,214		Exceeds criteria
FEEBRISAC-21A.047-048	1.96	J+	0.48	0.05	0.05	0.87	J	0.24	0.01	0.05	2.82		Less than criteria
FEEBRISAC-22.018-019	128.54		26.34	0.05	0.06	0.69		0.20	0.02	0.07	129		Exceeds criteria
FEEBRISAC-22.041-042	1.58		0.40	0.04	0.04	1.13		0.29	0.00	0.04	2.72		Less than criteria
FEEBRISAC-23.023-024	1,458	J+	314	8.57	9.68	12.66	J+	9.39	3.27	10.78	1471		Exceeds criteria
FEEBRISAC-23.067-068	4.77	J+	1.10	0.05	0.06	0.33	J+	0.13	0.01	0.06	5.11		Less than criteria
FEEBRISAC-24.004-005	6,029	J+	902	7.36	6.86	54.15	J+	18.45	0.38	5.97	6,083		Exceeds criteria
FEEBRISAC-24.014-015	20.50	J+	4.72	0.26	0.22	10.05	J+	2.27	0.11	0.37	30.55		Exceeds criteria
FEEBRISAC-24.039-041	0.99	J+	0.28	0.05	0.04	0.80	J+	0.22	0.00	0.04	1.79		Less than criteria
FEEBRISAC-24.047-048	0.56	J+	0.19	0.05	0.05	0.35	J+	0.14	0.00	0.06	0.90		Less than criteria
FEEBRISAC-25.037-038	0.79	J+	0.22	0.05	0.05	0.27	J+	0.11	0.02	0.07	1.07		Less than criteria
FEEBRISAC-25.043-045	4.52	J+	1.00	0.05	0.05	1.03	J+	0.27	0.01	0.05	5.55		Less than criteria
FEEBRISAC-26A.004-005	245.54	J+	58.15	0.06	0.06	2.09		0.57	0.01	0.08	248		Exceeds criteria
FEEBRISAC-26A.037-038	10.09	J+	2.30	0.05	0.05	1.49		0.39	0.00	0.05	11.58		Exceeds criteria
Cotter Borings													
WL-209-CT	1,470,000	J+	19,600	363	82.9	1,150		556	361	82.5	1,471,150		Exceeds criteria
WL-209-CT DUP	256,000	J+	7,560	308	70.5	420	J	305	166	70.1	256,420		Exceeds criteria
WL209CT.009-010	9330	J+	121	0.507	2.18	5.51	J	2.96	0.357	1.88	9,336		Exceeds criteria
WL209CT.021-023	0.799	J+	0.162	0.0129	0.0501	0.629		0.142	0.0074	0.0242	1.428		Less than criteria
WL209CT.021-023 FD	0.792	J+	0.158	0.016	0.0554	0.656		0.143	0.0071	0.0375	1.448		Less than criteria
WL209CT.026-027	0.547	J+	0.13	0.0099	0.0428	0.462		0.119	0.007	0.0368	1.009		Less than criteria
WL-234-CT	644,000	J+	9,870	113	47.8	662		321	208	47.6	644,662		Exceeds criteria
WL-234-CT DUP	65,500	J+	2,850	267	87.4	202	J	165	170	38.9	65,702		Exceeds criteria
WL234CT.018-019	4290	J+	81.5	0.504	2.17	3.81	J	2.44	0.24	1.64	4,294		Exceeds criteria
WL234CT.044-045	1.18	J+	0.194	0.0073	0.0383	0.976		0.175	0.0072	0.0236	2.16		Less than criteria
Cotter Samples from Core of Non-Cotter Borings													
WL-210-CT (AC-24)	57,000	J+	2,070	104	23.8	318	J	157	103	23.6	57,318		Exceeds criteria
AC24-WL210CT.045-046	0.517	J+	0.127	0.0071	0.0374	0.2		0.0785	0.0071	0.0231	0.7		Less than criteria
AC25-WL235CT.021-022	4.24	J+	0.362	0.01	0.0431	1.02		0.177	0.0071	0.0371	5.26		Less than criteria

Sample Designation	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	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA	Result	Final Q	CSU^1	CV	MDA			
FEEBRISAC-18.002-005	116	J	30.06	3.40	7.82	25.44	J	13.92	0.47	7.68	112	J	29.46	1.02	7.10	253		Exceeds criteria
FEEBRISAC-18.002-005 FD	180	J	42.12	2.95	9.99	32.55	J	16.74	0.53	8.58	208	J	46.35	1.99	9.94	420		Exceeds criteria
FEEBRISAC-18.010-011	133		30.89	3.30	7.55	16.58	J	10.37	0.61	7.43	154		34.04	0.65	5.24	303		Exceeds criteria
FEEBRISAC-19.005-006	74.84		23.09	3.80	8.76	4.49	J	6.25	0.96	9.47	75.02	J+	23.01	1.25	7.65	154		Exceeds criteria
FEEBRISAC-19.036-037	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
FEEBRISAC-20.023-024	423		83.61	5.59	12.40	39.08	J	19.65	0.61	9.69	391	J+	78.47	1.62	9.83	853		Exceeds criteria
FEEBRISAC-20.047-049	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
FEEBRISAC-20.047-049 FD	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
FEEBRISAC-21.012-013	956		144.05	3.38	7.87	66.83	J+	22.81	0.45	7.18	869	J+	132.47	0.95	6.64	1,892		Exceeds criteria
FEEBRISAC-21.030-032	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
FEEBRISAC-21.040-042	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
FEEBRISAC-21A.013-014	1,711	J	263	6.59	13.57	203	J+	49.99	1.45	12.12	1,823	J+	279	3.86	13.13	3,736		Exceeds criteria
FEEBRISAC-21A.047-048	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
FEEBRISAC-22.018-019	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
FEEBRISAC-22.041-042	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
FEEBRISAC-23.023-024	47.12		18.05	3.96	9.06	10.56	J	9.12	0.74	8.92	42.91	J+	17.01	1.30	7.90	101		Less than criteria
FEEBRISAC-23.067-068	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
FEEBRISAC-24.004-005	48.45		17.67	4.10	9.17	10.56	J	9.11	1.39	10.28	56.79	J+	19.23	1.90	8.73	116		Exceeds criteria
FEEBRISAC-24.014-015	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
FEEBRISAC-24.039-041	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
FEEBRISAC-24.047-048	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
FEEBRISAC-25.037-038	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
FEEBRISAC-25.043-045	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
FEEBRISAC-26A.004-005	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	10.12		Less than criteria
FEEBRISAC-26A.037-038	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	107	J	3.62	0.21	0.0584	5.22	J	0.896	0.22	0.0514	102	J	3.53	0.199	0.0532	214.2		Exceeds criteria
WL-209-CT DUP	101	J	3.58	0.23	0.0649	5.15	J	0.9	0.12	0.0305	107	J	3.68	0.0946	0.0245	213.2		Exceeds criteria
WL209CT.009-010	0.29		0.112	0.01	0.0492	0.0269	J	0.038	0.01	0.0403	0.507		0.148	0.00837	0.0324	0.82		Less than criteria
WL209CT.021-023	0.483	J	0.143	0.01	0.0591	-0.00485	U	0.00686	0.01	0.0672	0.548		0.151	0.00805	0.0472	1.026	*	Less than criteria
WL209CT.021-023 FD	0.219	J	0.0943	0.01	0.0457	0.025	J	0.0353	0.01	0.0375	0.509		0.143	0.00778	0.0456	0.753		Less than criteria
WL209CT.026-027	0.444		0.134	0.01	0.0461	0.0126	J	0.0252	0.01	0.0378	0.352		0.12	0.00784	0.046	0.809		Less than criteria
WL-234-CT	53.8	J	2.22	0.12	0.025	2.81	J	0.565	0.09	0.022	50.1	J	2.14	0.139	0.0353	106.7		Exceeds criteria
WL-234-CT DUP	44.2	J	1.92	0.13	0.0325	2.05	J	0.463	0.12	0.0202	43.3	J	1.9	0.119	0.028	89.6		Exceeds criteria
WL234CT.018-019	0.2		0.0941	0.01	0.0333	0.0336	J	0.0486	0.02	0.0785	0.186		0.0914	0.00859	0.0504	0.4		Less than criteria
WL234CT.044-045	0.545		0.152	0.01	0.0479	0.0131	J	0.0262	0.01	0.0393	0.72		0.174	0.0115	0.0545	1.28		Less than criteria
Cotter Samples from Core of Non-Cotter Borings																		
WL-210-CT (AC-24)	58.9	J	2.32	0.1	0.0178	2.84	J	0.57	0.15	0.0313	58.7	J	2.32	0.14	0.0355	120.4		Exceeds criteria
AC24-WL210CT.045-046	0.797		0.184	0.01	0.0601	0.0526	J	0.0526	0.01	0.0394	1.08		0.213	0.00819	0.0316	1.93		Less than criteria
AC25-WL235CT.021-022	0.769		0.186	0.01	0.0582	0.0531	J	0.056	0.01	0.0635	0.894		0.2	0.00868	0.0335	1.716		Less than criteria

Notes: NDE = gamma log not deep enough. No Log = no log from RI investigation exists. * Indicates that result for one of the two isotopes was non-detect Final Q = final qualifier CSU^1 = combined standard uncertainty (+/- sigma for McLaren/Hart samples) CV = critical value

🟨 indicates that combined value is 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 McLaren/Hart RI Soil Boring Data:

- In calculated 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".
- In calculated 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".

Table 2-5: Summary Statistics for Radium and Thorium Results - Areas 1 and 2

	Radium-226	Radium-228	Thorium-230	Thorium-232
Area 1				
Number of values	178	178	178	178
Median value	1.17	1.41	1.44	0.58
Average - single normally distributed population	81.3	2.38	547	7.77
Standard Deviation	510.5	2.96	2,851	47.28
Maximum value	4,926	31.8	25,825	515
95% UCL - single population	248	2.38	1,478	23.2
Weighted Bimodal Mean	81	1.7	550	7.8
Weighted Bimodal 95% UCL	890	5.2	1,900	46
Area 2				
Number of values	118	118	118	118
Median value	1.06	2.34	5.16	0.78
Average - single normally distributed population	152	2.34	1,706	10.5
Standard Deviation	572.8	4.23	7,148	33.6
Maximum value	3,720	29.1	57,300	240
95% UCL - single population	382	4.04	4,574	24
Weighted Bimodal Mean	150	2.4	1,500	11
Weighted Bimodal 95% UCL	340	82	4,000	29

All results except for number of values are in units of pCi/g.

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Table 2-6: Summary of Thorium-230 Decay and Radium-226 In-Growth Over Time - Area 1

		Radium -226		
Time (years)	Thorium-230 pCi/g	From Initial Ra_{226} (pCi/g)	Ingrowth from Th_{230} (pCi/g)	Total (pCi/g)
0	547	81	0	81
30	547	80	7	87
100	547	78	23	101
200	546	75	45	120
500	545	65	106	172
1,000	542	53	191	244
2,000	538	34	314	348
3,000	533	22	391	414
5,000	524	9	470	480
7,000	515	4	498	502
10,000	502	1	504	506
15,000	480	0	489	489
20,000	460	0	469	469
30,000	422	0	430	430
40,000	387	0	395	395
50,000	355	0	362	362
80,000	274	0	279	279

Constants	half life (y)	lambda (1/y)	Specific Mass to Activity (µg/pCi)
Th_{230} Half-Life	80,000	8.664E-06	4.95E-05
Ra_{226} Half-Life	1,602	4.327E-04	1.01E-06

Initial Values (from the RI report Appendix A Table A.2-5)

Thorium 230	547	pCi/g	Average activity level for Area 1
Radium-226	81	pCi/g	Average activity level 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)])}

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)	Ingrowth from Th_{230} (pCi/g)	Total (pCi/g)
0	1,706	152	0	152
30	1,706	150	22	172
100	1,705	146	72	218
200	1,703	139	141	281
500	1,699	122	331	454
1,000	1,691	99	596	695
2,000	1,677	64	978	1,042
3,000	1,662	42	1,221	1,262
5,000	1,634	17	1,467	1,484
7,000	1,606	7	1,554	1,562
10,000	1,564	2	1,573	1,575
15,000	1,498	0	1,526	1,526
20,000	1,435	0	1,464	1,464
30,000	1,316	0	1,342	1,342
40,000	1,206	0	1,231	1,231
50,000	1,106	0	1,129	1,129
80,000	853	0	870	870

Constants	half life (y)	lambda (1/y)	Specific Mass to Activity (µg/pCi)
Th_{230} Half-Life	80,000	8.664E-06	4.95E-05
Ra_{226} Half-Life	1,602	4.327E-04	1.01E-06

Initial Values (from the RI report Appendix A Table A.2-5)

Thorium 230	1,706	pCi/g	Average activity level for Area 2
Radium-226	152	pCi/g	Average activity level 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)])}

Table 2-8: Buffer Zone Crossroad Property Combined Radium, Thorium, and Uranium Results

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Sample Designati	Boring	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	McLaren/Hart RI Data																																															
FP1 0-3	FP-1	0.25	0.25	pCi/g	7.23	U			7.23	2.13	U			2.13	Non-detect	*	Non-detect	12.8		2.8		0.2	1.1		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
FP1 0-3	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		0.2		0.07	0.15		0.07		0.05	0.8		0.19		0.06	1.79		Less than criteria
FP1 12-24	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
FP2 0-3	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		0.1	1.08		0.29		0.14	4.00		Less than criteria	1.08		0.24		0.07	0.14		0.08		0.1	1.17		0.26		0.09	2.39		Less than criteria
FP2 12-24	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		0.1	2.37		Less than criteria	0.78		0.21		0.1	0.26		0.11		0.08	0.94		0.24		0.1	1.98		Less than criteria
FP3 0-3	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		0.1	2.11		Less than criteria	0.69		0.18		0.07	0.063		0.051		0.057	0.79		0.2		0.05	1.54		Less than criteria
FP3 12-24	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		0.4		0.07	0.38		0.13		0.05	2.62		0.51		0.07	4.94		Less than criteria
FP4 0-3	FP-4	0.25	0.25	pCi/g	9.06		3.81		3.62	2.6	U			2.6	10.36	*	Exceeds criteria	2.61		0.57		0.07	1.16		0.3		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
FP4 12-24	FP-4	2	2	pCi/g	5.58	U			5.58	1.73	U			1.73	Non-detect	*	Non-detect	2.2		0.49		0.07	1.28		0.32		0.05	3.5		Less than criteria	0.71		0.19		0.06	0.095		0.064		0.061	0.84		0.21		0.06	1.65		Less than criteria
FP5 0-3	FP-5	0.25	0.25	pCi/g	4.08		3.1		2.99	0.94	U			0.94	4.55	*	Less than criteria	28.6		5.2		0.08	1.38		0.34		0.08	30.0		Exceeds criteria	0.84		0.2		0.05	0.062		0.047		0.05	1.05		0.23		0.04	1.95		Less than criteria
FP5 12-24	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	1.2		0.3		0.02	6.5		Less than criteria	1.11		0.32		0.08	0.22		0.13		0.09	1.2		0.33		0.09	2.53		Less than criteria
FP6 0-3	FP-6	0.25	0.25	pCi/g	5.59	U			5.59	1.56	U			1.56	Non-detect	*	Non-detect	1.2		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		0.1	0.91		0.21		0.06	1.71		Less than criteria
FP6 12-24	FP-6	2	2	pCi/g	3.25	U			3.25	1.95	U			1.95	Non-detect	*	Non-detect	1.8		0.39		0.05	1.2		0.28		0.05	3.0		Less than criteria	0.86		0.21		0.04	0.093		0.061		0.025	1.07		0.25		0.05	2.02		Less than criteria
FP7 0-3	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		0.1		0.04	0.82		0.25		0.07	1.85		Less than criteria
FP7 12-24	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
FP8 0-3	FP-8	0.25	0.25	pCi/g	5.22	U			5.22	1.68	U			1.68	Non-detect	*	Non-detect	21.8		3.8		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
FP8 1-2	FP-8	2	2	pCi/g	5.78	U			5.78	2.92	U			2.92	Non-detect	*	Non-detect	2.04		0.42		0.082	1.29		0.29		0.067	3.33		Less than criteria	0.93		0.34		0.21	0.07		0.18		0.32	1.3		0.42		0.24	2.30		Less than criteria
WL-201	WL-201	5	5	pCi/g	1.06		0.22		0.34	1.13	U			1.13	1.63	*	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		0.4		0.17	1.95	*	Less than criteria
WL-201	WL-201	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	0.079		0.13	0.31		0.18		0.12	1.55	*	Less than criteria
WL-202	WL-202	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	0.076		0.17	0.88		0.37		0.12	2.24	*	Less than criteria
WL-202	WL-202	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	0.003		0.12	0.24		0.16		0.10	2.18	*	Less than criteria
WL-203	WL-203	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	WL-203	5	5	pCi/g	0.94		0.22		0.33	0.99	U			0.99	1.44	*	Less than criteria	0.8		0.27		0.1	0.14		0.1		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	WL-203	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	WL-204	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		0.2		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	WL-204	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		0.2		0.09	0.94	*	Less than criteria
WL-205	WL-205	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		0.5		0.09	3.39		Less than criteria
WL-205	WL-205	15	15	pCi/g	0.90		0.26		0.34	0.95	U			0.95	1.38	*	Less than criteria	1.01				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	WL-206	0	0	pCi/g	17.2		1.2		0.4	1.21	U			1.21	17.8	*	Exceeds criteria	429		135		0.7	11.2		4.4		0.6	440		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	WL-206	5	5	pCi/g	1.20		0.37		0.57	1.58	U			1.58	1.99	*	Less than criteria	7.51		1.54		0.23	1.12		0.4		0.15	8.63		Exceeds criteria	4.01	U			4.01	0.19		0.1		0.06	1.17		0.27		0.06	3.37	*	Less than criteria
WL-206	WL-206	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	0.064	U	0.05		0.064	0.6		0.17		0.04	2.46	*	Less than criteria
RC-01	RC-01	0	0.25	pCi/g	0.15	U			0.15	1.83		1.83		0.71	1.91	*	Less than criteria	2.75		2.75		0.09	1.4		1.4		0.07	4.2		Less than criteria	1		1		0.15	0.13	U			0.13	0.92		0.92		0.1	1.99	*	Less than criteria
RC-02	RC-02	0	0.25	pCi/g	0.13	U			0.13	1.47		1.47		0.68	1.54	*	Less than criteria	30.6		30.6		0.1	1.28		1.28		0.14	31.9		Exceeds criteria	1.06		1.06		0.05	0.14		0.14		0.1	1.08		1.08		0.05	2.28		Less than criteria
RC-03	RC-03	0	0.25	pCi/g	0.14	U			0.14	1.67		1.67		0.68	1.74	*	Less than criteria	6.3		6.3		0.2	0.97		0.97		0.23	7.3		Less than criteria	0.8		0.8		0.11	0.12	U			0.12	0.89		0.89		0.08	1.75	*	Less than criteria
RC-04	RC-04	0	0.25	pCi/g	0.13	U			0.13	1.92		1.92		0.69	1.99	*	Less than criteria	2.6		2.6		0.18	1.25		1.25		0.07	3.9		Less than criteria	0.93		0.93		0.14	0.064		0.064		0.058	0.94		0.94		0.05	1.93		Less than criteria
RC-05	RC-05	0	0.25	pCi/g	0.1	U			0.1	1.59		1.59		0.66	1.64	*	Less than criteria	2.48		2.48		0.08	1.21		1.21		0.09	3.69		Less than criteria	0.91		0.91		0.16	0.14		0.14		0.14	0.69		0.69		0.09	1.74		Less than criteria
RC-06	RC-06	0	0.25	pCi/g	0.12	U			0.12	1.26		1.26		0.72	1.32	*	Less than criteria	4.6		4.6		0.1	1.18		1.18		0.04	5.8		Less than criteria	0.97		0.97		0.13	0.18	U			0.18	0.96		0.96		0.05	2.02	*	Less than criteria
RC-07	RC-07	0	0.25	pCi/g	0.12	U	0.378		0.12	0.96		0.96		0.68	1.02	*	Less than criteria	2.84		2.84		0.16	1.56		1.56		0.08	4.40		Less than criteria	0.63		0.63		0.13	0.05	U			0.05	0.897		0.897		0.32	1.55	*	Less than criteria

Notes: No Log = no log from RI investigation exists. * Indicates that result for one of the two isotopes was non-detect Final Q = final qualifier CSU[1] = combined standard uncertainty (+/- sigma for McLaren/Hart samples) CV = critical value

🟨 indicates that combined value is 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 McLaren/Hart RI Soil Boring Data:

- In calculated 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".
- In calculated 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".

Table 2-9: Summary Comparison of Soil Sample Results to RCRA Toxicity Characteristic Regulatory Levels

EPA HW No.	Contaminant	Regulatory Level (mg/L)	x DAF of 20	Maximum Concentration in Soil (mg/kg)[1]	Location and Depth (ft)
D004	Arsenic	5.0	100	**610**	AC-16 @ 19-20
D005	Barium	100.0	2,000	**11,000**	AC-23 @ 23-24 & WL-234-CT @ 18-19
D006	Cadmium	1.0	20	**57**	1D-15 @ 77-80
D007	Chromium	5.0	100	**890**	WL-208 @ 20
D008	Lead	5.0	100	**30,000**	1C-6-CT @ 25-27
D009	Mercury	0.2	4	**12**	1D-15 @77-80
D010	Selenium	1.0	20	**250**	WL-114 @ 0 & AC-16 @ 19-20
D011	Silver	5.0	100	8.8 J-	1D-3 @ 28-29
D012	Endrin	0.02	0	0.18	WL-218 @ 25
D013	Lindane (gamma BHC)	0.4	8	ND	
D014	Methoxychlor	10.0	200	0.0057	WL-227 @ 40
D015	Toxaphene	0.5	10	ND	
D016	2,4-D	10.0	200	NA	
D017	2,4,5-TP (Silvex)	1.0	20	NA	
D018	Benzene	0.5	10	**120 J**	Wl-208 @ 20
D019	Carbon tetrachloride	0.5	10	ND	ND
D020	Chlordane	0.03	0.6	0.015	WL-104 @ 25
D021	Chlorobenzene	100.0	2,000	180	WL-230 @ 16
D022	Chloroform	6.0	120	**890**	Wl-208 @ 20
D023	o-Cresol (2-Methylphenol)	200.0	4,000	0.17 J	WL-213 @ 25
D024	m-Cresol (3-Methylphenol)	200.0	4,000	NA	NA
D025	p-Cresol (4-Methylphenol)	200.0	4,000	5.8 JY	WL-210 @ 15
D026	Cresol	200.0	4,000	NA	NA
D027	1,4-Dichlorobenzene	7.5	150	**530 Y ***	WL-230 @ 16
D028	1,2-Dichloroethane	0.5	10	ND	ND
D029	1,1-Dichloroethylene	0.7	14	ND	ND
D030	2,4-Dinitrotoluene	0.13	3	ND	
D031	Heptachlor (and its epoxide)	0.008	0	ND	
D032	Hexachlorobenzene	0.13	3	ND	
D033	Hexachlorobutadiene	0.5	10	ND	
D034	Hexachloroethane	3.0	60	ND	
D035	Methyl ethyl ketone (2-butanone)	200.0	4,000	52	WL-208 @ 15
D036	Nitrobenzene	2.0	40	ND	
D037	Pentachlorophenol	100.0	2,000	0.085 J	WL-208 @ 28
D038	Pyridine	5.0	100	NA	
D039	Tetrachloroethylene	0.7	14	ND	
D040	Trichloroethylene	0.5	10	6.0 JY	WL-210 @ 15
D041	2,4,5-Trichlorophenol	400.0	8,000	ND	
D042	2,4,6-Trochlorophenol	2.0	40	ND	
D043	Vinyl chloride	0.2	4	ND	

Notes: [1] Bolded maximum concentrations indicate that the measured contaminant concentration is greater than the Regulatory Level times a Dilution-Attenuation Factor (DAF) of 20.

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 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

	Test Duration	Test Duration	Test Duration		
	5/1/15 7/23/15	7/23/15 10/14/15	10/14/15 1/7/16	Average	Average
Station No.	Result (pCi/L)	Result (pCi/L)	Result (pCi/L)	(1/2 RL for NDs)	(RLs for NDs)
1	<0.4	<0.4	0.5	0.30	0.43
2	<0.4	0.7	0.6	0.50	0.57
3	<0.4	<0.4	<0.4	0.20	0.40
4	<0.4	0.4	<0.4	0.27	0.40
5	<0.4	<0.4	<0.4	0.20	0.40
6	<0.4	0.5	0.4	0.37	0.43
7	<0.4	0.7	0.5	0.47	0.53
8	<0.4	0.5	<0.4	0.30	0.43
9	<0.4	<0.4	<0.4	0.20	0.40
10	<0.4	0.5	0.4	0.33	0.43
10 DUP			<0.4		
11	<0.4	<0.4	<0.4	0.23	0.40
11 DUP		0.4			
12	<0.4	<0.4	0.5	0.30	0.43
12 DUP	<0.4				
13	<0.4	<0.4	<0.4	0.20	0.40

Notes:

According to EPA (2012b), about 0.4 pCi/L of Radon is normally found in outside air.

EPA Off-site air montioring results reported radon levels at its reference station (No. 5) of 0.11 to 1.45 with a median of 0.30 pCi/L.

Table 2-11: Summary of Gross Alpha Results in Particulate Air Samples

On-Site Perimeter Monitoring Stations

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)	Station 6 (pCi/m^3)	Station 7 (pCi/m^3)
Detections	9/9	5/9	9/9	9/9	9/9	9/9	9/9
Minimum Concentration	1.45E-03	1.54E-03 J+	1.52E-03	1.28E-03	1.40E-03	5.27E-04 J+	1.37E-03
Median Concentration	3.49E-03	3.15E-03	3.59E-03	3.85E-03	4.31E-03	4.27E-03	4.01E-03
Maximum Concentration	5.31E-03 J+	4.57E-03 J+	5.64E-03 J+	6.09E-03 J+	5.38E-03 J+	5.05E-03 J+	5.70E-03 J+

Summary Statistic	Station 8 (pCi/m^3)	Station 9 (pCi/m^3)	Station 10 (pCi/m^3)	Station 11 (pCi/m^3)	Station 12 (pCi/m^3)	Station 13 (pCi/m^3)
Detections	9/9	8/9	9/9	9/9	9/9	9/9
Minimum Concentration	1.50E-03	2.43E-03 J+	1.09E-03	1.95E-03	1.58E-03	1.40E-03
Median Concentration	4.57E-03	3.72E-03	3.15E-03	4.07E-03	4.26E-03	3.68E-03
Maximum Concentration	5.75E-03 J+	4.57E-03 J+	4.46E-03 J+	6.16E-03 J+	5.72E-03 J+	5.61E-03 J+

EPA Off-Site (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

Table 2-12: Summary of Gross Beta Results in Particulate Air Samples

On-Site Perimeter Monitoring Stations

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)	Station 6 (pCi/m^3)	Station 7 (pCi/m^3)
Detections	9/9	5/9	9/9	9/9	9/9	9/9	9/9
Minimum Concentration	1.84E-02	1.94E-02	2.05E-02	1.76E-02	1.73E-02	4.06E-03 J+	1.56E-02
Median Concentration	3.39E-02	3.25E-02	3.25E-02	3.49E-02	3.57E-02	3.71E-02	3.18E-02
Maximum Concentration	4.45E-02 J+	3.93E-02 J+	4.60E-02 J+	4.77E-02 J+	4.31E-02 J+	4.43E-02 J+	4.34E-02 J+

Summary Statistic	Station 8 (pCi/m^3)	Station 9 (pCi/m^3)	Station 10 (pCi/m^3)	Station 11 (pCi/m^3)	Station 12 (pCi/m^3)	Station 13 (pCi/m^3)
Detections	9/9	8/9	9/9	9/9	9/9	9/9
Minimum Concentration	1.89E-02	2.21E-02 J+	1.53E-02	2.03E-02 J+	2.15E-02	1.86E-02
Median Concentration	3.55E-02	3.19E-02	2.60E-02	3.36E-02	3.79E-02	3.37E-02
Maximum Concentration	4.36E-02 J+	4.01E-02 J+	3.80E-02 J+	4.76E-02 J+	4.46E-02 J+	4.43E-02 J+

EPA Off-Site (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	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

Table 2-13: Thorium-230 Statistics for Particulate Air Samples (May, June, September and December, 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)	Station 6 (pCi/m^3)	Station 7 (pCi/m^3)
Detections	4/4	4/4	4/4	4/4	4/4	4/4	4/4
Minimum Concentration	1.75E-05 J	8.08E-06	1.90E-05	3.14E-05	2.85E-05 J+	1.05E-05 J	2.93E-05
Median Concentration	2.91E-05	2.76E-05	4.37E-05	4.34E-05	3.16E-05	4.55E-05	4.74E-05
Maximum Concentration	6.58E-05 J+	5.18E-05 J+	7.03E-05 J+	4.94E-05 J+	7.02E-05 J+	8.06E-05 J+	7.22E-05 J+

Summary Statistic	Station 8 (pCi/m^3)	Station 9 (pCi/m^3)	Station 10 (pCi/m^3)	Station 11 (pCi/m^3)	Station 12 (pCi/m^3)	Station 13 (pCi/m^3)
Detections	4/4	4/4	4/4	4/4	4/4	4/4
Minimum Concentration	1.93E-05	2.34E-05 J+	2.66E-05	2.23E-05	3.51E-05 J	1.78E-05
Median Concentration	4.48E-05	3.05E-05	5.20E-05	5.64E-05	6.50E-05	3.12E-05
Maximum Concentration	5.87E-05 J+	4.84E-05 J+	7.20E-05 J+	8.19E-05 J+	8.64E-05 J+	4.39E-05 J

Table 2-14: Uranium-238 Statistics for Particulate Air Samples (May, June, September and December, 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)	Station 6 (pCi/m^3)	Station 7 (pCi/m^3)
Detections	4/4	4/4	4/4	4/4	4/4	4/4	4/4
Minimum Concentration	2.45E-05 J+	1.84E-05 J+	2.99E-05 J+	2.43E-05 J+	1.38E-05 J	2.09E-05	2.12E-05 J+
Median Concentration	2.86E-05	3.05E-05	3.23E-05	3.10E-05	3.07E-05	2.41E-05	2.93E-05
Maximum Concentration	3.36E-05	3.43E-05	5.08E-05 J	3.65E-05 J	4.28E-05 J	3.19E-05	4.32E-05 J

Summary Statistic	Station 8 (pCi/m^3)	Station 9 (pCi/m^3)	Station 10 (pCi/m^3)	Station 11 (pCi/m^3)	Station 12 (pCi/m^3)	Station 13 (pCi/m^3)
Detections	4/4	4/4	4/4	4/4	4/4	4/4
Minimum Concentration	2.30E-05 J+	2.36E-05 J+	2.60E-05 J+	2.39E-05 J+	2.23E-05 J+	1.95E-05 J
Median Concentration	2.91E-05	3.32E-05	3.49E-05	2.91E-05	2.61E-05	2.69E-05
Maximum Concentration	4.61E-05 J	3.57E-05 J+	4.34E-05 J+	3.96E-05	4.13E-05	3.49E-05

Table 2-15: Total Radium Statistics for Particulate Air Samples (May, June, September and December, 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)	Station 6 (pCi/m^3)	Station 7 (pCi/m^3)
Detections	2/4	3/4	3/4	3/4	3/4	2/4	3/4
Minimum Concentration	6.58E-05 J	1.64E-04	7.11E-05	1.44E-04	4.93E-05	-1.94E-04	2.19E-04
Median Concentration	1.56E-04	1.71E-04	1.73E-04	2.22E-04	1.06E-04	2.20E-04	2.83E-04
Maximum Concentration	3.22E-04	3.27E-04	3.23E-04	3.18E-04	1.34E-04	3.50E-04	3.94E-04

Summary Statistic	Station 8 (pCi/m^3)	Station 9 (pCi/m^3)	Station 10 (pCi/m^3)	Station 11 (pCi/m^3)	Station 12 (pCi/m^3)	Station 13 (pCi/m^3)
Detections	4/4	0/4	2/4	4/4	1/4	3/4
Minimum Concentration	5.86E-05	2.75E-05	-1.43E-05	1.95E-04	2.61E-05	1.15E-04
Median Concentration	1.62E-04	4.44E-05	1.20E-04	2.43E-04	1.33E-04	1.82E-04
Maximum Concentration	2.71E-04	8.41E-05	2.26E-04	3.73E-04	2.38E-04	3.50E-04

Table 2-16: Summary of EPA Off-Site Isotopic and Radium Results

SUMMARY STATISTICS OF URANIUM-238 RESULTS	Station 1 (pCi/m^3)	Station 2 (pCi/m^3)	Station 3 (pCi/m^3)	Station 4 (pCi/m^3)	Station 5 (reference) (pCi/m^3)
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

SUMMARY STATISTICS OF THORIUM-230 RESULTS	Station 1 (pCi/m^3)	Station 2 (pCi/m^3)	Station 3 (pCi/m^3)	Station 4 (pCi/m^3)	Station 5 (reference) (pCi/m^3)
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

SUMMARY STATISTICS OF TOTAL ALPHA-EMITTING RADIUM RESULTS	Station 1 (pCi/m^3)	Station 2 (pCi/m^3)	Station 3 (pCi/m^3)	Station 4 (pCi/m^3)	Station 5 (reference) (pCi/m^3)
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	3.05E-04	4.58E-04	4.68E-04
Maximum Concentration	1.10E-03 J	1.80E-03 JG	2.01E-03	3.66E-03 J	4.40E-03

Source: TetraTech, 2015

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	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.	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	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	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	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.)	Neither applicable nor relevant and appropriate to Areas 1 & 2 Potentially relevant and appropriate for radiologically impacted soil on Buffer Zone/ Crossroad 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. They are potentially relevant and appropriate for impacted soil on the Buffer Zone/ Crossroad Property.
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 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	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 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).	Neither 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. As alpha and gamma radiation is a potential exposure route for OU-1, these regaulations are considered to be potentially relevant and appropriate.
National Emissions Standards for Hazardous Air Pollutants (40 CFR 61), Subpart T, National Emissions Standards for Radon Emissions from disposal of Uranium Mill Tailings	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-s.	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.

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.

Contaminant	MCLG (mg/L)	MCL (mg/L)
Trace metals		
Antimony	0.006	0.006
Asbestos	7 x 10^6 fibers/liter	7 mfl
Barium	2	2
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	3E-08		
			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	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	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.

Table 3-1: Preliminary Identification of Potential Chemical-Specific ARARs and TBC Criteria

Citation	Chemical	Medium	Requirement			Preliminary Determination	Remarks
NRC Standards for Protection	Specific	Air	The concentrations above natural background of radionuclides			Potentially	Because the site is not licensed by NRC, these requirements
Against Ionizing Radiation	radionuclides		in air ouside a controlled area, averaged over any calendar			relevant and	are not applicable.
(10 CFR 20 Appendix B)	(see table)		quarter, should not exceed the following limits:			appropriate	These requirements would be potentially relevant and
Annual Liimits on Intake (ALIs)				Effluent Concentration Limit (uCi/mL)			appropriate to protection of the public during implementation
Derived Air Concentrations (DACs)			Isotope	Air	Water		of any remedial action. Specifically, these
Effluent Concentrations			Actinium-227	1 x 10-15	5 x 10-9		regulations potentially may require perimeter
			Lead-210	6 x 10-13	1 x 10-8		monitoring to be undertaken during any activities
			Protactinium-231	8 x 10-15	6 x 10-9		that may expose or disturb the radiologically-
			Radium-226	9 x 10-13	6 x 10-8		impacted materials at the Site.
			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.				
Missouri Water Quality	Inorganics	Ground-	Water contaminants shall not cause or contribute to an				These standards are only applicable to public drinking
Standards 10 CSR 20-7.031(5)	Trace metals	water	exceedance of the following (Table A) standards:				water systems; however, these standards may potentially
	Organics						be relevent and appropriate standards for groundwater.
	Pesticides		Inorganics (mg/L)				
	Man-made		Fluoride		4		
	Volatiles		Nitrate		10		
	PAHs						
	Phthalates		Trace metals (ug/L)				
	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			Atrazine 3		
Standards 10 CSR 20-7.031(5)			Carbofuran 40		
(cont.)			Dalapon 200		
			Dibromochloropropane 0.2		
			Dinoseb 7		
			Diquat 20		
			Endothall 100		
			Ethylene dibromide 0.05		
			Oxamyl (vydate) 200		
			Picloram 500		
			Simazine 4		
			Glyphosate 700		
			<u>Bioaccumulatie Anthropogenic Toxics (ug/L)</u>		
			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) 1.3E-08		
			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.)			<u>Polynuclear Aromatic Hydrocarbons (ug/L)</u>			
			Anthracene	9,600		
			Fluoranthene	300		
			Fluorene	1,300		
			Pyrene	960		
			Benzo(a)pyrene	0.2		
			Other polynuclear aromatic hydrocarbons	0.0044		
			Acenaphthene	1,200		
			<u>Phthalate Esters (ug/L)</u>			
			Bis(2-ethylhexyl) phthalate	6		
			Butylbenzyl phthalate	3,000		
			Diethyl phthalate	23,000		
			Dimethyl phthalate	313,000		
			Di-n-butyl phthalate	2,700		
			<u>Health Advisory Levels (ug/L)</u>			
			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	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		Potentially relevant and appropriate	
			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	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).		Not an ARAR but potentially a TBC for the Buffer Zone/ Crossroad 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 Buffer Zone/Crossroad Property, this guidance would be a TBC for alternatives that include excavation of soil from these properties.
			Radium 226 +228	5 pCi/g plus background		
			Thorium 230 +232	5 pCi/g plus background		

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 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	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.
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 3-3: 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.

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 3, Sanitary Landfills, 3.010(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 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.	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).
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	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.
National Ambient Air Quality Standards	Radionuclides	Air	Air quality standards	Potentially applicable	Potential standards for air emissions during remedy

Table 3-3: Preliminary Identification of Potential Action-Specific ARARs and TBC Criteria

Citation	Action	Medium	Requirement	Preliminary Determination	Remarks
40 CFR 50	Radon and Particulates				implementation.
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		Storm-water	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.

Table 6-1: Summary of Estimated Costs

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Estimated Cost	No Action Alternative		ROD-Selected Remedy		"Complete Rad Removal" 7.9 pCi/g Excavation Alternative		Partial Excavation Alternatives 52.9 pCi/g		Partial Excavation Alternatives 1,000 pCi/g	
	i = 7%	*i = 1.5%*	*i = 7%*	*i = 1.5%*	*i = 7%*	*i = 1.5%*	*i = 7%*	*i = 1.5%*	*i = 7%*	*i = 1.5%*
Capital ($M)	0		67		616		313		361	
Operation, Maintenance, and Monitoring ($1,000/yr)	35 every 5 years		167 - 326		167 - 326		167 - 326		167 - 326	
30 year:										
Present Worth ($M)	0.1	0.2	64	70	420	566	265	305	275	342
Non-discounted Total ($M)	0.2	0.2	73	73	619	619	318	318	365	365
200 year:										
Present Worth ($M)	0.1	0.4	64	77	421	573	265	312	276	349
Non-discounted Total ($M)	1	1	102	102	649	649	348	348	395	395
1,000 year:										
Present Worth ($M)	0.1	0.5	64	78	421	573	265	312	276	350
Non-discounted Total ($M)	7	7	241	241	788	788	487	487	534	534

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 to Projected OU-1 RIM Concentrations

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"Complete Rad Removal" Alternative (removal of RIM to 7.9 pCi/g total Thorium or Radium)

	WAC Criteria		OU-1 RIM Concentrations per Conveyance or Container					
USEI Category Radionuclide	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[a]	Area 2[a]
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media								
Natural uranium in equilibrium with progeny[b]	<500 ppm Unat or 167 pCi ^{238}U/g	≤ 3,000 pCi/g	4.0	51.1	5.6	72.5	16 (3 dtrs)	204 (3 dtrs)
^{230}Th	0.1 ppm or ≤ 2,000 pCi/g	NC [c]	52	300	0.003	0.015	52 (0 dtrs)	300 (0 dtrs)
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤ 2,000 pCi/g	3.9	8.6	17.9	39.0	39 (9 dtrs)	86 (9 dtrs)
Mixture of Thorium and Uranium	Sum of ratios ≤ 1	≤ 2,000 pCi/g	0.04	0.27	NA [d]	NA [d]	0.1	0.3[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	33.4	129	0.00003	0.00013	200 (5 dtrs)	773 (5 dtrs)
^{210}Pb with ^{210}Bi and ^{210}Po	1,500 pCi/g	≤ 1,500 pCi/g	6.2	27.1	0.0000001	0.0000004	19 (2 dtrs)	81 (2 dtrs)

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a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotope.

b 238U used as surrogate for U nat. Assumes natural isotopic abundance of 238U, 235U and 234U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable, see activity concentration.

e Insitu activity in Area 2 may exceed WAC at times. Must control excavation and handling while monitoring outbound loads.

Table 6-3: Comparison of USEI Waste Acceptance Criteria to Projected OU-1 RIM Concentrations

DRAFT

Partial Excavation of Shallow RIM with Activities above 52.9 pCi/g total Thorium or Radium

	WAC Criteria		OU-1 RIM Concentrations per Conveyance or Container					
			Activity Concentration (pCi/g)		Mass Concentration (ppm)		Series Activity, Assuming Equilibrium with Parent (pCi/g)	
USEI Category Radionuclide	Maximum Concentration of Insitu Material	Sum of Concentrations of Parents and all Progeny	Area 1	Area 2	Area 1	Area 2	Area 1[a]	Area 2[a]
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media								
Natural uranium in equilibrium with progeny[b]	<500 ppm Unat or 167 pCi ^{238}U/g	≤ 3,000 pCi/g	19	91	27	130	76 (3 dtrs)	363 (3 dtrs)
^{230}Th	0.1 ppm or ≤ 2,000 pCi/g	NC[c]	250	529	0.01	0.03	250 (0 dtrs)	529 (0 dtrs)
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤ 2,000 pCi/g	18.5	15.2	84	69	185 (9 dtrs)	152 (9 dtrs)
Mixture of Thorium and Uranium	Sum of ratios ≤ 1	≤ 2,000 pCi/g	0.20	0.48	NA[d]	NA[d]	0.3	0.5[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	157	229	0.00016	0.00023	939 (5 dtrs)	1373 (5 dtrs)
^{210}Pb with ^{210}Bi and ^{210}Po	1,500 pCi/g	≤ 1,500 pCi/g	29	48	0.0000004	0.0000006	87 (2 dtrs)	144 (2 dtrs)

---

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotope.

b 238U used as surrogate for U nat. Assumes natural isotopic abundance of 238U, 235U and 234U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable, see activity concentration.

e Insitu activity in Area 2 may exceed WAC at times. Must control excavation and handling while monitoring outbound loads.

Table 6-4: Comparison of USEI Waste Acceptance Criteria to Projected OU-1 RIM Concentrations

DRAFT

Partial Excavation of RIM with Activities above 1,000 pCi/g total Thorium or Radium

	WAC Criteria		OU-1 RIM Concentrations per Conveyance or Container					
			Activity Concentration (pCi/g)		Mass Concentration (ppm)		Series Activity, Assuming Equilibrium with Parent (pCi/g)	
USEI Category Radionuclide	**Maximum Concentration of Insitu Material**	**Sum of Concentrations of Parents and all Progeny**	**Area 1**	**Area 2**	**Area 1**	**Area 2**	**Area 1**[a]	**Area 2**[a]
Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media								
Natural uranium in equilibrium with progeny[b]	<500 ppm Unat or 167 pCi ^{238}U/g	≤ 3,000 pCi/g	5.3	99.4	7.5	142.6	21 (3 dtrs)	397 (3 dtrs)
^{230}Th	0.1 ppm or ≤ 2,000 pCi/g	NC [c]	76	694	0.0038	0.034	76 (0 dtrs)	694 (0 dtrs)
Natural thorium (^{232}Th + ^{228}Th)	<500 ppm or 110 pCi/g	≤ 2,000 pCi/g	5.2	16.7	23.5	75.7	52 (9 dtrs)	167 (9 dtrs)
Mixture of Thorium and Uranium	Sum of ratios ≤ 1	≤ 2,000 pCi/g	0.06	0.58	NA [d]	NA [d]	0.1	0.6[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	42.8	241	0.00004	0.00024	257 (5 dtrs)	1447 (5 dtrs)
^{210}Pb with ^{210}Bi and ^{210}Po	1,500 pCi/g	≤ 1,500 pCi/g	8.16	53	0.0000001	0.0000007	24 (2 dtrs)	158 (2 dtrs)

---

a () in this column indicate the number decays the parent atom undergoes before becoming a stable isotope.

b 238U used as surrogate for U nat. Assumes natural isotopic abundance of 238U, 235U and 234U.

c NC = Not calculated. Daughter activity accounted for in Radium-226 line item.

d NA = Not applicable, see activity concentration.

e Insitu activity in Area 2 may exceed WAC at times. Must control excavation and handling while monitoring outbound loads.

Table 7-1: Summary of Comparative Analysis of Alternatives

Evaluation Criteria	**No Action**	**ROD-Selected Remedy**	**52.9 Partial Excavation**	**1,000 Partial Excavation**	**“Complete Rad Removal”**
THRESHOLD CRITERIA					
Overall Protection of Human Health and the Environment	Per the BRA, OU-1 does not currently pose unacceptable risks. Potential risks to a <u>future</u> groundskeeper may 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 eliminate or reduce potential exposures to (1) external gamma radiation, (2) radon emissions, (3) inhalation or ingestion of contaminated soil or wastes, (4) dermal contact with contaminated soil or waste, and (5) dispersal of contaminants in fugitive dust. All of the remedial alternatives would reduce potential infiltration of precipitation into the waste and thereby reduce the potential for leaching 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 installation and maintenance of 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 (Buffer Zone and Crossroad Property); (2) radon NESHAP; (3) Nuclear Regulatory Commission (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 standards 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.			

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
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 Missouri solid waste regulations closure and post-closure standards; the NRC radiation protection standards; the UMTRCA standards for longevity of disposal facilities; 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 Missouri solid waste regulation closure and post-closure standards; the NRC radiation protection standards; the UMTRCA standards for longevity of disposal facilities; 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; and offsite disposal facility waste acceptance criteria.		
PRIMARY BALANCING CRITERIA					
Long-Term Effectiveness and Permanence					
Magnitude of residual risks	Projected long-term risks to a site groundskeeper exceed EPA's acceptable risk range.	All of the alternatives would result in projected long-term risks that far are below EPA's target risk range of 10^{-4} to 10^{-6}.			
Adequacy and reliability of controls	Not applicable as no controls would be implemented.	Engineering measures would be augmented and supported by existing and additional institutional controls which also have been used at numerous solid waste and NCP sites.			

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
Long-Term Effectiveness and Permanence (cont.)					
Climate Change and Tornado Impacts	Not applicable as no engineered controls would be implemented.	• Increased temperatures or decreased precipitation could damage the vegetation cover or dry out the low-permeability layer included in the landfill cover included as part of all of the alternatives. • Increased heavy precipitation could erode the vegetation layer and potentially the underlying low-permeability layer; however, the presence of the underlying rock/rubble layer is expected to prevent exposure of the underlying waste materials, except for the "complete rad removal" alternative, which does not include the rock/rubble layer. • None of the alternatives are expected to be impacted by flooding that may occur in the area because Areas 1 and 2 are not located in the floodplain.			
Impacts from a Subsurface Heating Event	The only impact that may occur from subsurface heating is a temporary, localized increase in radon emissions; however, the total emissions from the Site during such an event is projected to remain below the UMTRCA standard and radon NESHAP.				
Thermal Isolation Barrier (IB) interaction	Not applicable as no engineered controls would be implemented.	• No adverse impacts or unacceptable risks are expected to result if an SSR or SSE were to extend into in Area 1; therefore, regardless of the location or type of IB that may be installed, or even if no barrier is installed, no unacceptable risks are expected to occur. • 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 IB.			
Environmental Justice	A screening level analysis did not identify any environmental justice concerns relative to the Site. However, EPA did identify a need to utilize more traditional communication methods (US Mail) to inform residents of the Terrisan Reste mobile home park.				
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, combined with the fact that radionuclides are naturally occurring elements that cannot be fully 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 (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
Short-Term Effectiveness					
Protection of the community during any remedial action					
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. Projected total carcinogenic risks are less than 1 x 10^{-7} and projected hazard indices for non-carcinogenic effects were less than 0.001 for all of the alternatives.			
Waste excavation volumes (yards)	Not applicable as no waste would be moved	126,000	501,000	825,000	1,572,000
Projected incidence of transportation-related accidents	Not applicable as no engineered controls would be implemented	0.61	10.6	16.6	34.9
Greenhouse gas emissions (tons)	Not applicable as no actions would be taken	19,000	43,000	53,000	83,000
Environmental Justice	A screening level analysis did not identify any environmental justice concerns relative to the Site; however, EPA did identify a need to utilize more traditional communication methods (US Mail) to inform residents of the Terrisan Reste mobile home park.				
Protection of workers					
Protection of workers during remedial actions	Not applicable as no actions would be taken	Remediation workers could be exposed to gamma radiation resulting in potential cancer risks above the upper bound of EPA's target risk range of 10^{-4} and also to non-carcinogenic risks with a hazard index greater than 1 during implementation of any of the remedial alternatives. None of the alternatives are expected to result in radiation doses (TEDEs) greater than the 5,000 mrem/yr limit established by OSHA and NRC.			
Carcinogenic Risks	Not applicable	9.23 x 10^{-5}	1.18 x 10^{-3}	2.38 x 10^{-3}	2.19 x 10^{-3}
TEDEs	Not applicable	187	720	867	405
Hazard indices	Not applicable	1.22	1.22	1.22	1.22
Industrial accident incidence	Not applicable	2.76	8.47	11.7	17.8
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 construction would be performed.	2.7	5.9	9	13.4

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
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.	Landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable. Stormwater controls and environmental monitoring are commonly used techniques that have been demonstrated to be reliable.	• Excavation and offsite disposal is a common and reliable technology. • Landfill cover systems have been used extensively and with proper inspection and maintenance have been demonstrated to be reliable. • 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 the actual disposal volume. • 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 rail cars could impact the schedule for this alternative. • 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. • Excavation of RIM would also present significant implementability concerns associated with the excavation and handling of contaminated materials; management of fugitive dust and potential		

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
Implementability (cont.)					
Reliability of the technologies (cont.)			• 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 all of the alternatives are ongoing inspection, monitoring, maintenance and, if needed, repair of the final landfill covers. Each of these future actions can be easily implemented. • All of the alternatives include a provision for a contingent landfill gas control system in the event 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			
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.			
Administrative Feasibility	Not applicable as no engineered controls or additional institutional controls would be implemented.	All of the alternatives could require: • coordination and permitting with MSD for disposal of leachate during construction; • access to Crossroad Property for investigation/removal of soil; • coordination with Earth City Flood Control District for design and operation of long-term stormwater management systems; and • preparation and approval of a traffic control plan for St. Charles Rock Road.			
Administrative Feasibility (cont.)			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.		
Availability of Specialized Services and Materials	Not applicable as no engineered controls would be implemented.	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 the selected alternative is implemented.			

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
Implementability (cont.)					
Availability of Materials, Equipment, and Personnel	Not applicable as no engineered controls would be implemented.	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	• 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. 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 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. • 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.		
Availability of Technologies	Not applicable as no engineered controls would be implemented.	Technologies for this alternative are generally available and sufficiently demonstrated. No prospective technologies are anticipated as part of this alternative.	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 this alternative; 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 necessary to make such determinations.		

Table 7-1: Summary of Comparative Analysis of Alternatives (cont.)

Evaluation Criteria	No Action	ROD-Selected Remedy	52.9 Partial Excavation	1,000 Partial Excavation	"Complete Rad Removal"
Cost					
Capital cost	$0	$67,000,000	$313,000,000	$361,000,000	$616,000,000
O&M costs	$35,000 every 5 years	$167,000 – 326,000	$167,000 – 326,000	$167,000 – 326,000	$167,000 – 326,000
Present Worth Costs					
30 years					
(i=7%)	$100,000	$64,000,000	$265,000,000	$275,000,000	$420,000,000
(i=1.5%)	$200,000	$70,000,000	$305,000,000	$342,000,000	$566,000,000
Total (non-discounted)	$200,000	$73,000,000	$318,000,000	$365,000,000	$619,000,000
200 years					
(i=7%)	$100,000	$64,000,000	$265,000,000	$276,000,000	$421,000,000
(i=1.5%)	$400,000	$77,000,000	$312,000,000	$349,000,000	$573,000,000
Total (non-discounted)	$1,000,000	$102,000,000	$348,000,000	$395,000,000	$649,000,000
1,000 years					
(i=7%)	$100,000	$64,000,000	$265,000,000	$276,000,000	$421,000,000
(i=1.5%)	$500,000	$78,000,000	$312,000,000	$350,000,000	$573,000,000
Total (non-discounted)	$7,000,000	$241,000,000	$487,000,000	$534,000,000	$788,000,000

FIGURES

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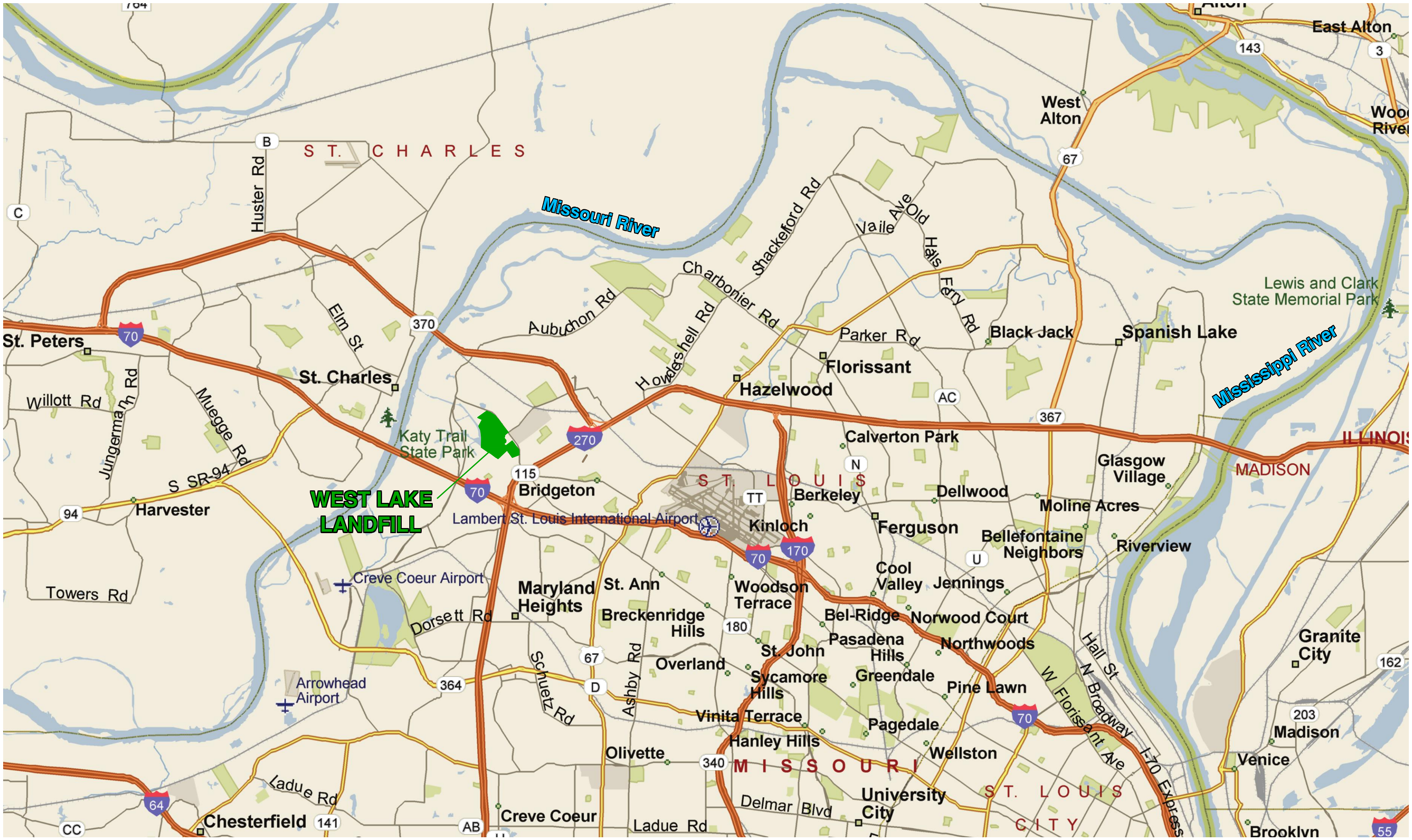

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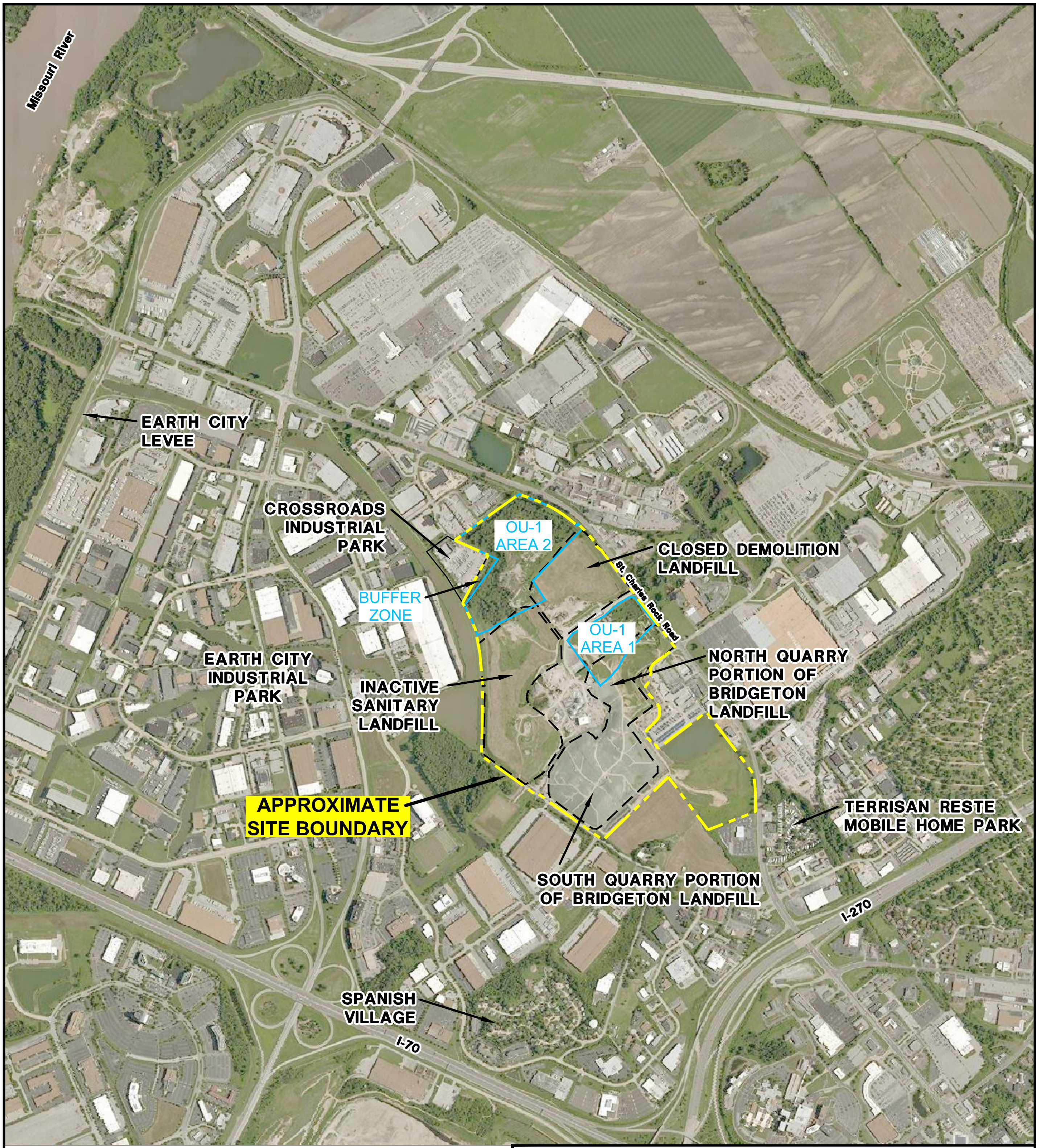
Figure 2-1

Site Vicinity Map

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



Source: USGS Aerial Photography

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Figure 2-2

Site Location Map

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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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.

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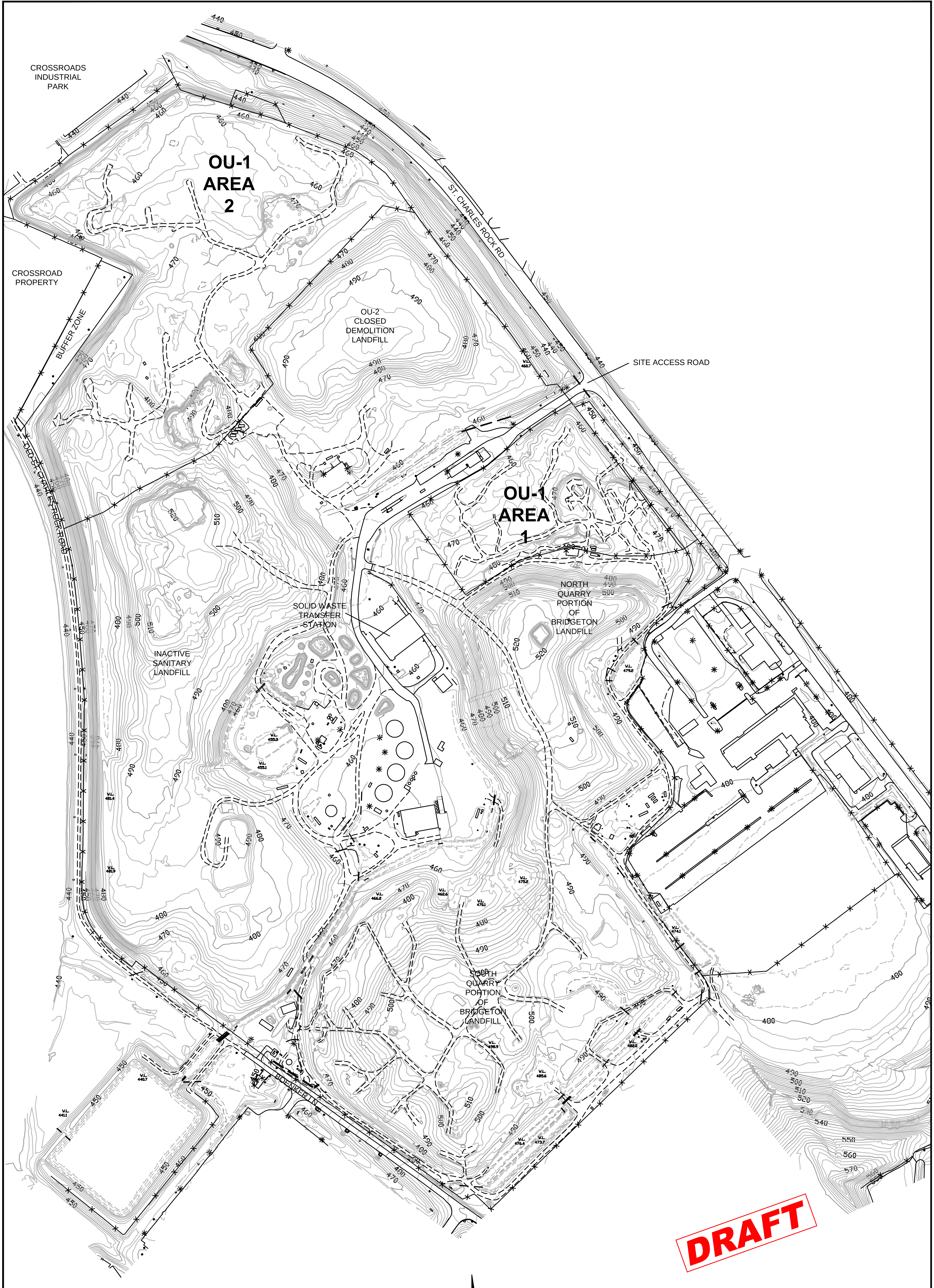

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LEGEND

440 CONTOUR ELEVATION (FEET ABOVE MEAN SEA LEVEL)

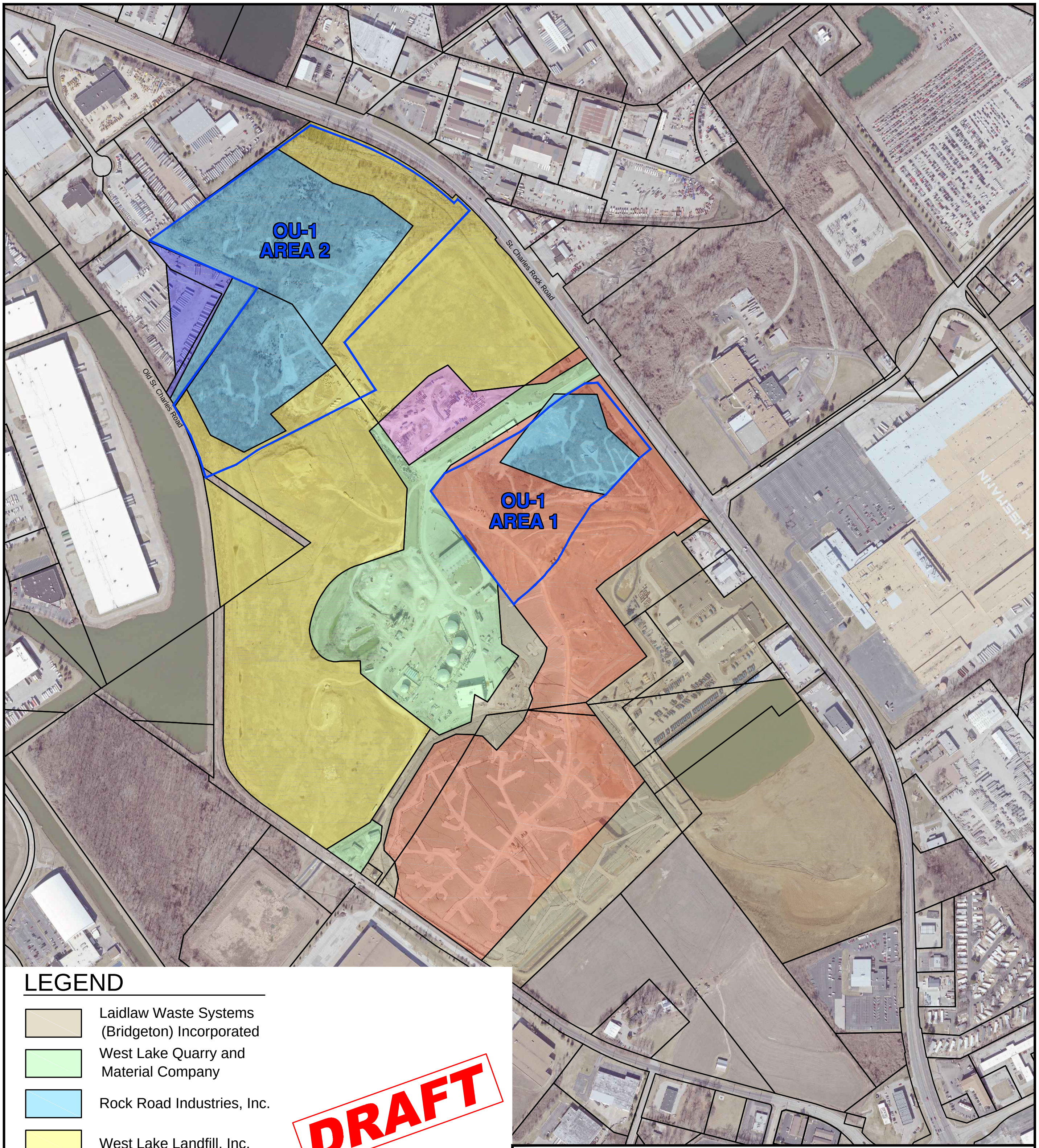
NOTES:
- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED FEBRUARY 27, 2016
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

400 0 400
SCALE IN FEET

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

Notes:
2. Parcels from Saint Louis County Missouri, GIS Department
1. Aerial provided by Cooper Aerial Surveys Company (February, 2016)

N

0 600
SCALE IN FEET

Figure 2-5

Landfill Property Ownership

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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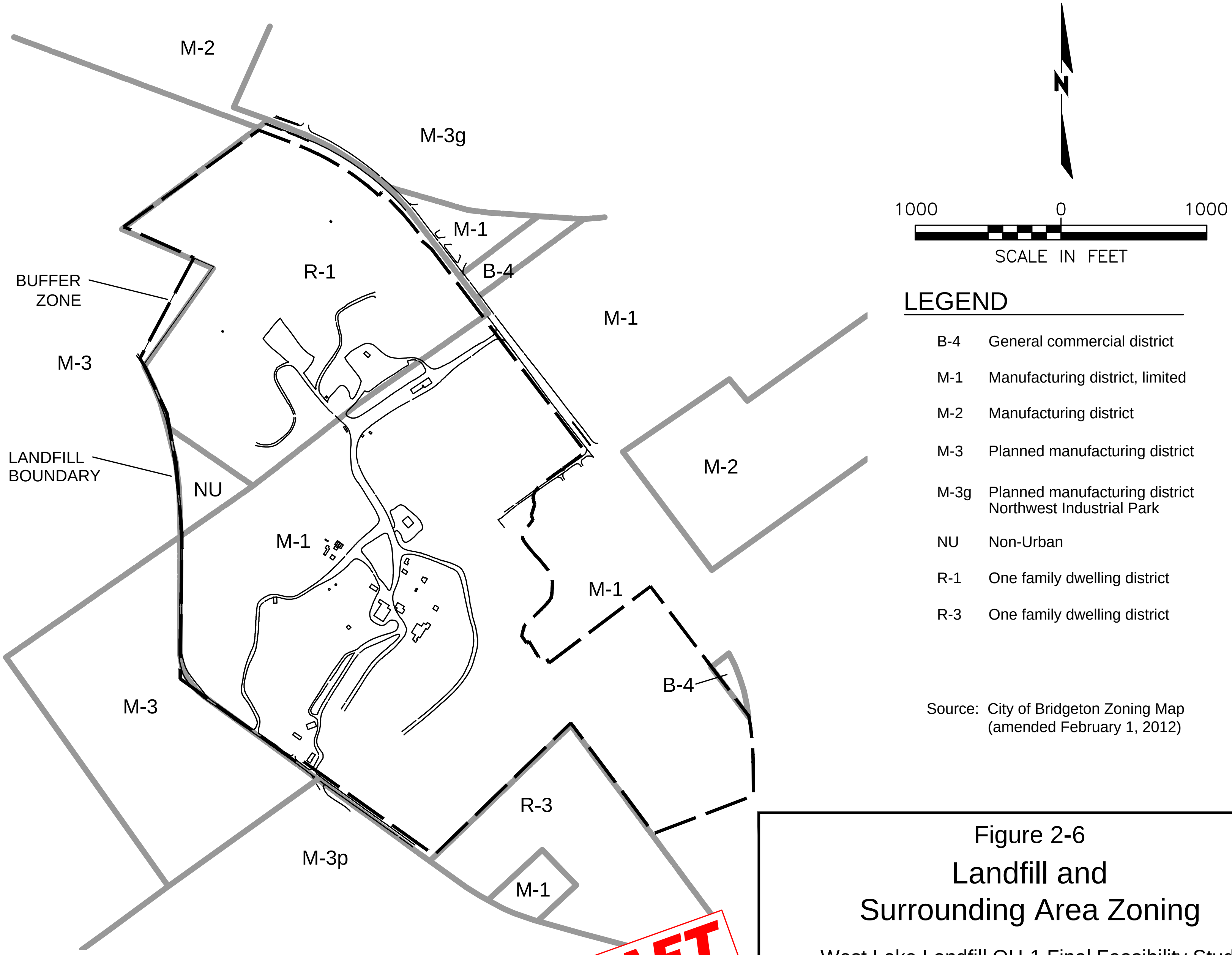

LEGEND

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
NU	Non-Urban
R-1	One family dwelling district
R-3	One family dwelling district

Source: City of Bridgeton Zoning Map
(amended February 1, 2012)

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.

Figure 2-6

Landfill and Surrounding Area Zoning

West Lake Landfill OU-1 Final Feasibility Study

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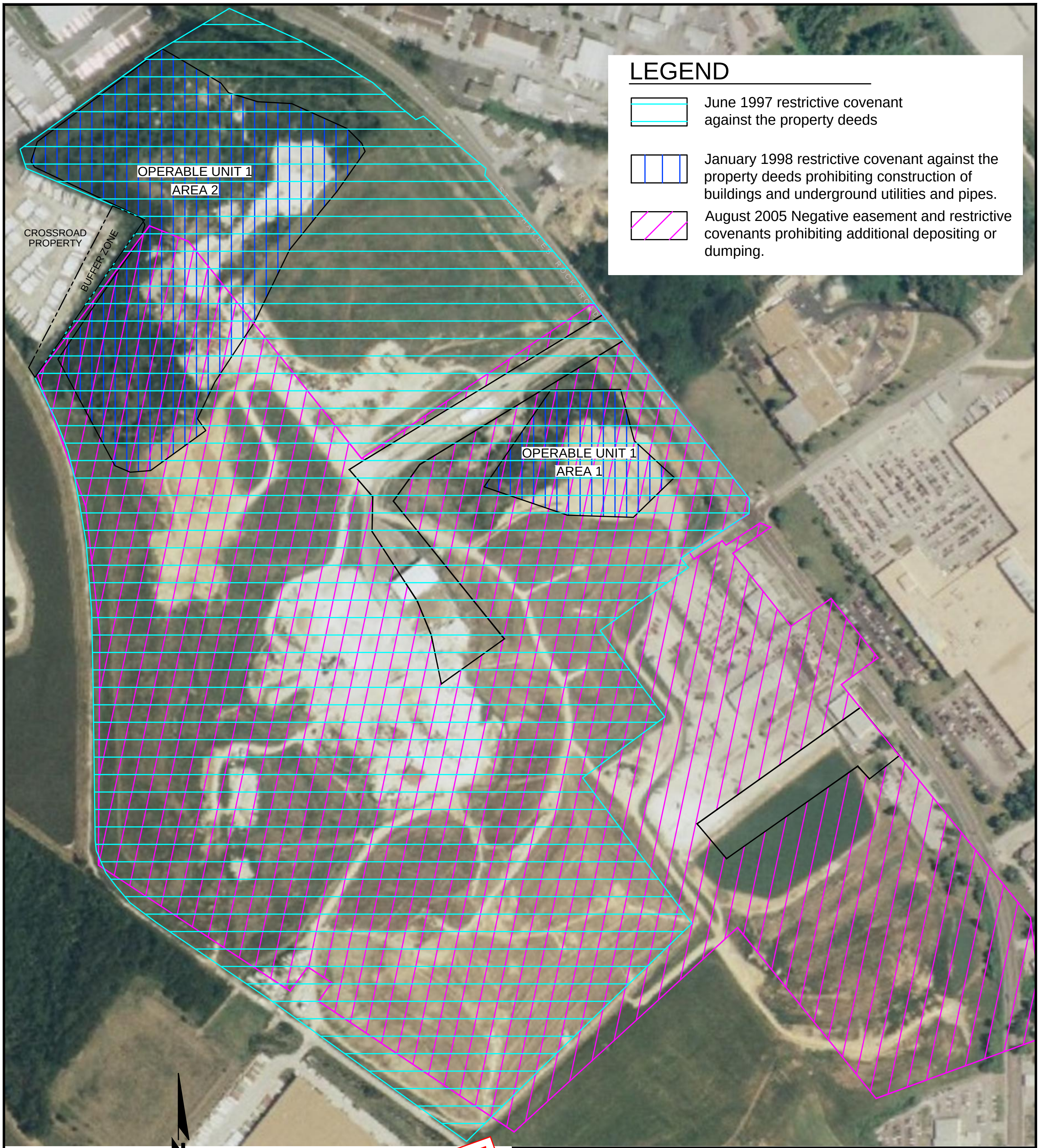

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Figure 2-7

Land Use Restrictions

West Lake Landfill OU-1 Final Feasibility Study

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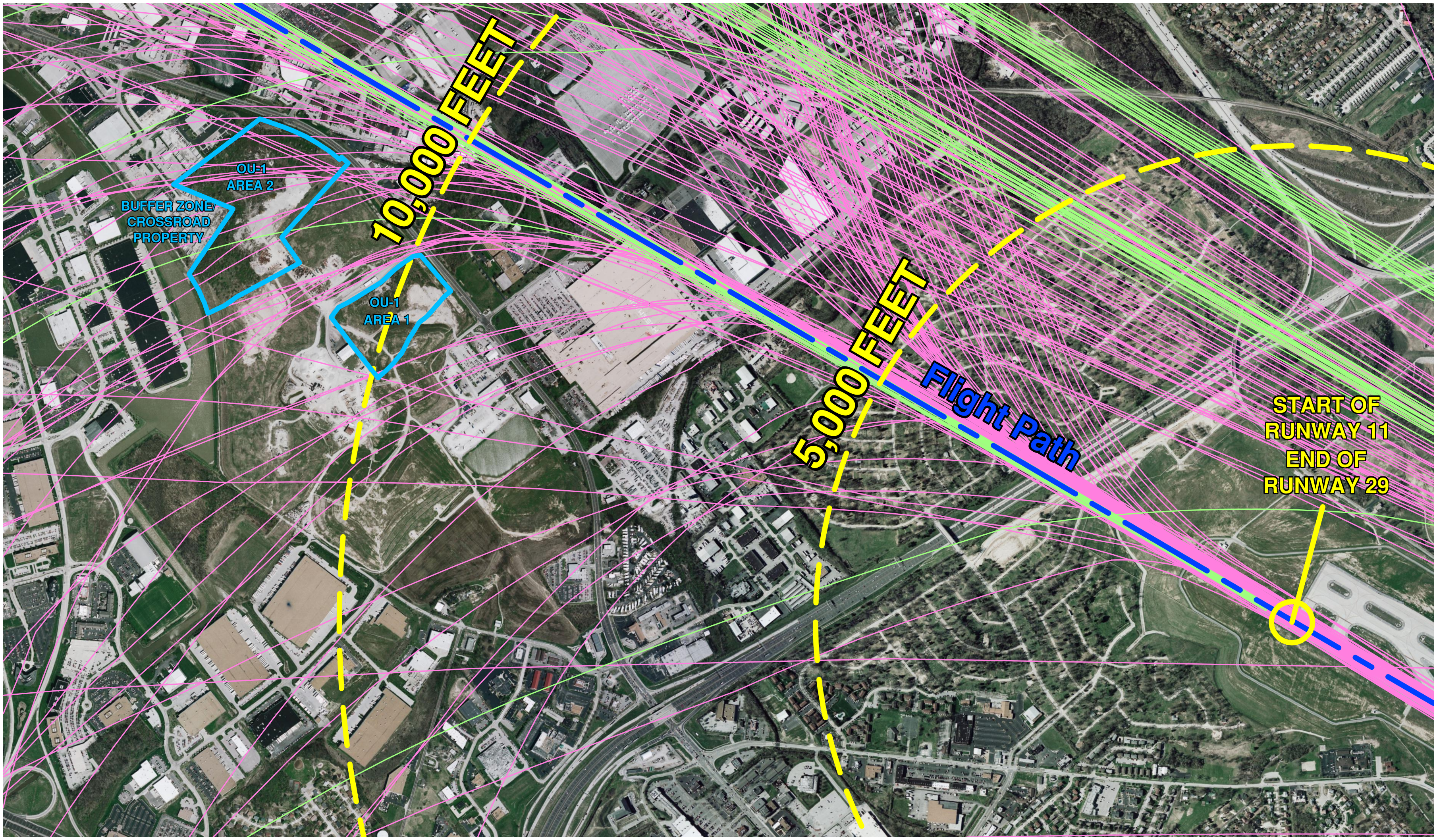
M:\clients\EMSI\westlake\2016\Final-FS\Section-2\FIG2-8-Airport-Setbacks.dwg plotted: 07/19/2016



Source: Google Earth

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)

DRAFT

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)
$^{42}76^{000m}$E	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

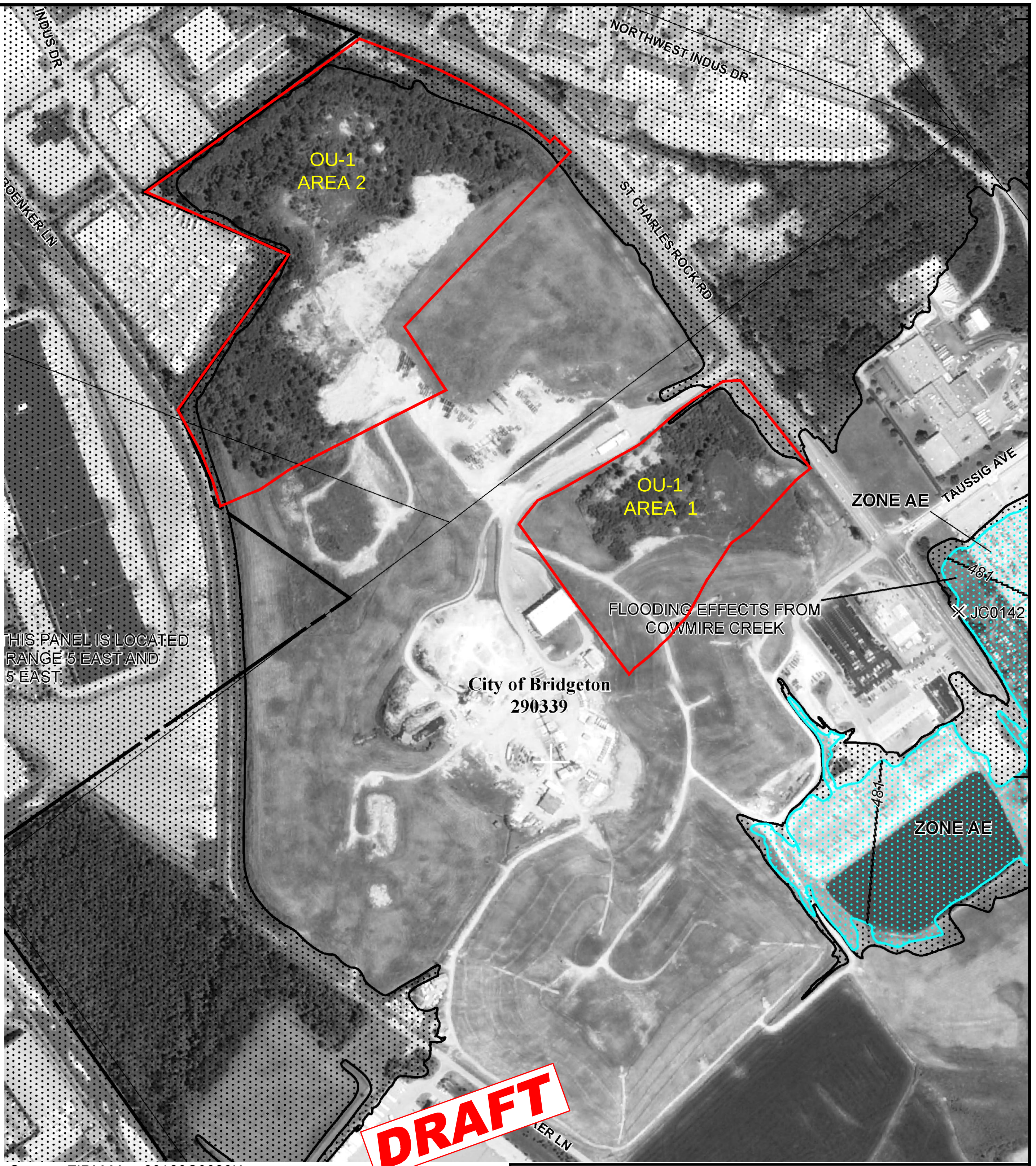
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

U.S. DEPARTMENT OF HOMELAND SECURITY

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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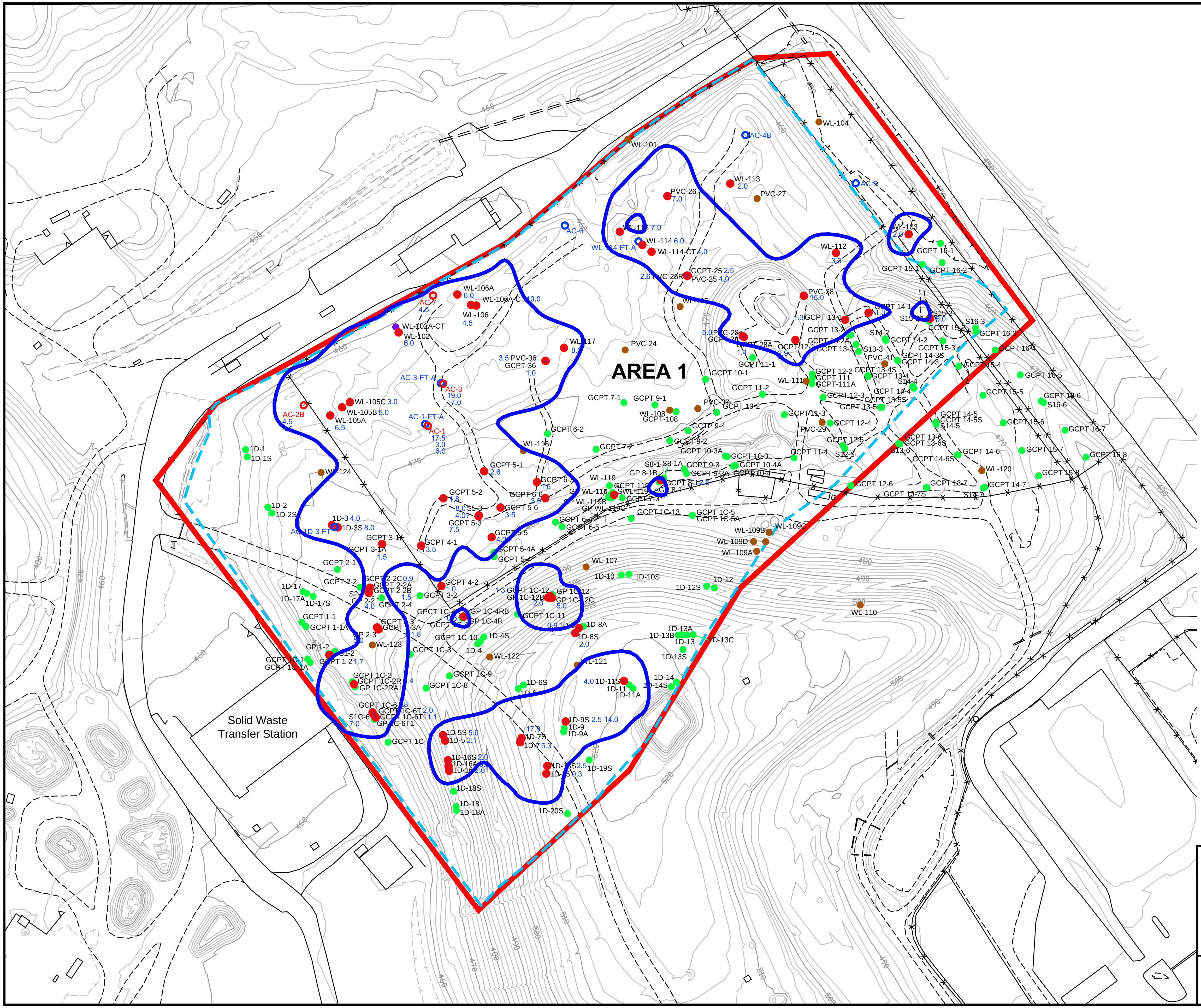
Figure 2-9

FEMA FIRM Map
City of Bridgeton Area

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-2\FIG-2-9-Flood-Plain.dwg



LEGEND

🟥	OU-1 AREA 1 BOUNDARY
- -	APPROXIMATE EDGE OF REFUSE
●	RI SOIL BORING
●	PHASE 1 SOIL BORING
●	COTTER SOIL BORING
○	ADDITIONAL SOIL BORING
●	PRESENCE OF RIM
5.0	THICKNESS OF RIM (IN FEET)
—	GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

DRAFT

N

150 0 150

SCALE IN FEET

NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED FEBRUARY 27, 2016
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

Figure 2-10

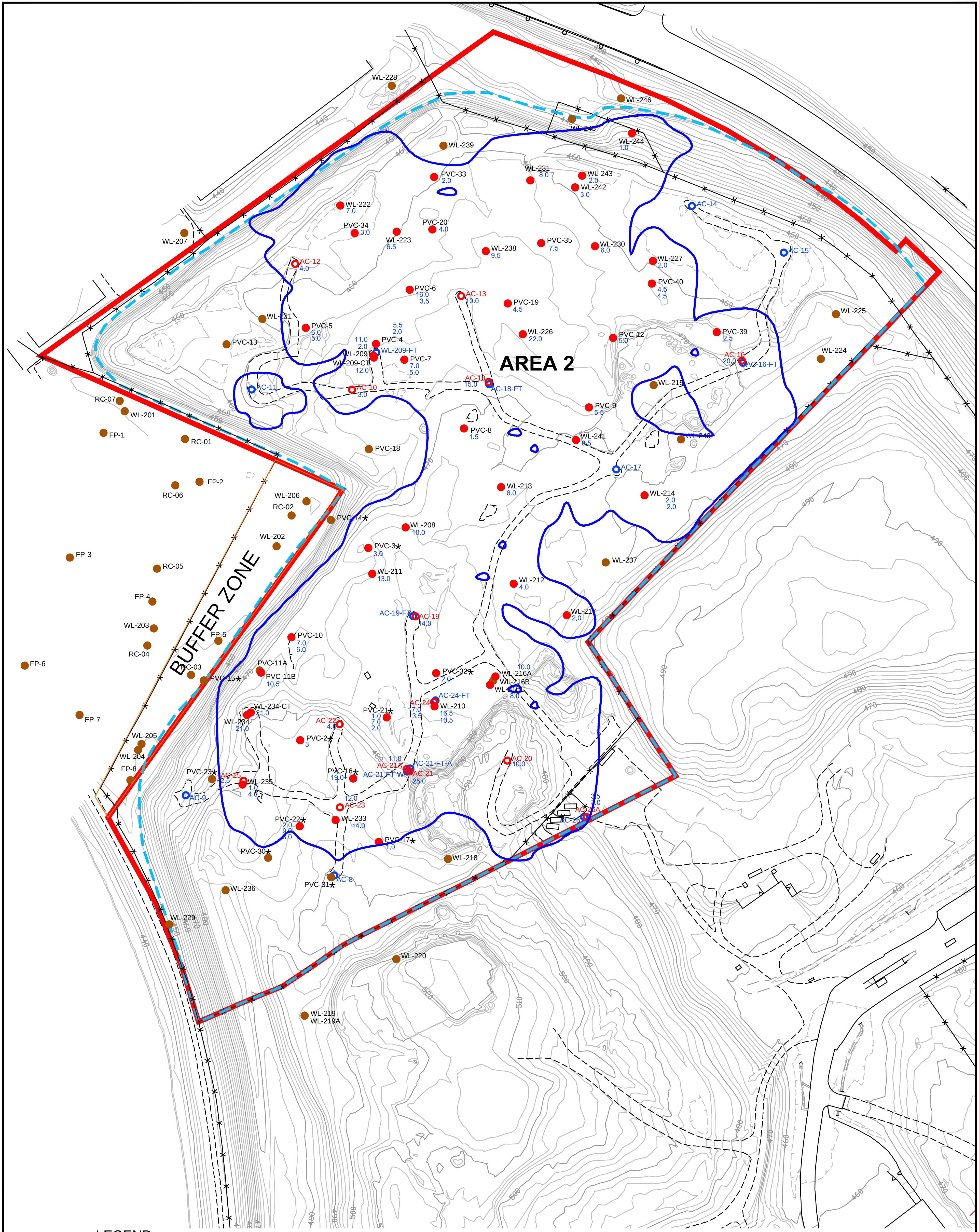
Approximate Extent of RIM
Area 1

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-2\FIG-2-10_2-11-Extent-RIM.dwg

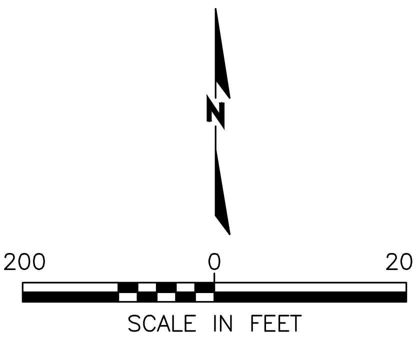
M:\CLIENTS\EMSI\WESTLAKE\2016\FINAL-FS\SECTION-2\FIG-2-10_2-11-EXTENT-RIM.DWG-AREA2 NO-YELLOW 07/19/2016 4:05PM



LEGEND

▬	OU-1 AREA 2 BOUNDARY
- -	APPROXIMATE EDGE OF REFUSE
*	LOCATION APPROXIMATE-NO SURVEY DATA AVAILABLE
●	RI SOIL BORING
●	COTTER SOIL BORING
○	ADDITIONAL SOIL BORING
●	PRESENCE OF RIM
5.0	THICKNESS OF RIM (IN FEET)
▬	GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

DRAFT



NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED FEBRUARY 27, 2016
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

Figure 2-11

Approximate Extent of RIM
Area 2

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

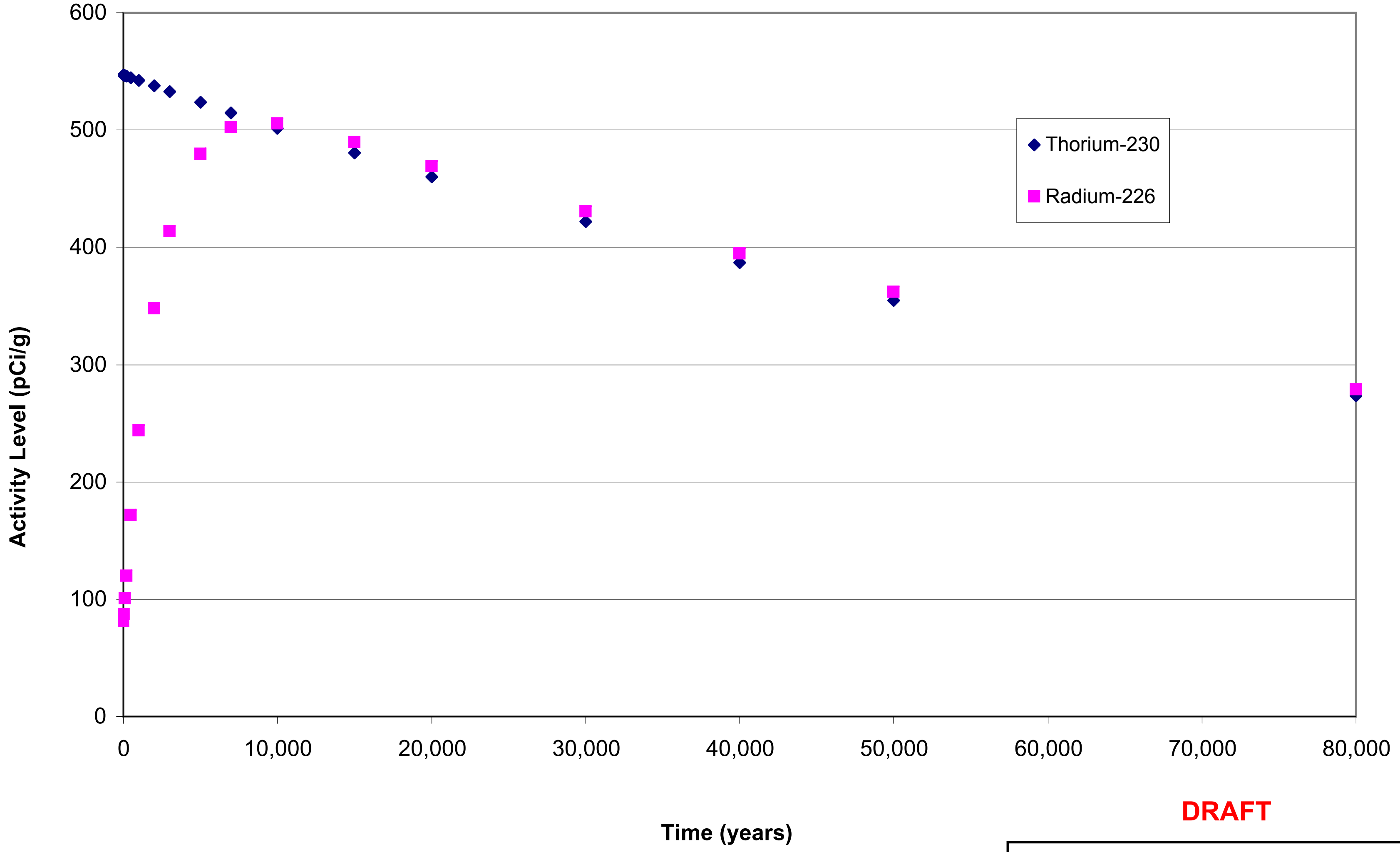


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Figure 2-12

Thorium-230 Decay and Radium-226 Ingrowth Over Time
Area 1

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

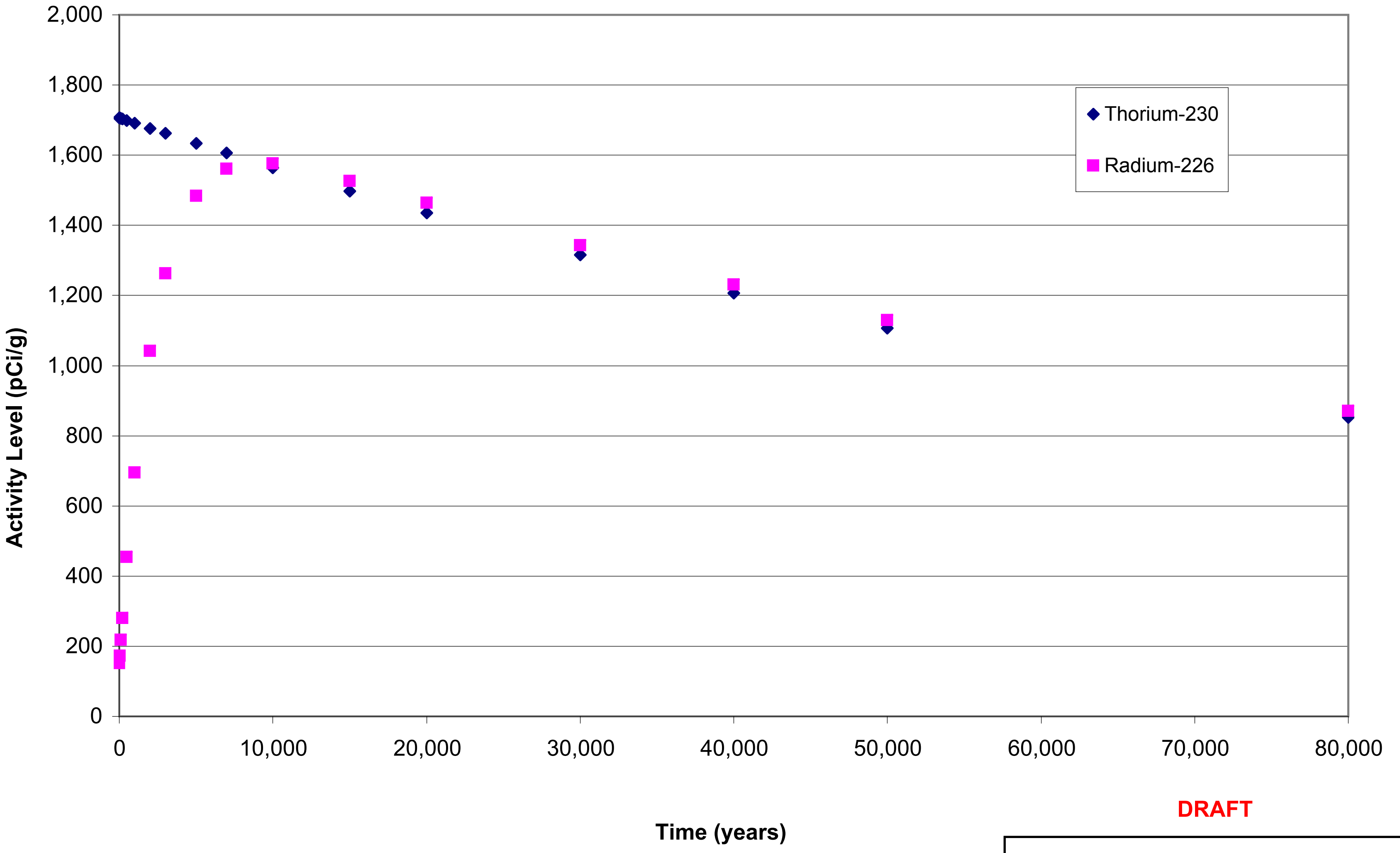

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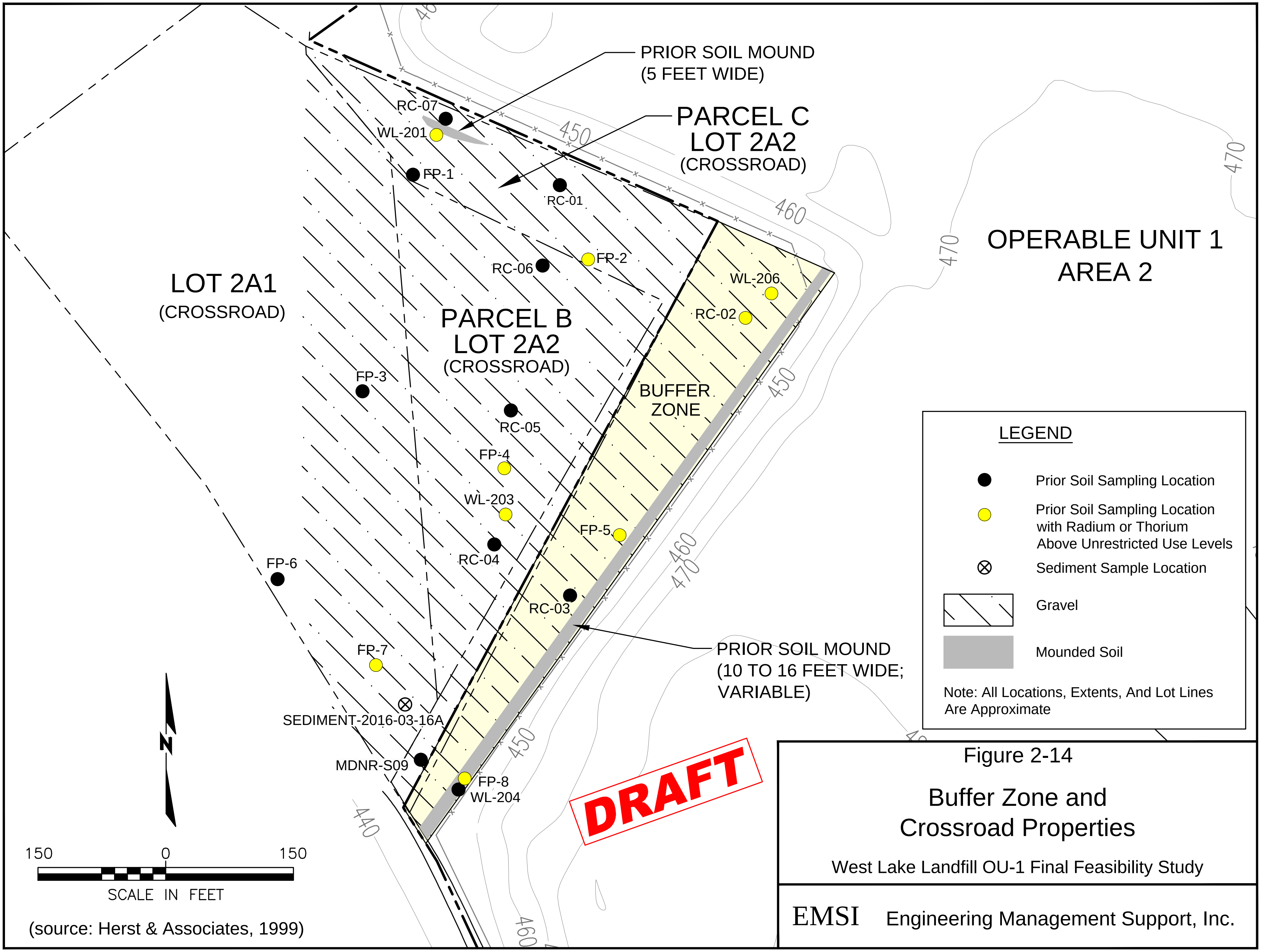
Figure 2-13

Thorium-230 Decay and Radium-226 Ingrowth Over Time Area 2

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-2\FIG-2-14-Buffer-Zone_Crossroad.dwg



Note: All Locations, Extents, And Lot Lines Are Approximate

(source: Herst & Associates, 1999)

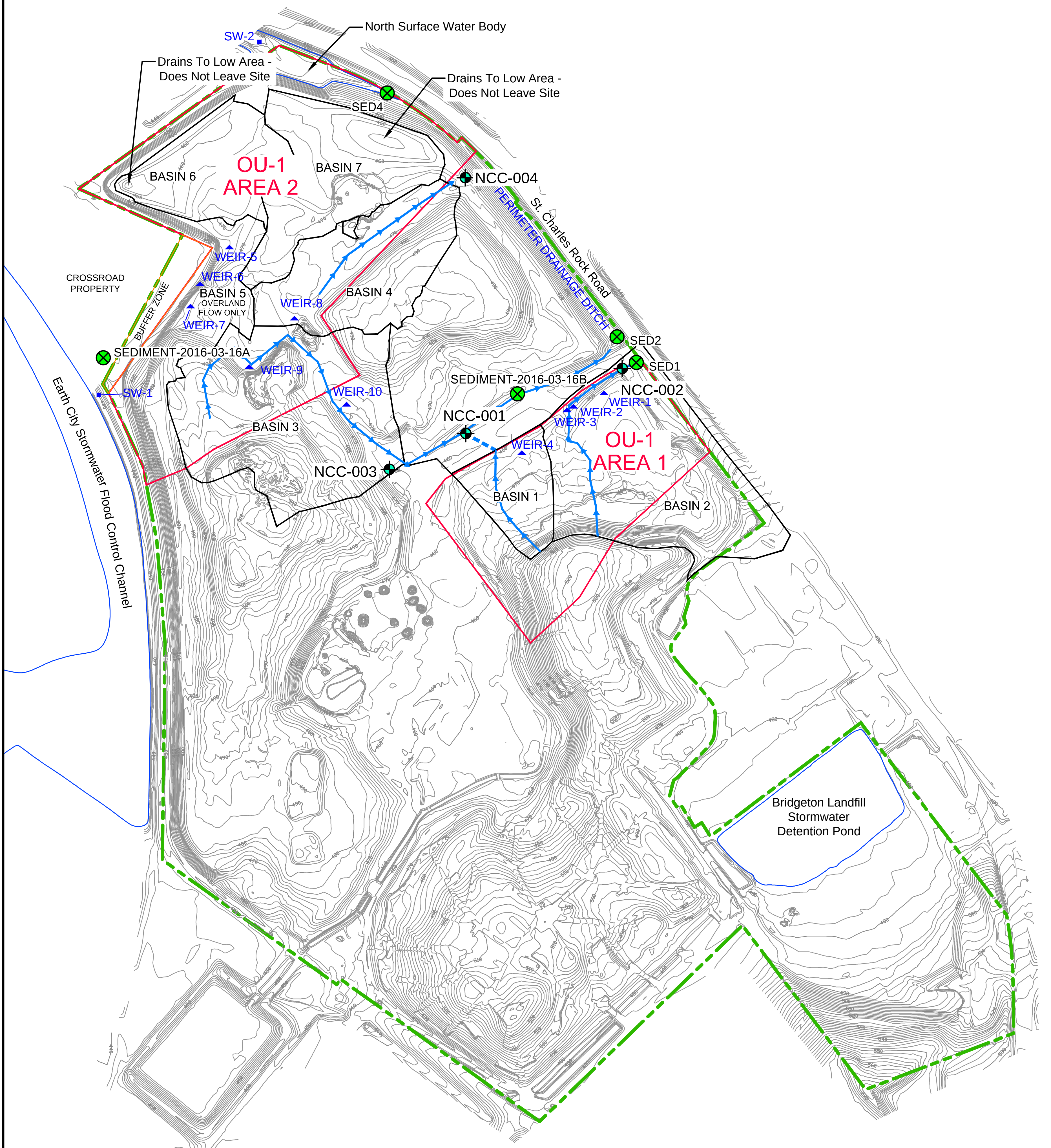
Figure 2-14

Buffer Zone and Crossroad Properties

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WESTLAKE\2016\FINAL-FS\SECTION-2\FIG-2-15-SW-SED-MON-LOCS.DWG-LAYOUT 09/30/2016 3:17PM



LEGEND

▬ ▬ · ▬	Landfill Boundary
──	2015 Topography (2' Contour)
——500——	2015 Topography (10' Contour)
──	Watershed Catchment Area
→→→	Flow Path
– – –	Culvert
⊕ NCC-001	Sampling Location
⊗ SED2	Sediment Sample Location
▲ WEIR-3	Rainwater runoff and sediment sampling locations
■ SW-1	Surface water sampling location

NOTES:
2015 TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS, INC. AND IS DATED MARCH 10, 2015

N

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SCALE IN FEET

DRAFT

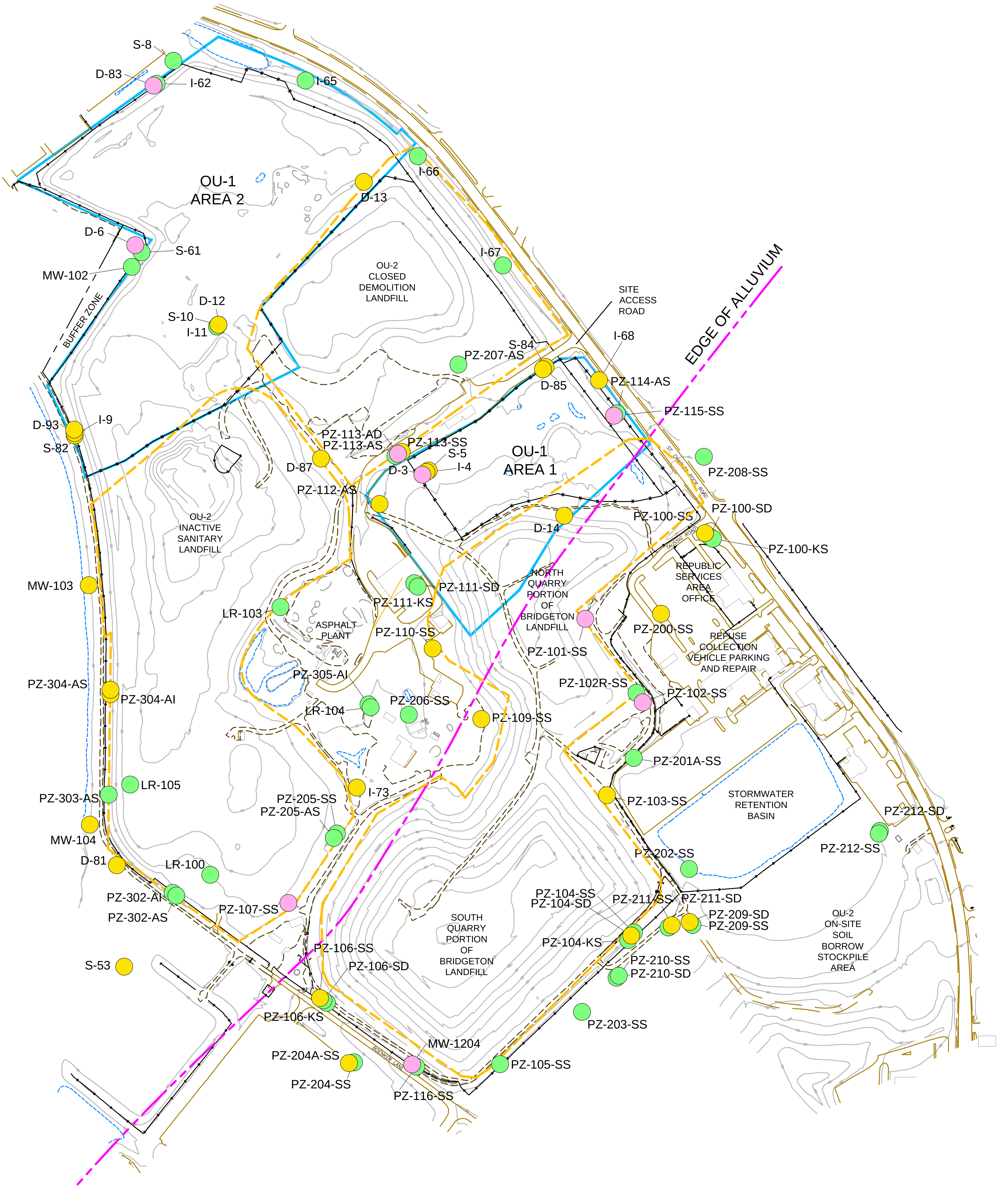
Figure 2-15

Stormwater, Surface Water and Sediment Monitoring Locations

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WESTLAKE\2016\FINAL-FS\SECTION-2\FIG-2-16-COM-TOT-RAD-226-228-PYG.DWG-1 09/30/2016 3:16PM



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 data 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)

LEGEND

Operable Unit-1 Area

Paved Road

Unpaved Road

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

DRAFT

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.

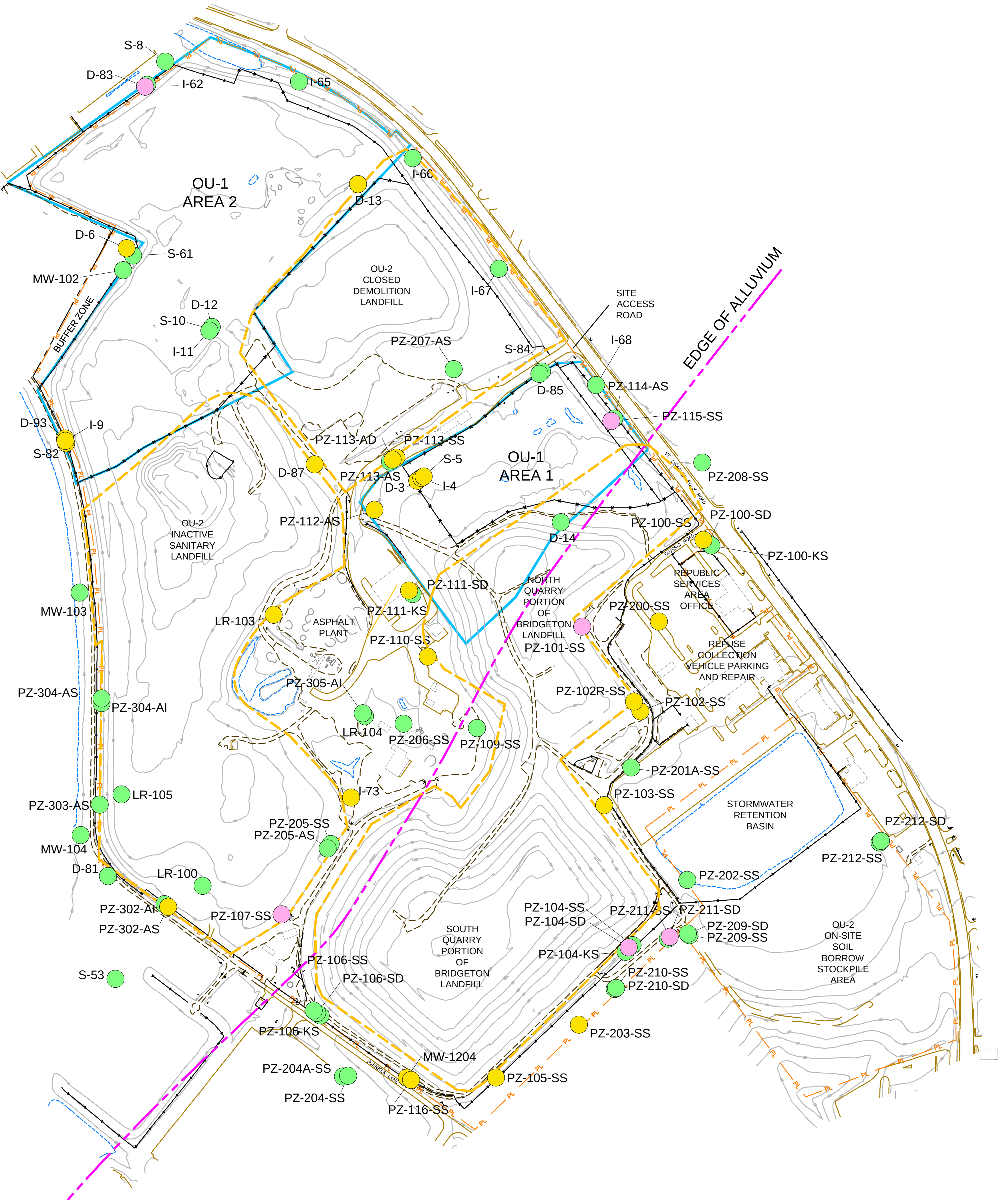
NORTH

0 250 500
SCALE IN FEET

Figure 2-16
Combined Total Radium-226 + Total Radium-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\2016\FINAL-FS\SECTION-2\FIG-2-17-COM-DIS-RAD-226-228-PYG.DWG-1 09/30/2016 3:15PM



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 data 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)

LEGEND

―	Operable Unit-1 Area
═	Paved Road
‒ ‒ ‒	Unpaved Road

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

DRAFT

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.

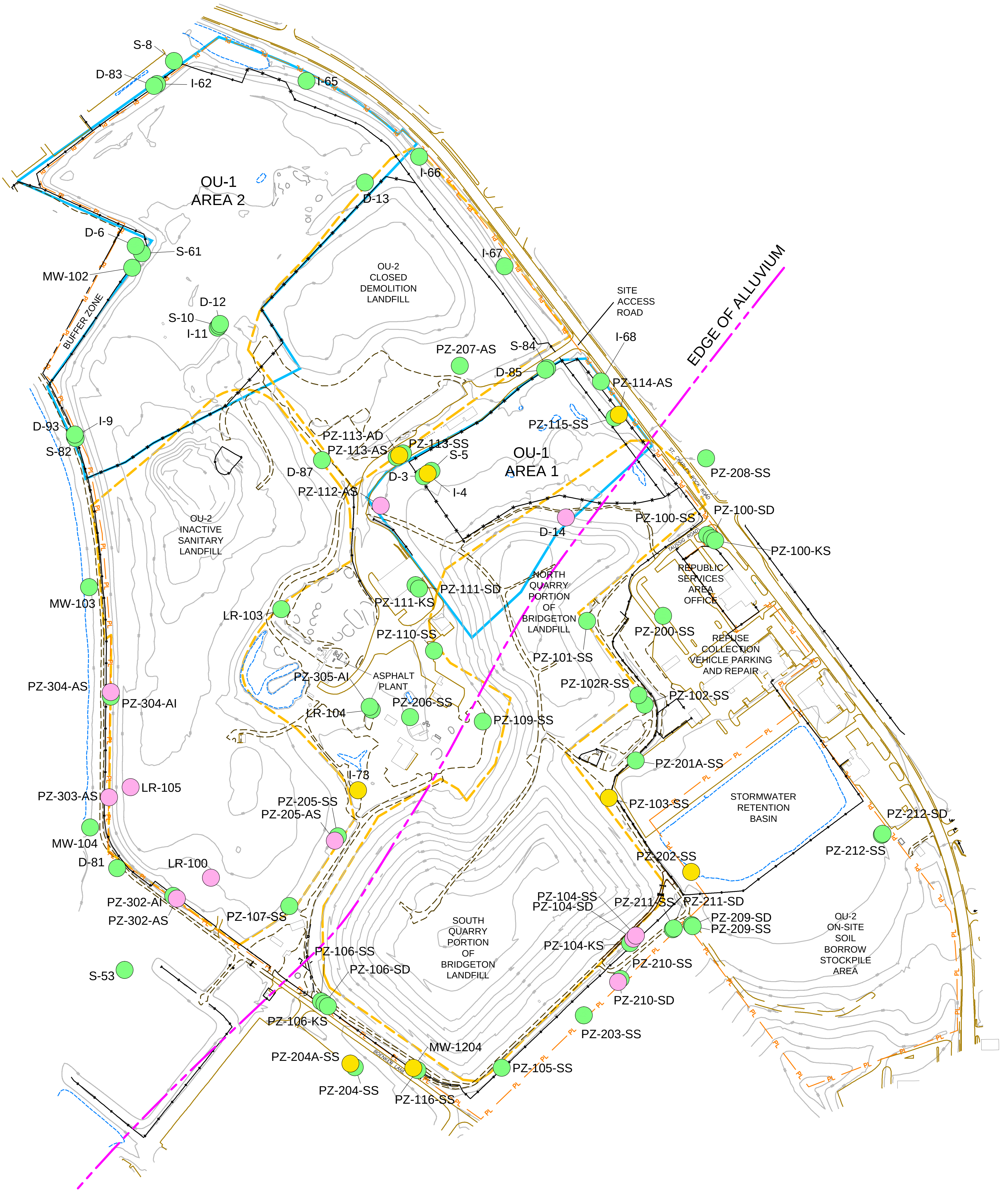
NORTH

0 250 500
SCALE IN FEET

Figure 2-17
Combined Dissolved Radium-226 + Dissolved Radium-228 in Groundwater, August 2012 Through February 2014

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

Operable Unit-1 Area

Paved Road

Unpaved Road

BENZENE EXPLANATION

● Benzene greater than the Maximum Contaminant Level of 5 μg/L for Benzene (all sampling dates)

● Benzene greater than the Maximum Contaminant Level of 5 μg/L for Benzene (at least one sampling data but not all sampling dates)

● Benzene less than the Maximum Contaminant Level of 5 μg/L for Benzene (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
SS: St. Louis Formation Well
SD: Salem Formation Well
KS: Keokuk Formation Well

DRAFT

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.

NORTH

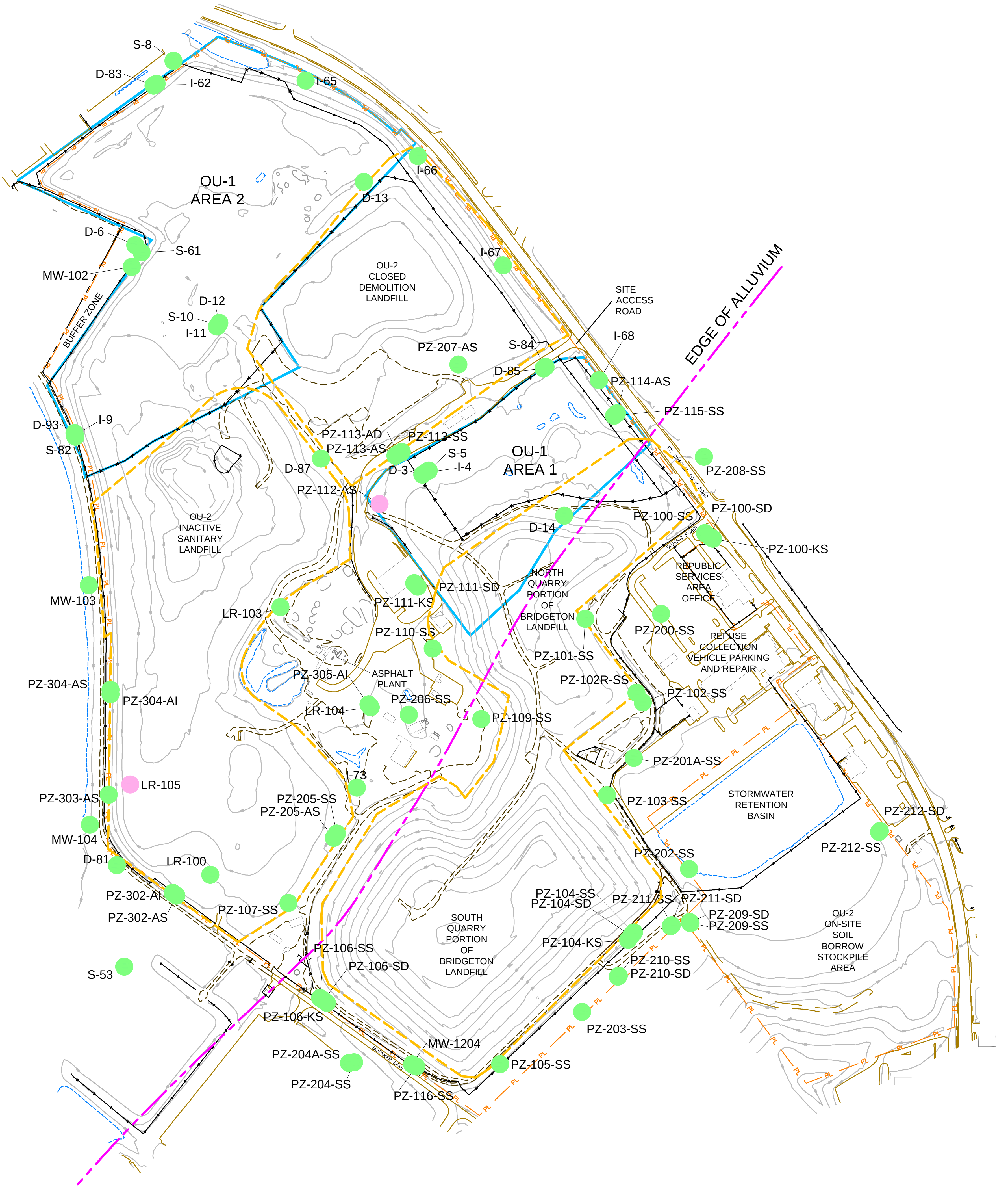
0 250 500
SCALE IN FEET

Figure 2-18

Benzene in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



CHLOROBENZENE EXPLANATION

● Total Chlorobenzene greater than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (all sampling dates)

● Total Chlorobenzene greater than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (at least one sampling data but not all sampling dates)

● Total Chlorobenzene less than the Maximum Contaminant Level of 100 $\mu g/L$ for Chlorobenzene (all sampling dates)

LEGEND

Operable Unit-1 Area
Paved Road
Unpaved Road

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

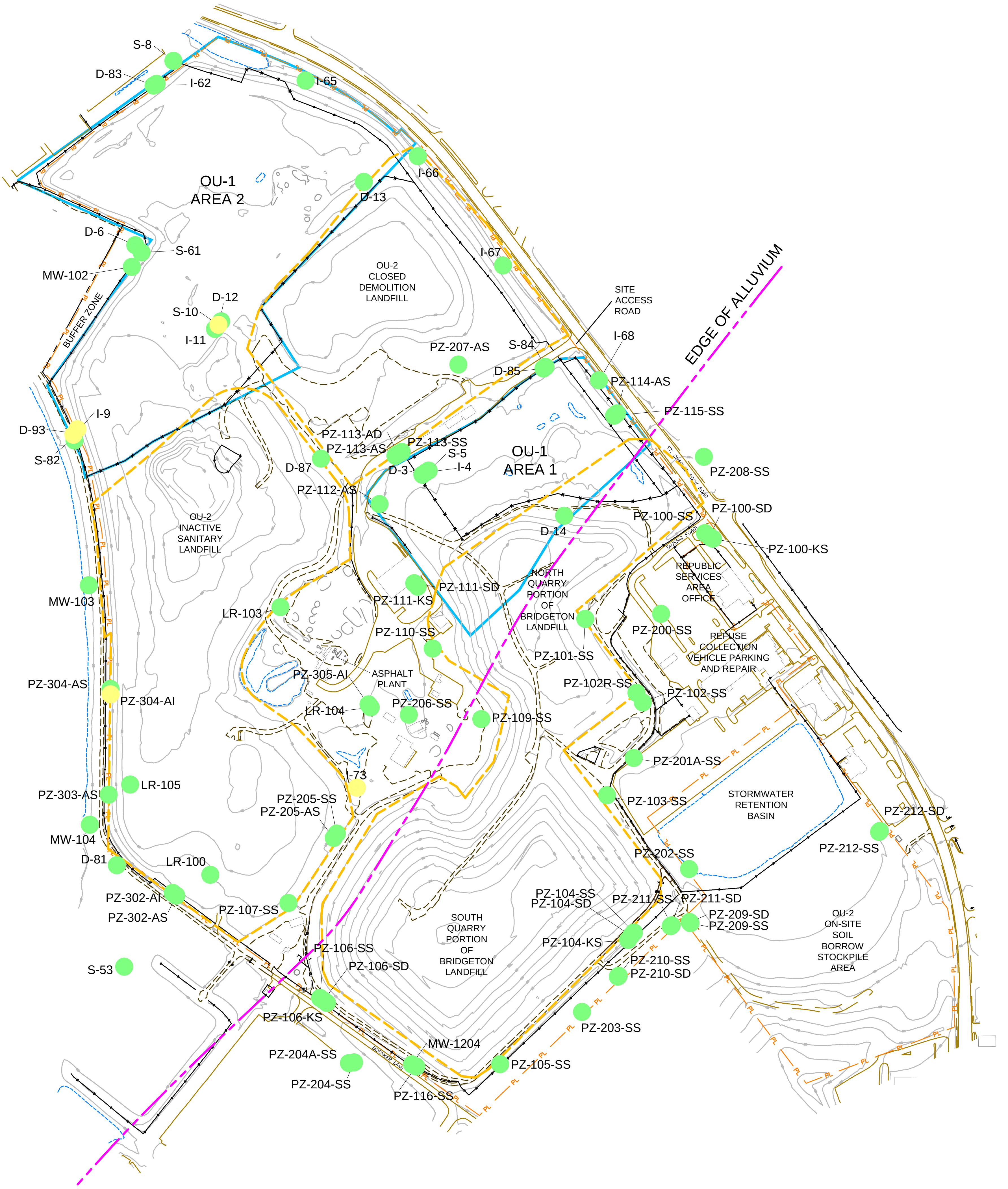
Figure 2-19

Chlorobenzene in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WESTLAKE\2016\FINAL-FS\SECTION-2\FIG-2-20-HIST-VINYL_PYG.DWG-WO-TOPO 09/30/2016 3:25PM



LEGEND

━━	Operable Unit-1 Area
═══	Paved Road
— — —	Unpaved Road

VINYL CHLORIDE EXPLANATION

● Total Vinyl Chloride greater than the Maximum Contaminant Level of 2 μg/L for Vinyl Chloride (all sampling dates)

● Total Vinyl Chloride greater than the Maximum Contaminant Level of 2 μg/L for Vinyl Chloride (at least one sampling data but not all sampling dates)

● Total Vinyl Chloride less than the Maximum Contaminant Level of 2 μg/L for Vinyl Chloride (all sampling dates)

DRAFT

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.

NORTH

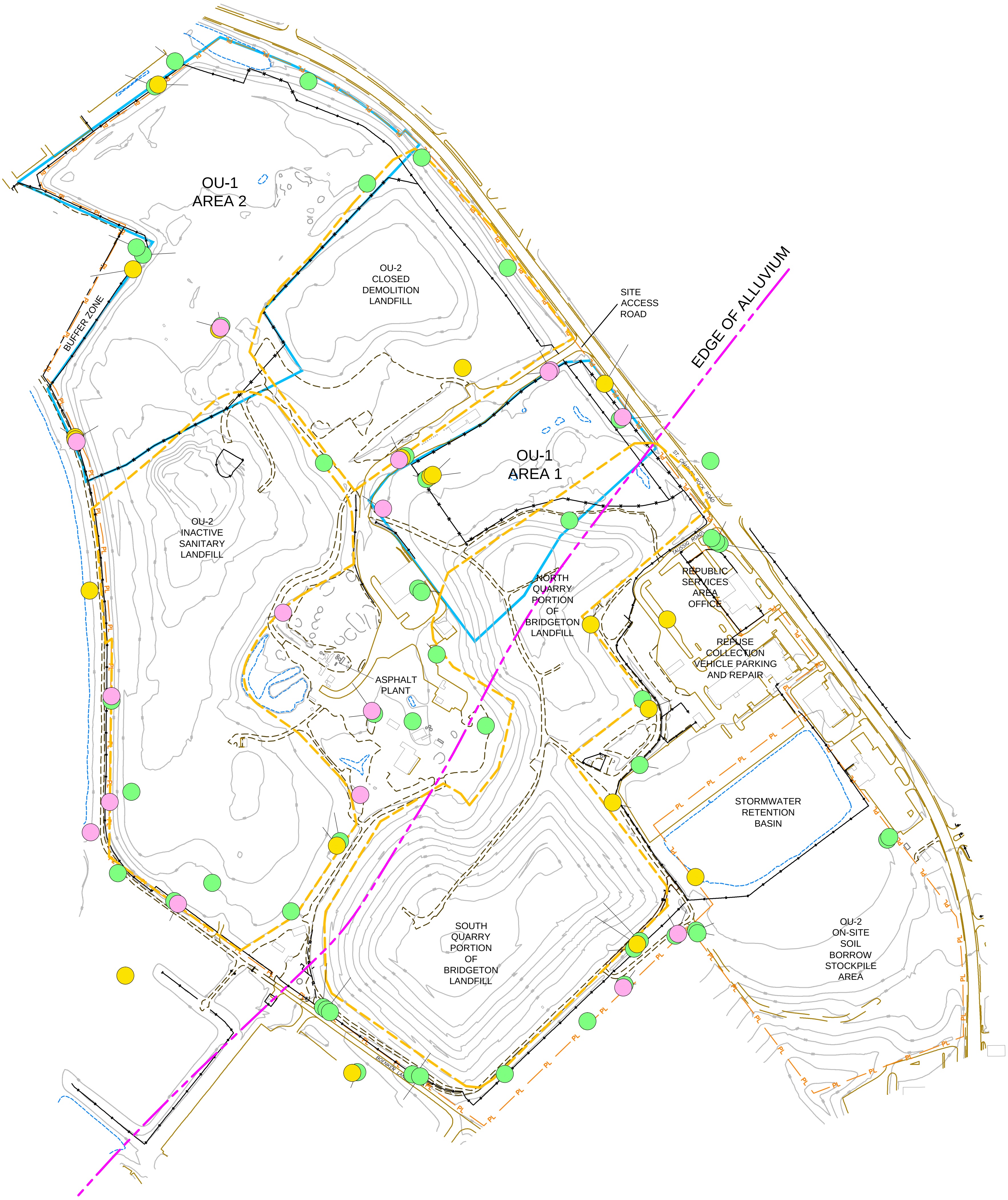
0 250 500
SCALE IN FEET

Figure 2-20

Vinyl Chloride in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



ARSENIC EXPLANATION

🟣 Total Arsenic greater than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (all sampling dates)

🟡 Total Arsenic greater than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (at least one sampling data but not all sampling dates)

🟢 Total Arsenic less than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (all sampling dates)

LEGEND

━	Operable Unit-1 Area
═	Paved Road
╌	Unpaved Road

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

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

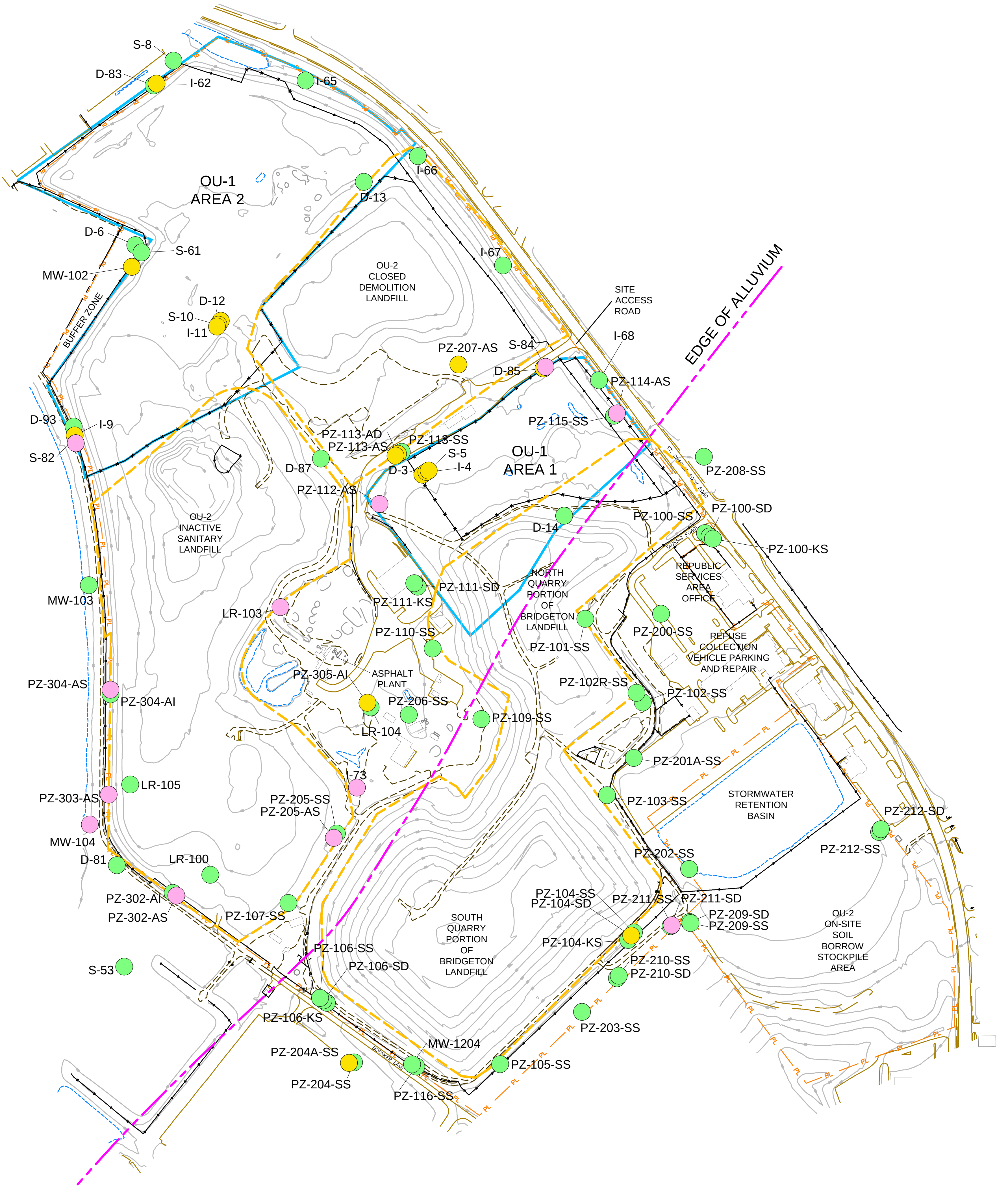
Figure 2-21

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\2016\FINAL-FS\SECTION-2\FIG-2-22-HIST-DISS-ARSENIC_PYG.DWG-WO-TOPO 09/30/2016 3:23PM



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 data but not all sampling dates)
🟢	Dissolved Arsenic less than the Maximum Contaminant Level of 10 $\mu g/L$ for Arsenic (all sampling dates)

LEGEND

━━	Operable Unit-1 Area
══	Paved Road
╌╌	Unpaved Road

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

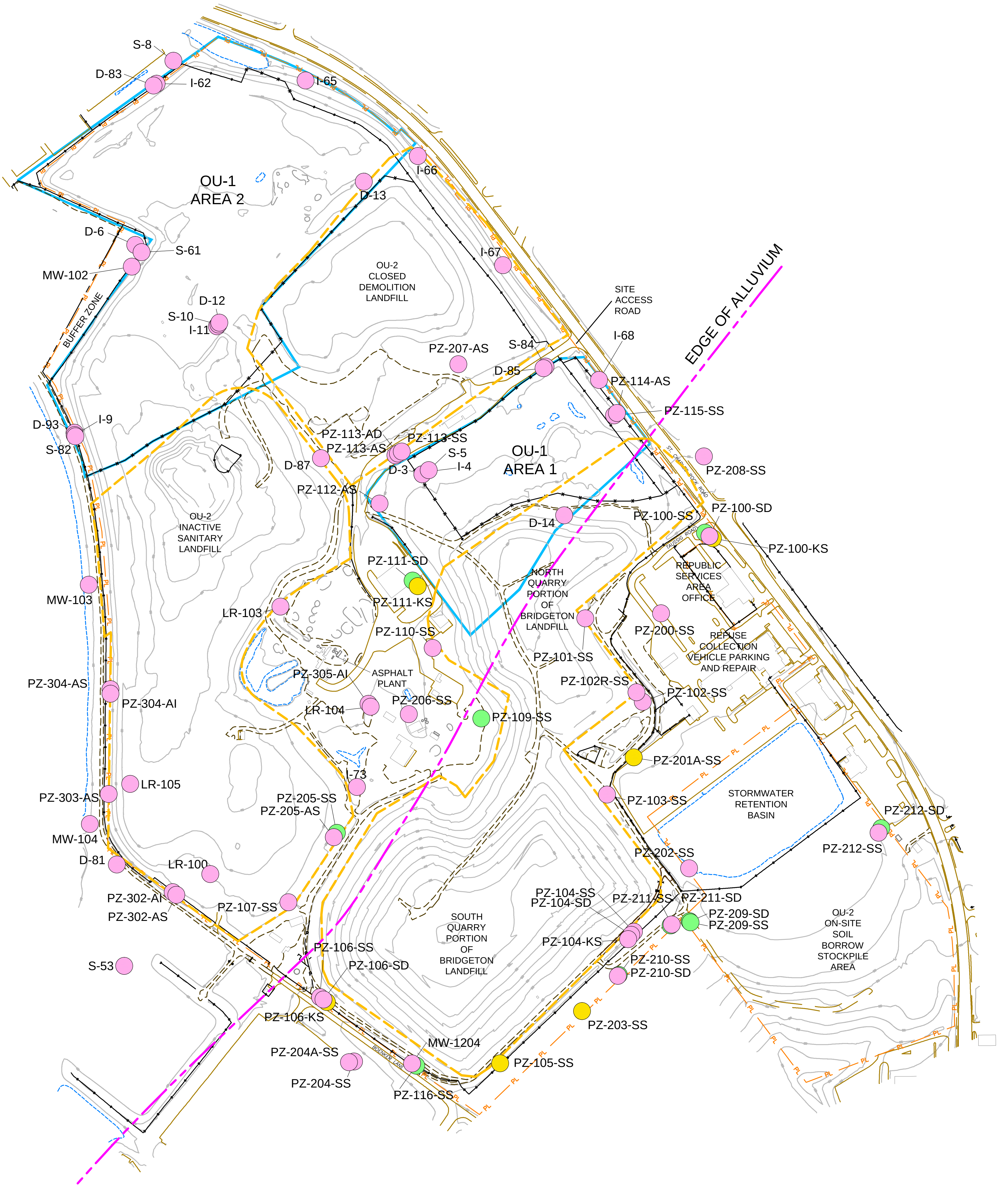
Figure 2-22

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\2016\FINAL-FS\SECTION-2\FIG-2-23-HIST-FE_PYG.DWG-WO-TOPO 09/30/2016 3:22PM



LEGEND

━━	Operable Unit-1 Area
═══	Paved Road
‒ ‒ ‒	Unpaved Road

IRON EXPLANATION

●	Total Iron greater than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)
●	Total Iron greater than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (at least one sampling data but not all sampling dates)
●	Total Iron less than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

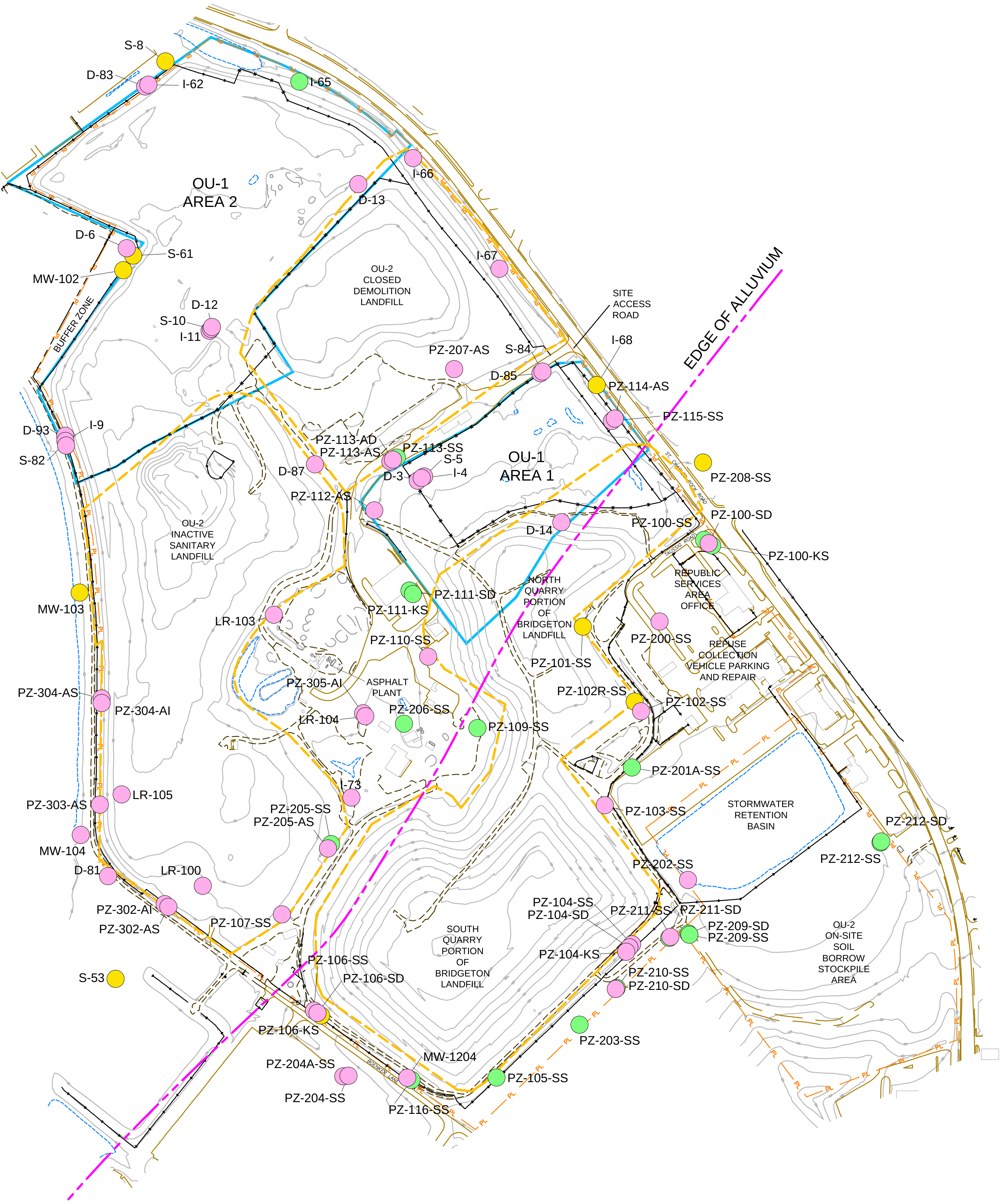
Figure 2-23

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\2016\FINAL-FS\SECTION-2\FIG-2-24-HIST-DISS-FE_PYG.DWG-WO-TOPO 09/30/2016 3:22PM



LEGEND

━━ Operable Unit-1 Area
═══ Paved Road
– – – Unpaved Road

IRON EXPLANATION

🟣 Dissolved Iron greater than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)

🟡 Dissolved Iron greater than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (at least one sampling data but not all sampling dates)

🟢 Dissolved Iron less than the Maximum Contaminant Level of 300 $\mu g/L$ for Iron (all sampling dates)

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

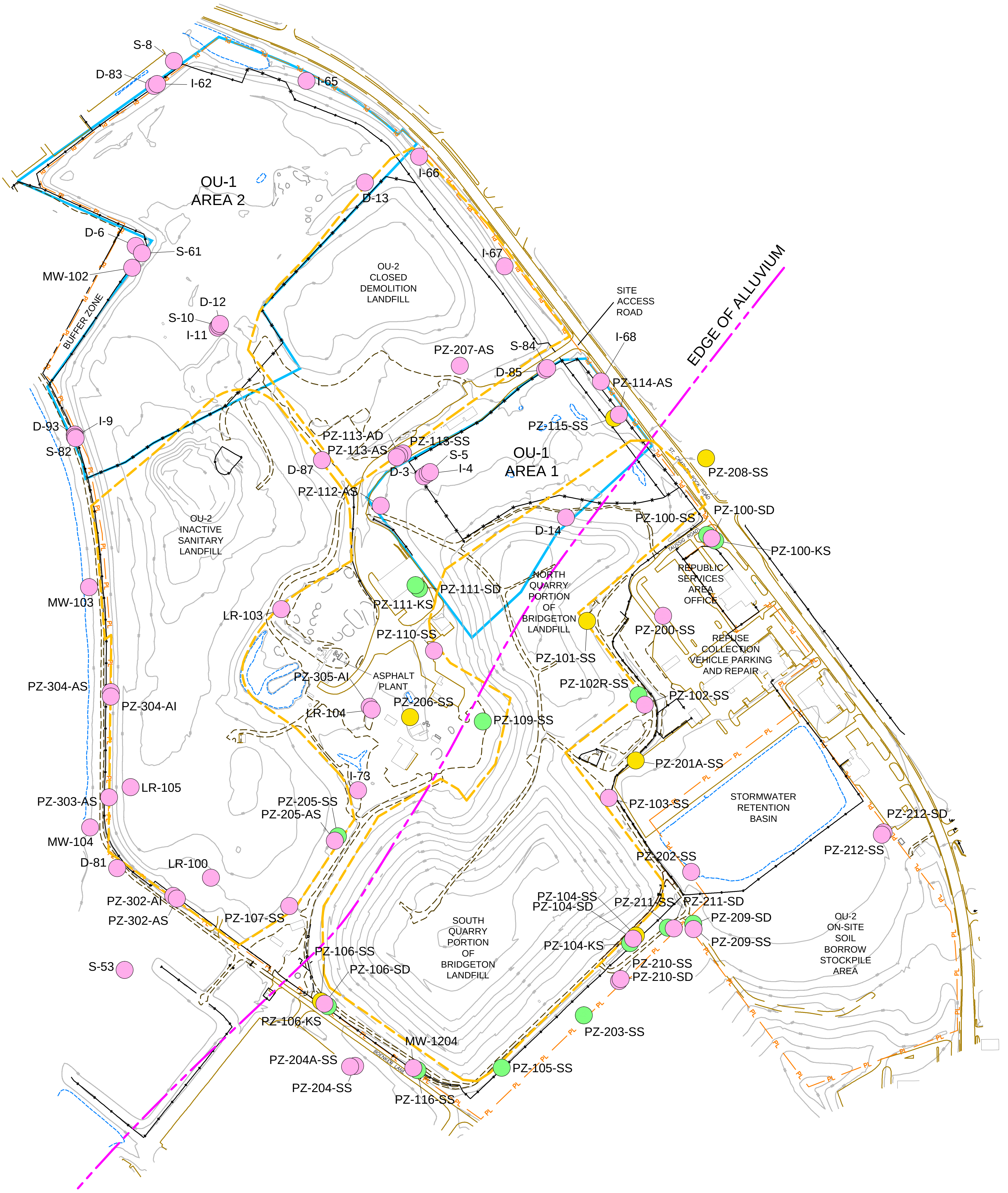
Figure 2-24

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\2016\FINAL-FS\SECTION-2\FIG-2-25-HIST-MANG_PYG.DWG-WO-TOPO 09/30/2016 3:21PM



MANGANESE EXPLANATION

● Total Manganese greater than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (all sampling dates)

● Total Manganese greater than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (at least one sampling data but not all sampling dates)

● Total Manganese less than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (all sampling dates)

LEGEND

Operable Unit-1 Area
Paved Road
Unpaved Road

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

NORTH

0 250 500
SCALE IN FEET

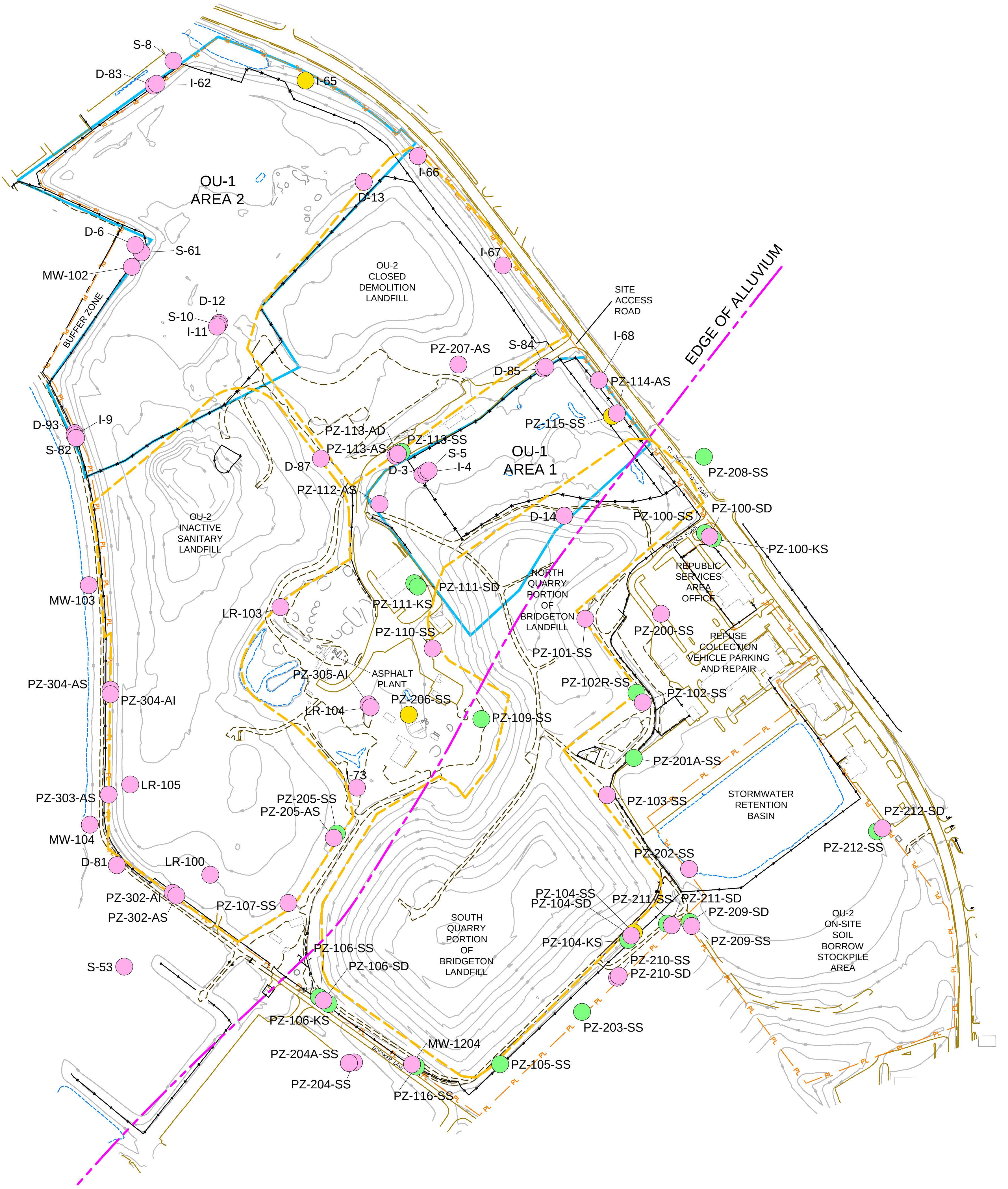
Figure 2-25

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\2016\FINAL-FS\SECTION-2\FIG-2-26-HIST-DISS-MANG_PYG.DWG-WO-TOPO 09/30/2016 3:20PM



MANGANESE EXPLANATION

● Dissolved Manganese greater than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (all sampling dates)

● Dissolved Manganese greater than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (at least one sampling data but not all sampling dates)

● Dissolved Manganese less than the Maximum Contaminant Level of 50 $\mu g/L$ for Manganese (all sampling dates)

LEGEND

Operable Unit-1 Area
Paved Road
Unpaved Road

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

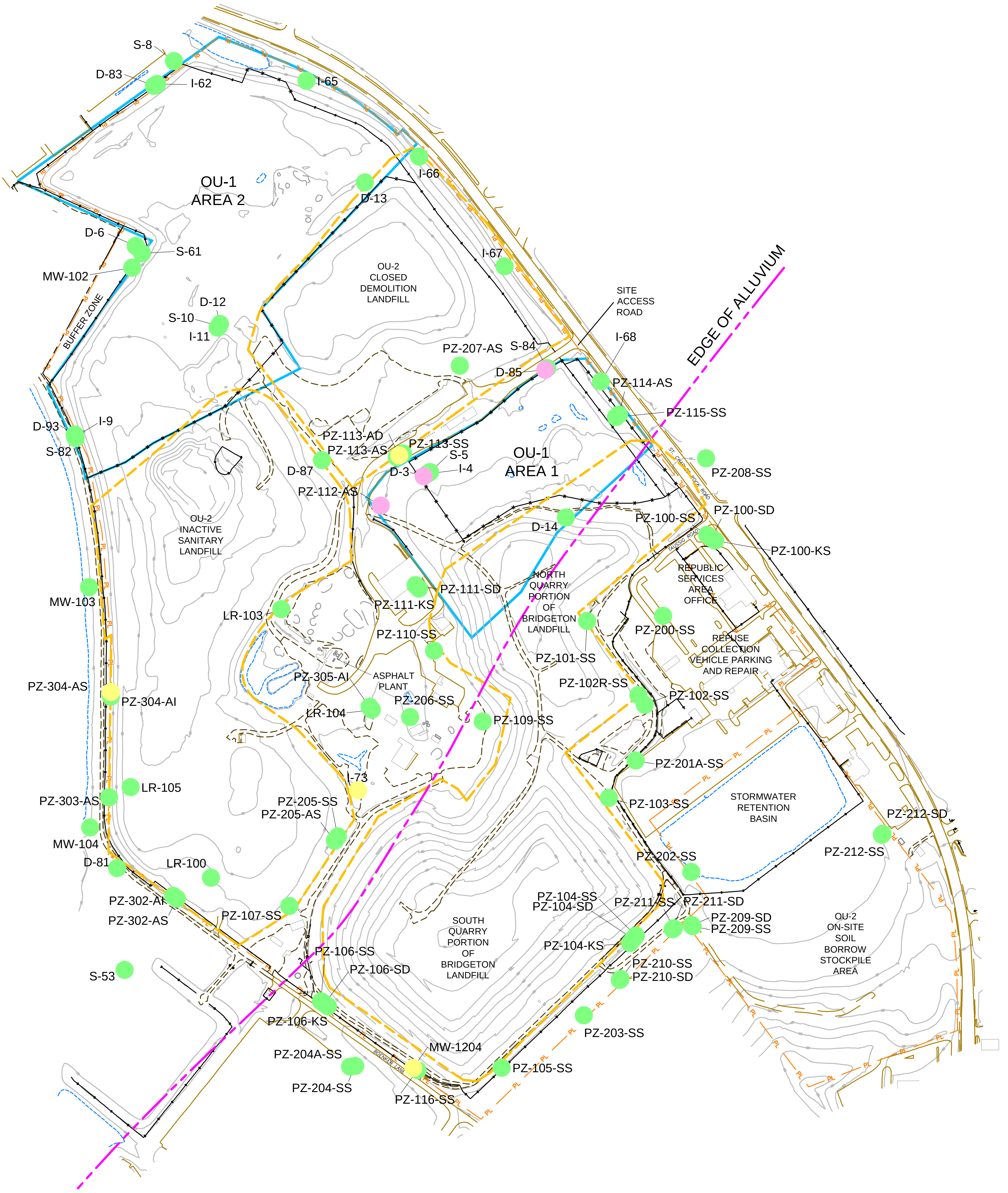
Figure 2-26

Dissolved 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\2016\FINAL-FS\SECTION-2\FIG-2-27-HIST-TOTAL-BARIUM_PYG.DWG-WO-TOPO 09/30/2016 3:19PM



BARIUM EXPLANATION

● Total Barium greater than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (all sampling dates)

● Total Barium greater than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (at least one sampling data but not all sampling dates)

● Total Barium less than the Maximum Contaminant Level of 2,000 $\mu g/L$ for Barium (all sampling dates)

LEGEND

— Operable Unit-1 Area

═ Paved Road

- - - Unpaved Road

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

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

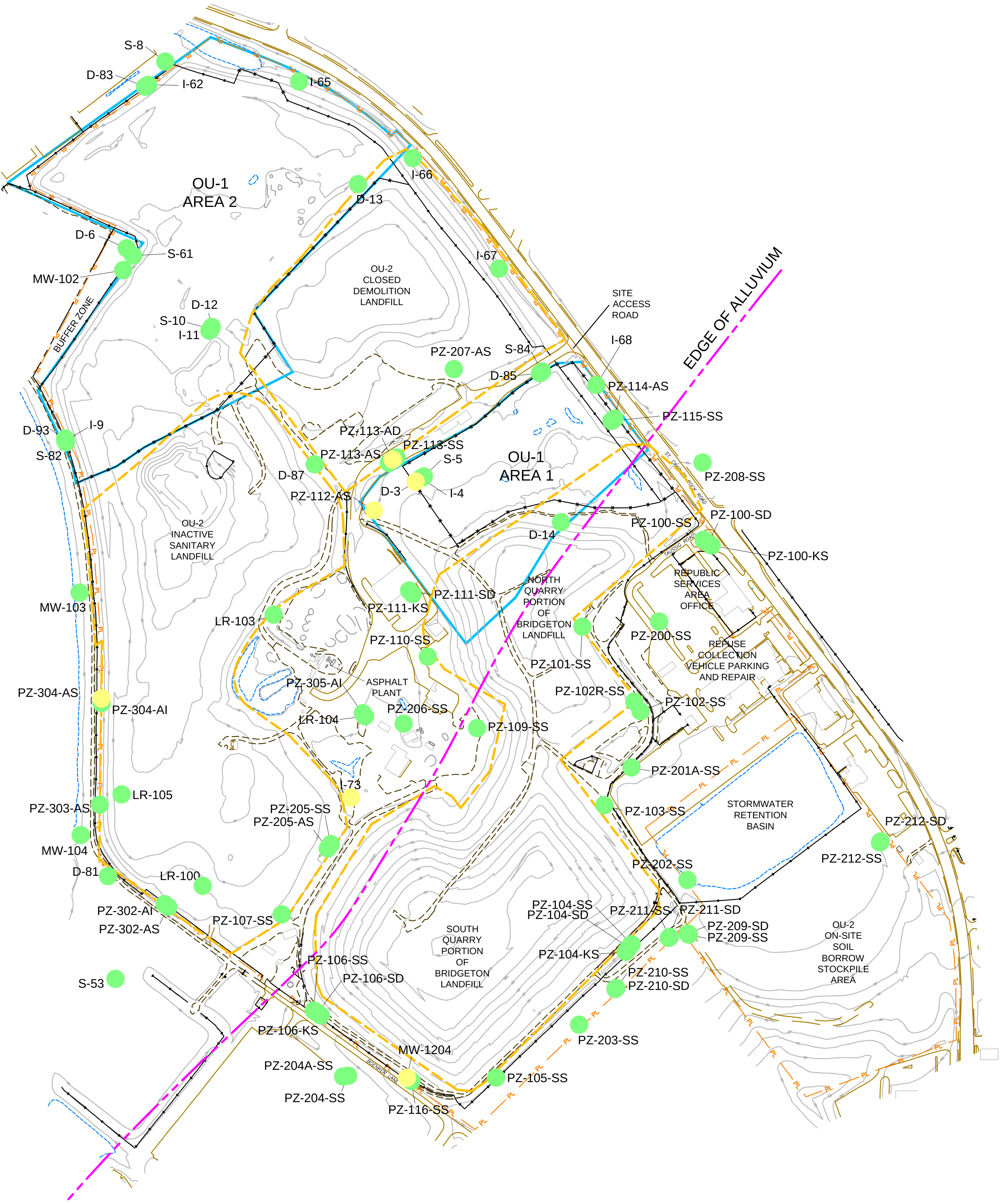
Figure 2-27

Total 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\2016\FINAL-FS\SECTION-2\FIG-2-28-HIST-DISS-BARIUM_PYG.DWG-WO-TOPO 09/30/2016 3:19PM



LEGEND

▬	Operable Unit-1 Area
═	Paved Road
╌	Unpaved Road

BARIUM EXPLANATION

●	Dissolved Barium greater than the Maximum Contaminant Level of 2,000 μg/L for Barium (all sampling dates)
●	Dissolved Barium greater than the Maximum Contaminant Level of 2,000 μg/L for Barium (at least one sampling data but not all sampling dates)
●	Dissolved Barium less than the Maximum Contaminant Level of 2,000 μg/L for Barium (all sampling dates)

DRAFT

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.

NORTH

0 250 500
SCALE IN FEET

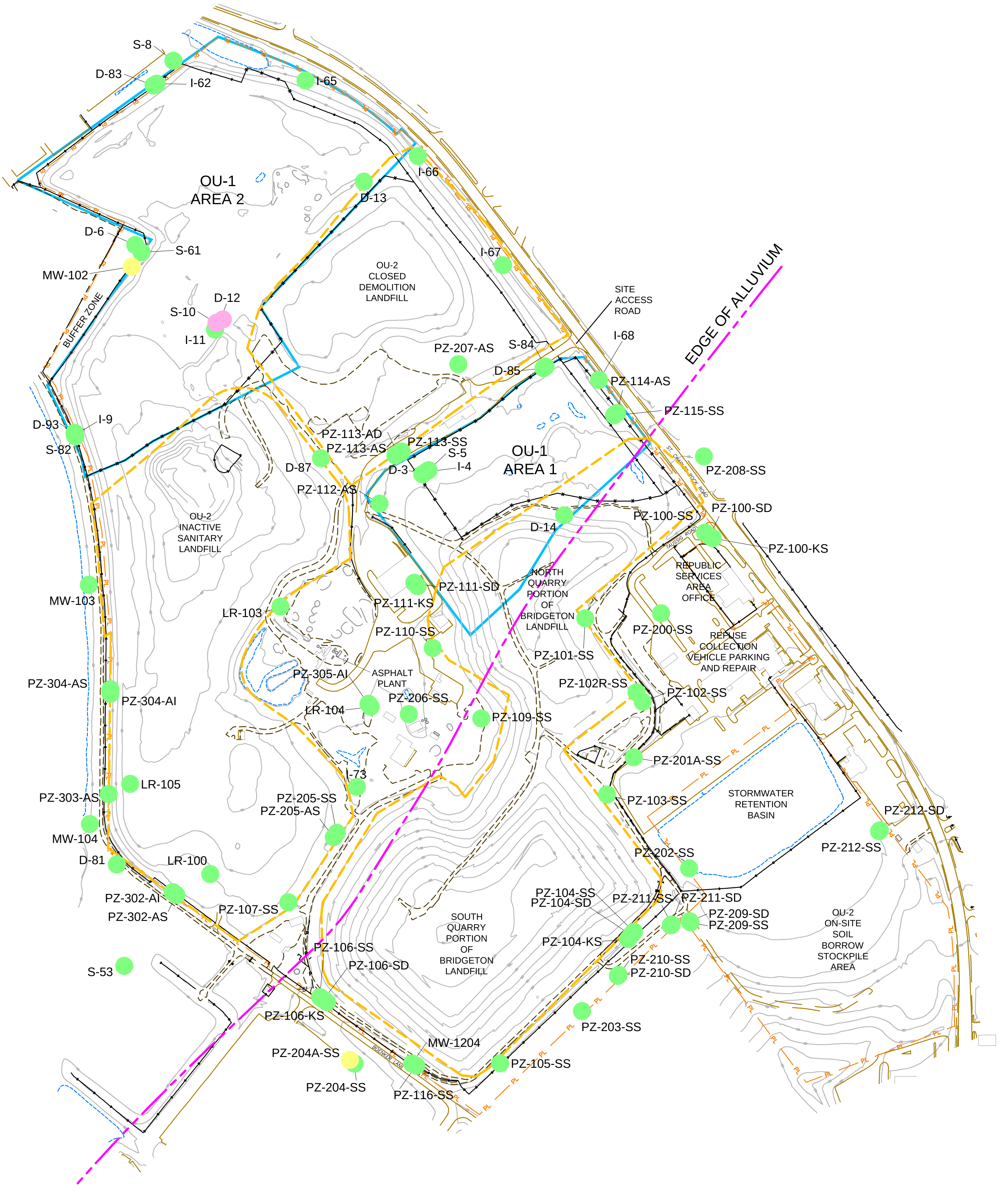
Figure 2-28

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\2016\FINAL-FS\SECTION-2\FIG-2-29-HIST-SULFATE_PYG.DWG-WO-TOPO 09/30/2016 3:18PM



SULFATE EXPLANATION

● Total Sulfate greater than the Maximum Contaminant Level of 250 mg/L for Sulfate (all sampling dates)

● Total Sulfate greater than the Maximum Contaminant Level of 250 mg/L for Sulfate (at least one sampling data but not all sampling dates)

● Total Sulfate less than the Maximum Contaminant Level of 250 mg/L for Sulfate (all sampling dates)

LEGEND

Operable Unit-1 Area
Paved Road
Unpaved Road

DRAFT

WELL FORMATION DESIGNATIONS

LR or MW: Undifferentiated
S or AS: Alluvial Shallow Well
I or AI: Alluvial Intermediate Well
D or AD: 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.

NORTH

0 250 500
SCALE IN FEET

Figure 2-29

Sulfate in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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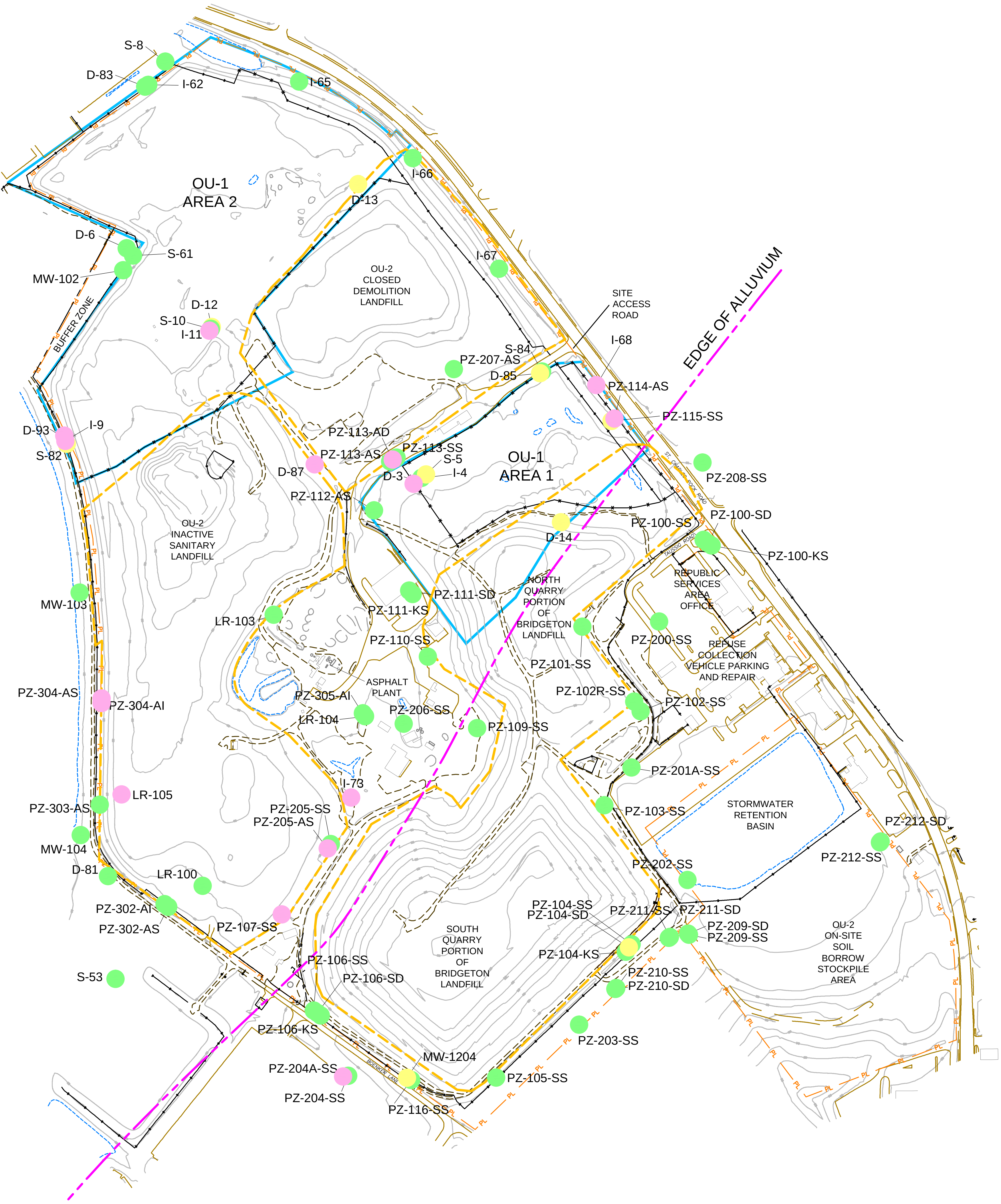

CHLORIDE EXPLANATION

● Chloride greater than the Maximum Contaminant Level of 250 mg/L for Chloride (all sampling dates)

● Chloride greater than the Maximum Contaminant Level of 250 mg/L for Chloride (at least one sampling data but not all sampling dates)

● Chloride less than the Maximum Contaminant Level of 250 mg/L for Chlorobenzene (all sampling dates)

LEGEND

—	Operable Unit-1 Area
═	Paved Road
- - -	Unpaved Road

DRAFT

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 Performed 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 2-30

Chloride in Groundwater,
August 2012 Through November 2013

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
No Action	See Figure 4-1 in FS (EMSI, 2006)			
Institutional Controls[1]	See Figure 4-1 in FS (EMSI, 2006)			
Monitoring	Long-term performance monitoring	Groundwater, surface water, sediment, landfill gas, and radon gas monitoring	Monitoring to evaluate site conditions over time and/or remedial action performance.	Potentially applicable.
	Short-term monitoring during construction	Perimeter environmental media air monitoring	Monitoring station contains low volume air sampler to collect airborne particulates and organic vapor samples for analysis of VOCs and radionuclide activity; continuous radon monitor; and radiation dosimeter. Data to be collected pre-, during, and post-remedial action.	Potentially applicable. Would be required during construction of any remedy to monitor doses, activities, and concentrations at the fenceline and areas where workers will frequent, to assure that non-remediation workers present in other portions of the landfill site are not exposed, and to assure that remediation workers are not exposed to unnecessary radiation exposure.
		Work zone monitoring	Site workers would participate in medical and dosimetry monitoring programs. Breathing zone samplers might be assigned to selected workers to evaluate intake of airborne particulates and radon. Equipment and workers leaving radiologically-controlled area will be surveyed and decontaminated, if necessary.	Potentially applicable. Would be required during construction of any remedy.
		Excavation guidance/ clearance monitoring	Use of walkover field radiological survey equipment and solids sampling to identify impacted materials above cleanup levels to guide excavation equipment. Final walkover radiological scans of exposed faces and base of excavated areas and sampling of soil/trash at base of excavation to document that RIM have been removed.	Potentially applicable. Would be required during construction of any remedy if RIM were to be relocated.
		Waste acceptance monitoring	If excavated RIM were to be disposed off-site, each load of material removed from the site would be scanned to ensure that the radiological Waste Acceptance Criteria of the facility where the RIM would disposed would be met.	Potentially applicable. Would be required if RIM is to be disposed off-site.
		Post cover construction radon flux monitoring	Use of Large Area Activated Charcoal Canisters (LAACCs) to measure radon flux of the cover surface after construction is complete.	Potentially applicable. Would be required during construction of any remedy if radionuclides remain under the cover.

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[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1
Technical Implementability Screening
of Remediation Technologies
and Process Options
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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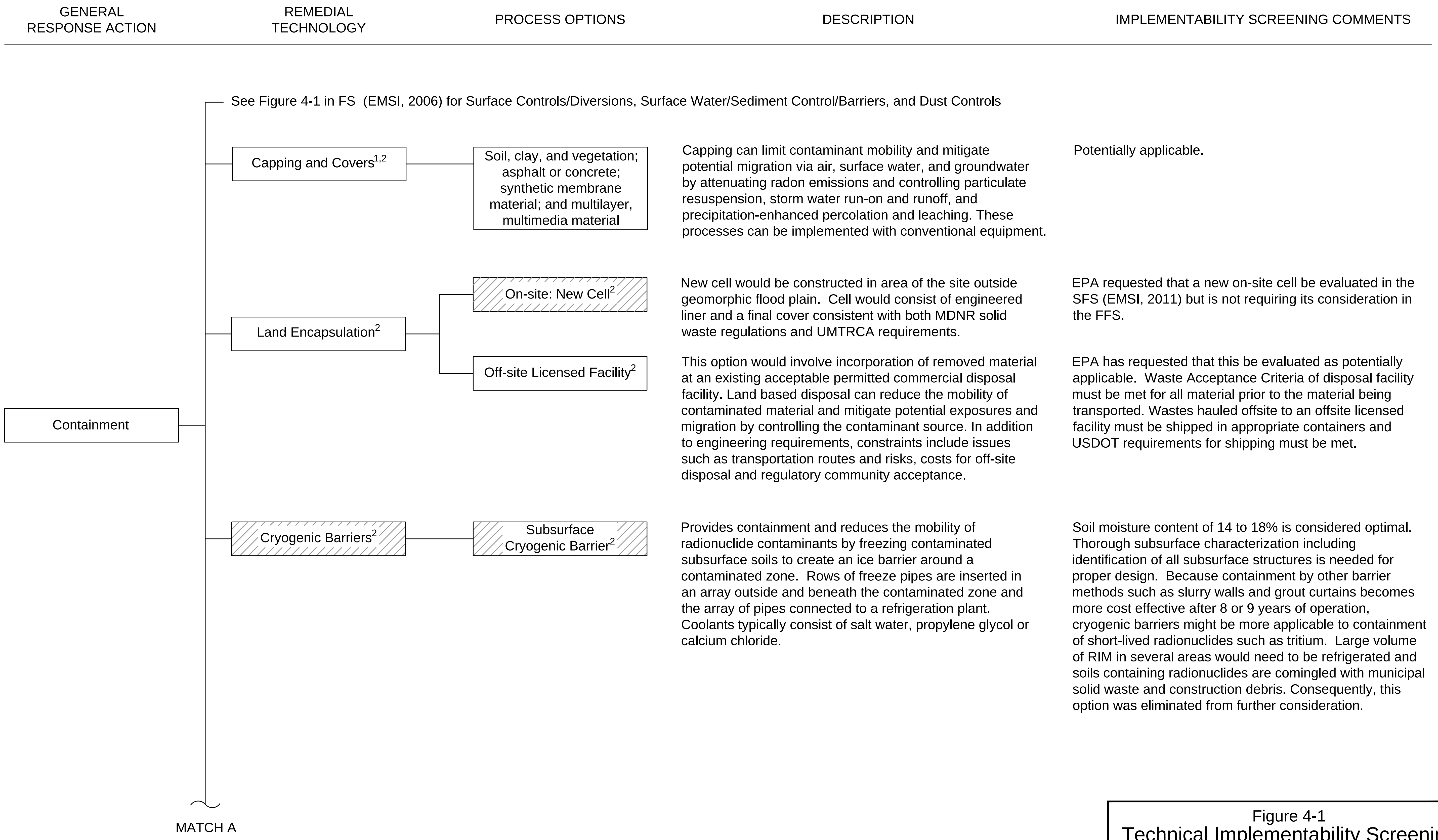

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Containment	See Figure 4-1 in FS (EMSI, 2006) for Surface Controls/Diversions, Surface Water/Sediment Control/Barriers, and Dust Controls			
	Capping and Covers[1,2]	Soil, clay, and vegetation; asphalt or concrete; synthetic membrane material; and multilayer, multimedia material	Capping can limit contaminant mobility and mitigate potential migration via air, surface water, and groundwater by attenuating radon emissions and controlling particulate resuspension, storm water run-on and runoff, and precipitation-enhanced percolation and leaching. These processes can be implemented with conventional equipment.	Potentially applicable.
	Land Encapsulation[2]	▨ On-site: New Cell[2]	New cell would be constructed in area of the site outside geomorphic flood plain. Cell would consist of engineered liner and a final cover consistent with both MDNR solid waste regulations and UMTRCA requirements.	EPA requested that a new on-site cell be evaluated in the SFS (EMSI, 2011) but is not requiring its consideration in the FFS.
		Off-site Licensed Facility[2]	This option would involve incorporation of removed material at an existing acceptable permitted commercial disposal facility. Land based disposal can reduce the mobility of contaminated material and mitigate potential exposures and migration by controlling the contaminant source. In addition to engineering requirements, constraints include issues such as transportation routes and risks, costs for off-site disposal and regulatory community acceptance.	EPA has requested that this be evaluated as potentially applicable. Waste Acceptance Criteria of disposal facility must be met for all material prior to the material being transported. Wastes hauled offsite to an offsite licensed facility must be shipped in appropriate containers and USDOT requirements for shipping must be met.
	▨ Cryogenic Barriers[2]	▨ Subsurface Cryogenic Barrier[2]	Provides containment and reduces 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.	Soil moisture content of 14 to 18% is considered optimal. Thorough subsurface characterization including identification of all subsurface structures is needed for proper design. Because containment by other barrier methods such as slurry walls and grout curtains becomes more cost effective after 8 or 9 years of operation, cryogenic barriers might be more applicable to containment of short-lived radionuclides such as tritium. Large volume of RIM in several areas would need to be refrigerated and soils containing radionuclides are comingled with municipal solid waste and construction debris. Consequently, this option was eliminated from further consideration.

MATCH A

[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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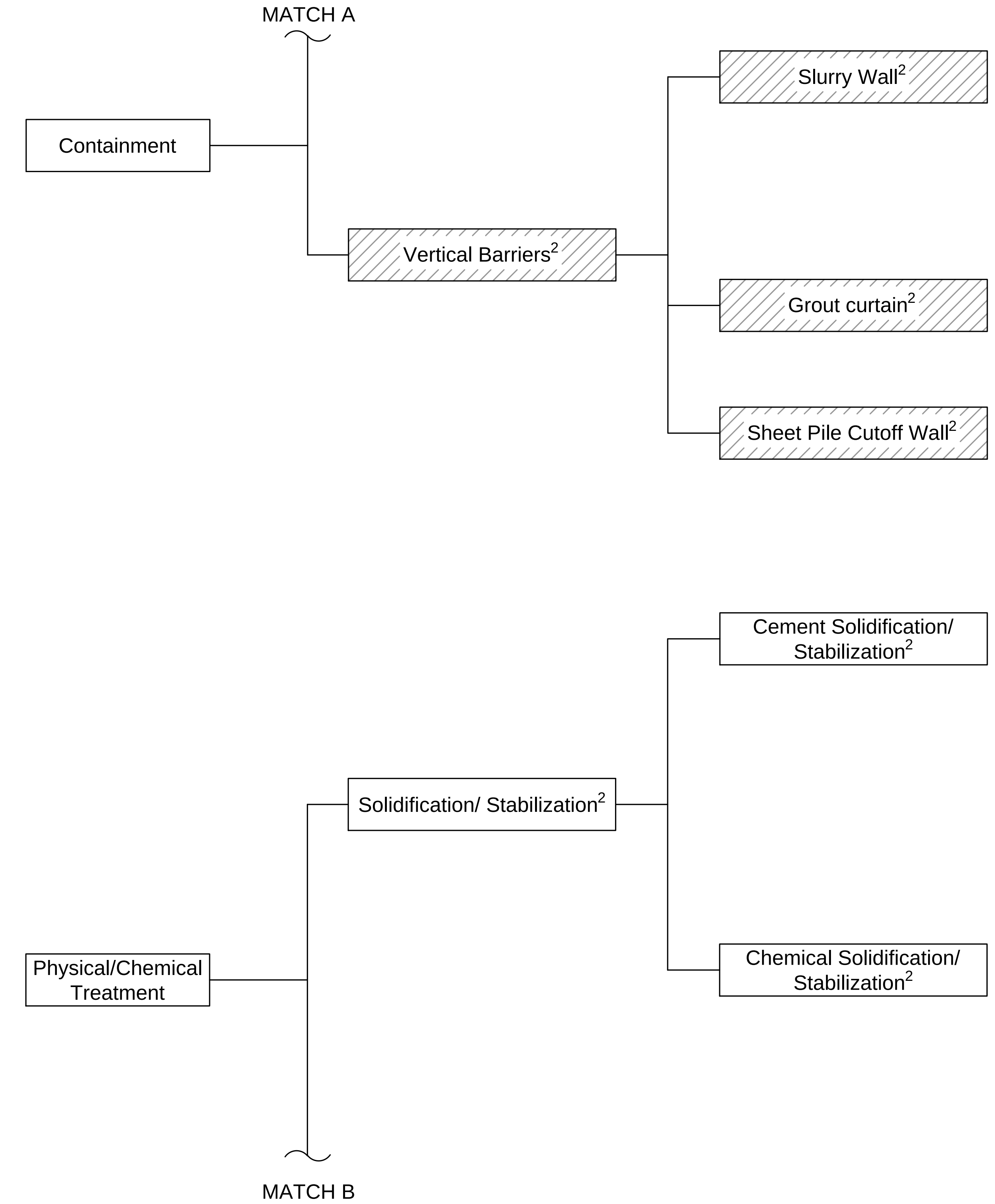

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Containment	▨ Vertical Barriers[2]	▨ Slurry Wall[2]	Mixture of soil and bentonite is used to construct a low conductivity wall that is typically keyed-into bedrock or an impermeable hydrostratigraphic layer. Wall is normally installed by introducing bentonite slurry into a trench as the trench is excavated to hydraulically shore the trench to prevent collapse. Soil from the excavation is mixed above ground with bentonite and the mixture is placed back into the trench, displacing the slurry.	Would be difficult to implement in landfill containing municipal solid waste and construction and demolition debris. Consequently, this option was eliminated from further consideration.
		▨ Grout curtain[2]	Grout is injected into the natural formation in-situ to fill interstitial void spaces and significantly reduce the hydraulic conductivity of the soil, forming a vertical barrier to groundwater flow.	Only applicable to low permeable zones. Would be difficult to implement in landfill containing municipal solid waste and construction and demolition debris. Consequently, this option was eliminated from further consideration.
		▨ Sheet Pile Cutoff Wall[2]	Sheet piling barriers are constructed by driving individual sections of interlocking steel sheets into the ground using impact or vibratory hammers to form an impermeable barrier. Joints between individual sheet piles can be filled with grout to provide a better seal.	Would be difficult to implement in landfill containing municipal solid waste and construction and demolition debris. Consequently, this option was eliminated from further consideration.
Physical/Chemical Treatment	Solidification/ Stabilization[2]	Cement Solidification/ Stabilization[2]	The cement solidification/stabilization process involves the addition of agents including Portland cement, gypsum and pozzolanic-based materials such as fly ash, blast furnace slag, kiln dust, and pumice with a waste to form a densified and hardened soil mass that limits the solubility or mobility of the waste constituents. It is conducted either in-situ by injecting a cement-based agent into the contaminated materials or ex-situ by excavating the materials, machine-mixing them with a cement-based agent, and depositing the solidified mass in a designated area. Is best suited to fine-grained soil with small pores.	Potentially applicable for use at an off-site licensed disposal facility if hazardous wastes are encountered that need to undergo solidification/stabilization or encapsulation at the off-site facility prior to disposal.
		Chemical Solidification/ Stabilization[2]	Similar to cement solidification/stabilization except agents include thermoplastic polymers, thermosetting polymers, and other proprietary additives. Is best suited to highly porous, coarse-grained, low-level radioactive waste in permeable matrices.	Potentially applicable for use at an off-site licensed disposal facility if hazardous wastes are encountered that need to undergo solidification/stabilization or encapsulation at the off-site facility prior to disposal.

[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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MATCH B

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Physical/Chemical Treatment	▨ Chemical Separation[2]	▨ Solvent/Chemical Extraction[2]	An ex-situ chemical separation technology that separates hazardous contaminants from soils, sludges, and sediments using solvent/chemical extraction to reduce the volume of waste that must be subsequently treated or disposed. Solvents that have been used to remove radionuclide contaminants include complexing agents such as EDTA; inorganic salts; organic solvents; and sulfuric, hydrochloric, and nitric mineral acids. When contaminants have been sufficiently extracted, solvent is separated from the soil and distilled or removed by precipitation. Distilled vapor consists of relatively pure solvent that is recycled into the extraction process. The liquid residue containing concentrated contaminants undergoes further treatment or disposal. If multiple radionuclides or metals are targeted for removal, multiple solvent extraction steps may be required using multiple solvents.	To be considered for potential removal of radionuclides from the soil component of the RIM, would require pilot-testing of a dry soil separation technology to remove comingled municipal solid waste and debris greater than 2.4 inches in diameter to obtain representative soil samples for bench- and pilot-testing. Since multiple radionuclides would be targeted for removal, multiple solvent extraction steps would be required using multiple solvents, each requiring treatability testing. Removal percentages cited in the literature for uranium, radium-226, and thorium-232 would not meet the criteria that would allow for unrestricted use. Consequently, this option was eliminated from further consideration.
	Physical Separation[2]	Dry Soil Separation[2]	Dry soil separation involves screening and sieving soils to separate finer fractions, such as silt and clay, from coarser fractions of the soil. Since contaminants tend to bind to the fine fraction of a soil, the purpose of solids separation processes is to concentrate the contaminants to a smaller volume of soil that would subsequently be treated or disposed. Large debris would be removed and rocks, concrete, and asphalt would be crushed before fixed, vibrating, or rotation (trommel) screening. The segmented gate technology uses conveyor belts and gamma radiation detectors to separate dry materials. Shredders may be employed prior to screening.	Data are not available to assess potential effectiveness, implementability or cost at this time. Full-scale pilot testing would be required using representative material from Areas 1 and/or 2 to assess the degree to which the radiologically-impacted soil fraction of RIM can be separated from the overall matrix of landfilled refuse, debris and fill materials, and unimpacted soil and quarry spoils. Potentially applicable for reducing the volume of RIM that needs to be addressed under the “complete rad removal” and partial excavtion alternatives if results of pilot-testing indicate that the separated non-soil fraction of RIM does not exhibit radionuclide concentrations exceeding the EPA - specified activity levels for the "complete rad removal" and partial excavation alternatives. It may be difficult to identify soil with a thorium-230 concentration that would allow for unrestricted use using gamma radiation detectors. Worker exposures, dust creation, and bird nuisance potential would increase.
		▨ Soil Washing[2]	A process in which water, with or without surfactants, is mixed with contaminated soil and debris to produce a slurry feed that is scrubbed to remove contaminated fine soil particles (silts and clays) from granular soil particles. Clean soil (sands and gravels) is returned to the excavation area, while remaining smaller volume of contaminated soil fines and process water are further treated and/or disposed.	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. Consequently, this option was eliminated from further consideration.

MATCH C

MATCH C

[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
MATCH C	MATCH C			
Physical/Chemical Treatment				
	Physical Separation[2]	▨ Flotation[2]	Radionuclide-contaminated soil is pretreated to remove coarse material and separated fine silt and clay soil particles are mixed with water to form a slurry. Flotation agent is added to the slurry. Small air bubbles passed upward through the slurry adhere to the floating particles, transport them to the surface, producing a foam containing the radionuclide-contaminated soil particles that is mechanically skimmed from the surface and further treated in a subsequent process to remove the radionuclides.	Flotation is most effective at separating soil particles in the very fine 0.0004 to 0.004 inch size range. For soils that include a wider range of particle sizes, flotation would need to be combined with other treatment processes. Has been employed extensively in the mining industry to segregate metal-containing fines, but has not been fully demonstrated for reducing the volume of radionuclide-contaminated soil. Consequently, this option was eliminated from further consideration.
	▨ Virtrification[2]	▨ In-situ Vitrification[2]	Vitrification involves heating contaminated media to extremely high temperatures, then cooling to form a dense, glassified solid mass, trapping and greatly reducing the mobility of radioactive contaminants. In-situ vitrification uses a square array of 4 graphite electrodes that allows a melt width of approximately 20 to 40 ft; the array is lowered progressively, as the melt grows, to the desired treatment depth. Offgas treatment may be required, depending on the amount/types of organics and metals that may volatilize.	Void volumes and percentages of metals, rubble, and combustible organics (e.g., methane in landfill gas) in contaminated media need to be considered - soils and waste containing greater than 55% inorganic debris and/or rubble are difficult to treat. Should not be used on contaminated soils with organic contents higher than 10%. Soils should have greater that 30% glass-forming materials (i.e., SiO2) to effectively immobilize radionuclides. RIM volume not expected to have greater than 30% glass-forming materials. Consequently, this option was eliminated from further consideration.
		▨ Ex-situ Vitrification[2]	In the ex-situ vitrification 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.	Not retained, see in-situ vitrification.
	▨ Apatite/Phosphate Based Treatment	▨ Mixing/Injection of crystalline minerals with wastes or groundwater	In an isomorphous mineral, such as apatite, certain ions or molecules can enter and be incorporated into the crystal-lattice of a mineral solid without causing any marked change in the crystal morphology or other physical properties of the mineral. Apatite or other phosphate-based materials or solutions would be added to the solid phase materials or to groundwater containing radionuclides in sufficient quantities and under appropriate geochemical conditions necessary to promote apatite crystallization, potentially resulting 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.	There is no demonstrated application of use of apatite and/or other phosphate-based materials for treatment to MSW. Uncertainty whether apatite solids or solutions could be delivered and homogeneously distributed within an overall heterogeneous matrix of MSW. Concerns about unintended consequences that could result from physical disturbance or modification of the geochemical conditions within the landfill from application of apatite based treatment technologies.

[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Biological Treatment	▨ Phytoremediation[2]	▨ Phytoextraction[2]	Phytoextraction is the uptake of contaminants by plant roots and the translocation/accumulation of contaminants in plant shoots and leaves. Plants are subsequently harvested from the growing area, dried, and disposed. Will produce harvested biomass residual waste that will require further treatment and/or disposal. Based on bench and field-testing, most promising candidates for phytoextraction are cesium and strontium.	Treatment technology is limited to shallow soils and sediments. RIM in Areas 1 and 2 is present at depths greater than 20 feet and is comingled with municipal solid waste and construction debris. Will not be effective year-round because of limited growing season. Little full-scale operating experience and technology not effective for removal of uranium and thorium radionuclides. Consequently, this option was eliminated from further consideration.
		▨ Phytostabilization[2]	Phytostabilization is the production of chemical compounds by plants to immobilize contaminants at the interface of roots and soil.	Treatment technology is limited to shallow soils and sediments. RIM in Areas 1 and 2 is present at depths greater than 20 feet and is comingled with municipal solid waste and construction debris. Will not be effective year-round because of limited growing season. Little full-scale operating experience. Technology not effective for removal of uranium and thorium radionuclides. Consequently, this option was eliminated from further consideration.
Removal	Excavation	Backhoe, bulldozer, scraper and front-end loader	Excavation can limit contaminant mobility and mitigate potential exposures at the affected area by removing the contaminant source. This technology can be implemented with conventional equipment.	Potentially applicable.
	Physical Separation	Dry Soil Separation	Since most contaminants tend to bind to the fine fraction of soils either chemically or physically, process involves screening and sieving soils to separate finer (silt and clay) fractions from coarser (sands and gravels) fractions of the soil. Separating the finer fraction of the soil can concentrate the contaminants to a smaller volume.	Because RIM at the Site occurs in soil that is intermixed with and interspersed within the overall matrix of landfilled refuse, debris, fill materials, and soil and quarry spoils, prior to a dry soil separation process being employed, the interstitial soil materials would need to be separated from the other landfilled materials using additional solids separation processes. 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. Concern that moist soil containing RIM could continue to adhere to landfilled materials after solids separation process(es).

MATCH D

MATCH D

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[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

MATCH D MATCH D

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Removal	Physical Separation	Rotating Screen - Trommel	Revolving cylindrical sieve (trommel) screens are commonly used during landfill mining and reclamation 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. Trommel screens are typically used downstream in series with a shear shredder to reduce volume fed to the trommel, break up pockets/clumps of organic and matted materials and soil, dislodge smaller materials that may be hidden in among larger materials, and pulverize materials such as brick and large chunks of concrete that contain rebar and to provide a stream of more uniformly-sized material such that fines and the soil fraction of the waste can be more easily separated.	Large landfilled objects such as white goods and steel beams need to be hand-picked from the waste stream prior to shear shredding. Would require full-scale pilot test at the Site during RD to assess whether the RIM soil can be separated from the overall matrix of landfilled refuse, debris, fill materials, and soil and quarry spoils. Non-soil MSW material (wire, rebar, plastics) can get jammed in the screen requiring personnel to enter the screen to remove the material, potentially increasing exposure to RIM. Concern that moist soil containing RIM could continue to adhere to landfilled materials after shear shredding and trommel screening. Therefore, potentially applicable to partial excavation alternatives; likely not applicable for complete rad removal alternative.
		Radiological Segregation/ Separation	Refinement of dry soil separation process using radiation detectors to further separate materials. Radionuclide-contaminated soil is first excavated and screened to remove large rocks and debris. Large rocks are crushed and placed with soil on a conveyor belt which carries the soil 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 into contaminated and clean segments.	Large debris needs to be removed before processing the soil and crushed rocks, concrete, or asphalt. Screening to size the feed material to a diameter of less than 0.5 inches is desirable; material greater than 1.5 inches cannot be processed without crushing. Optimal soil moisture content is between 5 and 15 percent. System is best suited to sort a dry matrix contaminated with no more than two radionuclides with different gamma energies that can be transported by conveyor belts. Since limited to gamma-emitting radionuclides; RIM with Th-230 restricts use. Therefore, potentially applicable to 1,000 pCi/gm criteria partial excavation alternative; likely not applicable for 52.9 pCi/gm criteria partial excavation and complete rad removal alternatives.
	Tranportation (hauling of waste material)	Truck	Includes off-road haul trucks that would move materials within a large construction or mining site; semi-trailer bottom-, end-, and side-dump trucks; standard dump; and transfer truck and pup vehicles for transporting loose material such as sand, gravel, asphalt, soil or waste materials on roads and highways.	Potentially applicable. If waste materials were to be transported to an off-site disposal facility, trucks can be used as the sole method of transportation to the facility, or alternatively to transfer materials to another transportation method such as rail. If hauled offsite, wastes with radionuclides must be placed in appropriate containers and USDOT requirements for shipping must be met.

MATCH E MATCH E

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▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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MATCH E MATCH E

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Removal	Tranportation (hauling of waste material)	Rail	Bulk waste material is placed directly into 90-100 ton gondola rail cars if a rail spur is extended on-site; or a truck-to-rail transloading operation is used. Truck-to-rail involves loading of rail cars at a non-shared dedicated rail spur or siding. For loading of bulk material, a back-on transloading ramp is located perpendicular to the rail cars and end dump trucks discharge material into the gondolas after backing onto the ramp. After filling, covers are bolted onto the gondolas to keep the bulk material in-place in route to a disposal facility. Alternatively, end-dump truck trailers can be lined with IP-1 DOT bags, filled with bulk waste material, the bags “zippered” shut, and the bags dumped into a gondola car at the transloading ramp. Another transloading operation involves loading bulk waste material into intermodal containers, hauling the containers on a flat-bed truck to the truck-to-rail transloading station, and stacking multiple intermodal containers on a flat railcar for rail transportation to the disposal facility.	Potentially applicable. Wastes hauled offsite to an offsite licensed facility must be shipped in appropriate containers and USDOT requirements for shipping must be met. Would require lease of nearby rail spur and a truck-to-rail transloading facility as spur does not exist on-site. Extension of a rail spur on-site would be difficult to implement. Number of rail cars per day would be constrained by the length of spur and railroad switching limitations.
	Diposal	Off-site Disposal in licensed facility	This option would involve incorporation of removed material at an existing acceptable permitted commercial disposal facility. Waste must meet the Waste Acceptance Criteria (WAC) of the facility before being transported from the Site.	Currently only four facilities in US that potentially could accept RIM from the Site. Distances to facilities range from 520 to 1,600 miles, likely requiring transportation by rail. Since there is no rail spur at the Site, RIM would need to be trucked from the Site to a truck-to-rail transloading operation set-up at a leased rail spur location for loading onto railcars. Rail transport would require a dedicated fleet of railcars, subject to the switching frequency of the railroad serving the leased rail spur, and a continuous flow of RIM from the Site to the rail spur.
	Storm Water Management	Implement Best Management Practices to route runon around working areas.	Involves use of diversion ditches, earthern berms, culverts, sumps, and pumps if necessary.	Potentially applicable.
		Implement Best Management Practices to minimize waste exposure to direct precipitation.	Involves use of selective excavation, staging, daily soil cover, and tarps.	Potentially applicable.

MATCH F MATCH F

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▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1
Technical Implementability Screening of Remediation Technologies and Process Options
West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

MATCH F

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
Removal	Storm Water Management	▨ Enclose excavation within temporary structure to minimize waste exposure to direct precipitation	Involves use of rigid-frame structure with fabric roofing that can be constructed over the excavation area and moved as work progresses. Maximum width of available structures is 200 feet, but reasonable max width is 140 feet. Length is added in 15-foot segments and is unlimited. Frame height can accommodate arm-height of heavy equipment. Building ends can be open or equipped with access doors. Ventilation can be provided to remove landfill emissions, engine exhaust, and ambient heat. Structure can be segmented such that it can be partially disassembled, lifted by crane to a new location, and reassembled. Foundation must be supported with piers or grade beam. Structures are designed for flat or uniform grade not to exceed 6% along length. Foundation width (side-to-side) must be level, or beam leg height must be adjusted so building does not lean.	Not practical because surface topography of landfills undulates and slope exceeds 6% in some areas. Considerable regrading would be needed to accommodate foundation, exposing organic waste to precipitation. Width of RIM in Areas 1 and 2 plus layback for overburden ranges from 250 to 1,050 feet. Thus, structure would need to be moved several times, overlapping excavated and backfilled areas every time. Even if the available structures could be partially disassembled, relocated, and reassembled, sufficient foundation beams and/or piers would be required to support the new locations. That would necessitate over-excavating soils and trash and/or installing foundation piers on 15-foot centers through base of landfills. Overall timeframe for remediation would be lengthened. Consequently, this option was eliminated from further consideration.
		Implement Best Management Practices to collect, detain, treat, and release runoff.	Involves use of sumps, pumps, pipelines, lined impoundments or temporary storage tanks, outlet structures to regulate discharge rate to design storm flow, and flow and water quality monitoring. If treatment is necessary, conventional processes such as gravity precipitation and/or filtration may be used and NPDES permit or discharge to a POTW would be necessary.	Potentially applicable.
Nuisance Control Technologies	Bird Nuisance Mitigation	Implement Best Management Practices	Involves use of selective excavation techniques to minimize exposure of in-place waste, temporarily staging excavated waste in as small an area as practical, daily cover of waste material with soil or tarp, and rapid recovering of exposed waste whenever practicable.	Particularly applicable to landfill regrading projects.

MATCH F

MATCH G

MATCH G

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▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
MATCH G	MATCH G			
Nuisance Control Technologies	Bird Nuisance Mitigation	▨ Enclose excavation within temporary structure	Involves use of rigid-frame structure with fabric roofing that can be constructed over the excavation area and moved as work progresses. Maximum width of available structures is 200 feet, but reasonable max width is 140 feet. Length is added in 15-foot segments and is unlimited. Frame height can accommodate arm-height of heavy equipment. Building ends can be open or equipped with access doors, but if left open, birds will enter. Ventilation can be provided to remove landfill emissions, engine exhaust, and ambient heat. Structure can be segmented such that it can be partially disassembled, lifted by crane to a new location, and reassembled. Foundation must be supported with piers or grade beam. Structures are designed for flat or uniform grade not to exceed 6% along length. Foundation width (side-to-side) must be level, or beam leg height must be adjusted so building does not “lean”.	Not practical because surface topography of landfills undulates and slope exceeds 6% in some areas. Considerable regrading would be needed to accommodate foundation, exposing organic waste to birds in the process. Width of RIM in Areas 1 and 2 plus layback for overburden ranges from 250 to 1,050 feet. Thus, structure would need to be moved several times, overlapping excavated and backfilled areas every time. Even if the available structures could be partially disassembled, relocated, and reassembled, sufficient foundation beams and/or piers would be required to support the new locations. That would necessitate over-excavating soils and trash and/or installing foundation piers on 15-foot centers through base of landfills. Overall timeframe for remediation would be lengthened. Consequently, this option was eliminated from further consideration.
		Erect wire or monofilament grids over exposed refuse	Involves use of stainless steel wire, monofilament, or Kevlar lines placed in parallel, or in spoke configurations to prevent bird access. Parallel spacings of between 10 and 50 feet should be effective for most birds near site. Lines must be placed above the maximum height of working equipment. Line length would depend on strength of the wire/filament used, poles and pole anchors, and available space for poles.	Potentially applicable. The size of open excavations may limit the constructability of wire or monofilament grids.
		Use of visual deterrents such as predator birds or effigies of predator birds	Involves use of predator birds and/or visual devices such as statues, flags, and kites of predator hawks, eagles, or owls as deterrents for birds.	Potentially applicable. Visual deterrents can be successful short-term, but not long term because birds habituate to the deterrent. Frequent relocation of predatory birds and predator effigies may help, but long-term effectiveness in not assured.
		Use of auditory “frightening” devices such as pyrotechnics, exploders, bird alarm calls, or sound generators.	Involves use of big “bang” devices such as pyrotechnics, cracker shells, racket bombs, screamer shells, whistle bombs, propane exploders, and recordings of bird distress calls. All can be successful short-term to frighten birds away, but over time, birds habituate to the deterrent.	Potentially applicable except for loud “bang” noises that will be a nuisance to nearby land owners, including the Airport Authority. Frequent repositioning and/or altering the timing of auditory activation may help, but long-term effectiveness in not assured.
		▨ Use of EPA-registered chemical frightening agents or toxicants.	Involves use of EPA-registered gull toxicant DRC-1339 and/or Avitrol® . DRC-1339 is applied to bread baits and causes renal failure, killing birds within days of ingestion. Avitrol® is a chemical frightening agent that causes birds to fly erratically and emit distress calls, frightening unaffected birds. Affected birds typically die within 4 hours. Avitrol® has not been formally evaluated for dispersing gulls.	Not likely applicable because killing or disorienting birds does not address the concern about congregating birds within the flight path of aircraft. Consequently, this option was eliminated from further consideration.
MATCH H	MATCH H			

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▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	IMPLEMENTABILITY SCREENING COMMENTS
MATCH H	MATCH H			
Nuisance Control Technologies	Fugitive Dust/Odor Control	Implement Best Management Practices	Involves use of selective excavation techniques to minimize exposure of in-place waste, temporarily staging excavated waste in as small an area as practical, daily cover of waste material with soil or tarp, and rapid recovering of exposed waste whenever practicable.	Particularly applicable to landfill regrading projects.
		Water spray/mist, foam, or other agents	Use of water mist/spray and/or foam agents to reduce dust and mask odors; including temporary misting systems on staged waste piles, water or foam spraying on excavation surfaces or staged waste, and water trucks for dust control on roads.	For exposed waste, water would have minimal effect on odor control, may freeze during cold season, and runoff may need to be collected if not absorbed by the waste. Foam would not present runoff concerns. Foam delivery equipment would need to be setup adjacent to excavations and staged waste areas.
		▨ Enclose excavation within temporary structure	Involves use of rigid-frame structure with fabric roofing that can be constructed over the excavation area and moved as work progresses. (see description above under Bird Nuisance Mitigation)	Not practical for the same reasons discussed above.
		Enclose waste sorting/ loading within temporary structure	For the partial excavation and “complete rad removal” alternatives, excavated waste that would be staged and sorted prior to shipment off-site for disposal would be enclosed within a temporary 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 include ventilation and emissions control facilities to reduce/eliminate fugitive dust and odor concerns associated with staged waste.	Temporary structure would require us of a large area (3-4 acres) of the West Lake Landfill site not within OU-1 and therefore use of and approval of the landowner. Structure would need to be on-site throughout the entire off-site shipping of RIM campaign. Significant lead time needed for procurement of structure and emissions control facilities, site preparation, and structure erection.

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▨ Technology and/or Process Option screened out on the basis of technical implementability.

Figure 4-1

Technical Implementability Screening of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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M:\clients\EMSI\westlake\2016\Final-FS\Section-4\WL-Fig-4-2-Waste-Separation.dwg plotted: 08/03/2016

Legend

MSW	Municipal Solid Waste
C & D	Construction and Demolition

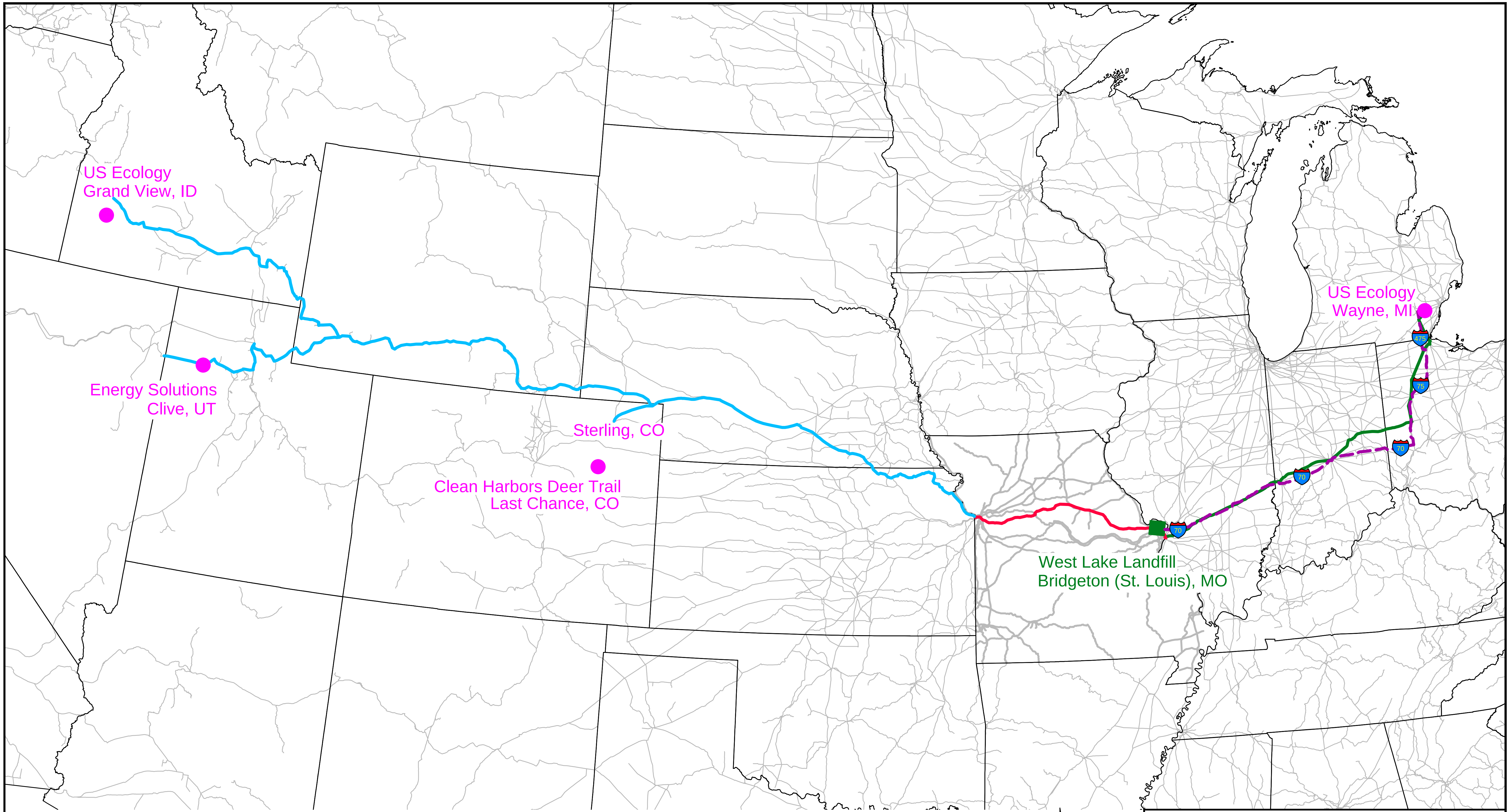
NOT TO SCALE

Figure 4-2

Waste Volume/Size Reduction and Separation Equipment

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



Legend

● Disposal Facility

— Railroad Line

— Norfolk Southern or BNSF Railroad

— Union Pacific Railroad

— CSX Railroad

- - Interstate Truck Route

Figure 4-3

Locations of Potential Off-Site Disposal Facilities and Rail Points

West Lake Landfill OU-1 Final Feasibility Study

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
No Action	See Figure 4-2 in FS (EMSI, 2006)					
Institutional Controls	See Figure 4-2 in FS (EMSI, 2006)					
Monitoring	Long-term performance monitoring	Groundwater, surface water, sediment, landfill gas, and radon gas monitoring	Effective at determining whether there is any migration of contamination from soil or landfilled areas to groundwater, surface water, and sediment as well as verifying if any remedy is performing as required.	Easily implemented; resources are readily available.	Low capital and low to moderate O&M costs.	Would be implemented under monitoring program.
	Short-term monitoring during construction	Perimeter environmental media air monitoring	For airborne particulates, volatile organics, and radon, effective at documenting background conditions prior to, during, and after remedy implementation. Multiple monitoring stations may be required.	Easily implemented; resources are readily available.	Relatively high capital costs to establish power at monitoring station. Can be high O&M costs depending on parameters requiring analyses in off-site laboratory.	Would be implemented under monitoring program.
		Work zone monitoring	Effective at monitoring exposures of workers to radionuclides and contaminants that may be in airborne particulates.	Easily implemented using various portable, hand-held, passive and breathing zone monitoring devices and equipment. Worker participation in medical monitoring program may be required.	Low capital for dosimeter badges. Most other equipment can be rented.	Would be implemented under monitoring program.
		Excavation guidance/ clearance monitoring	For radionuclides and indirectly for volatile organics, effective for assessing presence of, location/extent, and relative concentration of waste materials. Provides real-time information for decisions during waste excavation projects. Monitoring for metals and semi-volatile organics would require analysis at off-site laboratory and delay excavation.	Easily implemented. Real-time monitoring and sampling equipment and supplies are readily available.	High capital costs for some portable radionuclide survey equipment and on-site laboratory, if needed. Low O&M costs.	Would be implemented under monitoring program.

MATCH A

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Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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MATCH A

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
	Short-term monitoring during construction	Waste acceptance monitoring	Effective at assessing whether a container of waste meets off-site disposal facility acceptance criteria before waste material is shipped off-site. Results of field monitoring devices may need to be verified with samples analyzed in off-site laboratory.	Easily implemented with standard, readily-available equipment. Will require profile sampling and preparation/signature of waste manifests prior to shipment.	Low capital and O&M costs (unless laboratory confirmation required).	Would be implemented under monitoring program.
		Post cover construction radon flux monitoring	Effective at measuring radon flux of the cover surface of tailings piles and landfills.	Easily implemented with Large Area Activated Charcoal Canisters (LAACCs).	No capital and low O&M. LAACCs are rented from the analytical laboratory.	Would be implemented under monitoring program.
Containment	See Figure 4-2 in FS (EMSI, 2006) for Surface Controls/Diversions, Surface Water/Sediment Control/Barriers, and Dust Controls					
	Capping and Covers[1,2]	Soil, clay, and vegetation; asphalt or concrete; synthetic membrane material; and multilayer, multimedia material	Caps and covers can effectively limit airborne emissions (including radon) and external gamma radiation, and they can also reduce precipitation-enhanced percolation and leaching.	Can be easily implemented with conventional equipment and procedures. Resources are readily available. Consideration must be given to settlement of filled materials in OU-1 after a cover is placed. Surface depressions must be filled-in.	Moderate to high capital costs, depending on type of cover. Low maintenance and monitoring costs.	Soil, clay and vegetation layer covers retained. Asphalt or concrete covers screened-out because of potential settlement concerns if a cover were to be placed over Areas 1 and 2. Synthetic membrane and multilayer/multimedia material covers screened out because they are inconsistent with the existing landfill cover requirements.
	Land Encapsulation[2]	Off-site Licensed Facility[2]	Can effectively remove the source of contamination to limit contaminant mobility and volume at the affected area and reduce related exposures.	Difficult to implement; potentially only three facilities in U.S. will accept wastes. Will require construction of an on-site rail spur or truck-to-railcar transfer facility. Will require transportation of radiologically-impacted materials by truck and railroad and the attendant risks.	High	Associated with Excavation and Transportation.

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Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
Physical/Chemical Treatment	Solidification/ Stabilization[2]	Cement Solidification/ Stabilization[2]	Effective at reducing mobility of hazardous and radioactive contaminants.	Cement solidification/stabilization is best suited to highly porous, coarse-grained, permeable soils. Would be difficult to implement in-situ because of the nature of the matrix of landfilled refuse, debris and fill materials, soil, and quarry spoils. Easily implemented ex-situ at permitted off-site disposal facility prior to disposal of hazardous or mixed wastes if hazardous wastes encountered during excavation of RIM in Areas 1 and 2.	Moderate capital costs.	Would only be relevant if hazardous wastes were encountered during surface regrading or excavation of RIM in Areas 1 and 2.
		Chemical Solidification/ Stabilization[2]	Effective at reducing mobility of hazardous and radioactive contaminants.	Chemical solidification/stabilization best suited to fine-grained soil with small pores. Macroencapsulation is used for immobilizing low-level radioactive and mixed debris waste with dimensions greater than or equal to 2.5 inches while microencapsulation used to solidify wastes with smaller particles. Would be difficult to implement in-situ because of the nature of the matrix of landfilled refuse, debris and fill materials, soil, and quarry spoils. Easily implemented ex-situ at permitted off-site disposal facility prior to disposal of hazardous or mixed wastes if hazardous wastes encountered during excavation of RIM in Areas 1 and 2.	Moderate capital costs.	Would only be relevant if hazardous wastes were encountered during surface regrading or excavation of RIM in Areas 1 and 2.

MATCH C

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Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

MATCH C

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
Physical/Chemical Treatment	Physical Separation[2]	Dry Soil Separation[2]	Could potentially be effective at reducing volume of RIM by separating the soil materials containing radionuclides from the overall matrix of landfilled refuse, debris and fill materials, and unimpacted soil and quarry spoils if full-scale pilot-testing indicates that radionuclide concentrations in samples of the non-soil fraction of RIM that is discharged from the screening process would allow for unrestricted use of the non-soil fraction. If soil materials containing radionuclides remain adhered to the segregated refuse because of moisture content or other reasons, a separation process would not be effective. The effectiveness and degree of separation that may be achieved is uncertain until pilot-testing results are obtained. RIM matrix may require drying to improve separation effectiveness.	Pilot-testing using representative material from Areas 1 and/or 2 would be needed to determine the site-specific implementability. Equipment is readily available. Shear shredding pretreatment step prior to separation screening would be required. In maintaining the separation screening equipment, workers would be exposed to increased radiation emitted by RIM that adheres to the screen. 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. Use of separation equipment could extend the overall project schedule and increase the potential or amounts of stormwater accumulation, airborne (dust) emissions, and bird or other vector impacts due to a possible increase in the overall schedule.	High capital cost. High operating costs.	Full-scale pilot-testing using representative material from Areas 1 and/or 2 would need to be conducted as a pre-design study early in the Remedial Design schedule.
Removal	Excavation	Backhoe, bulldozer, scraper and front-end loader	Can effectively remove the source of contamination to limit contaminant mobility and volume at the affected area and reduce related exposures.	Can be implemented with conventional equipment and procedures, and resources are available. Consideration must be given to type and composition of material to be excavated and excavations at depths greater than 25 feet, as special excavation equipment may be required.	Cost dependent on material properties. Moderate if shallow. High if deep.	None.
	Physical Separation	Dry Soil Separation	Would potentially be effective at reducing volume of RIM if pilot testing shows that the activity of the separated non-soil MSW would be less than the activity criteria for the respective complete rad removal or partial excavation alternative.	Interstitial soil materials need to be separated from MSW using solids separation process (handpicking, magnetic and eddy current separation, air classification, screens).	Moderate to high capital costs, high operating costs.	Pilot testing of various methods needed during remedial design.

MATCH D

MATCH D

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Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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MATCH D

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
Removal	Physical Separation	Rotating Screen - Trommel	Would potentially be effective at reducing volume of RIM if pilot testing shows that the activity of the separated non-soil MSW would be less than the activity criteria for the respective complete rad removal or partial excavation alternative.	Shredding pretreatment needed prior to rotating screen to reduce size of larger materials. Materials such as rebar and plastics can jamb or clog rotating screen requiring workers to enter screen to remove, which would interrupt production. Full scale pilot testing using representative materials excavated from West Lake OU-1 required.	High capital and operating costs.	Air borne dust would be generated during shredding and screening activities if excavated materials are dry. Increased worker exposure when removing materials from clogged screen. Pilot testing needed during remedial design.
		Radiological Segregation/ Separation	Would potentially be effective at reducing volume of RIM if pilot testing shows that the activity of the separated non-soil MSW would be less than the activity criteria for the respective complete rad removal or partial excavation alternative. Effective for gamma emitting radionuclides only.	Materials greater than 1.5 inches would need to be hand-picked out, screened-out or crushed. Optimal soil moisture content of between 5 and 15% needed. Limited to analysis of 2 radionuclides at a time.	High capital and operating costs.	Likely not applicable for 7.9 pCi/g complete rad removal and 52.9 pCi/g partial excavation alternatives, may be applicable for 1,000 pCi/g partial excavation alternative. Pilot testing needed during remedial design.
	Transportation (hauling of waste material)	Truck	With the numerous types of trucks available, effective for hauling of waste materials over all types of terrain and distances.	Easily implemented. Can be mobilized quickly. Depending on the characteristics of the waste material, truck beds may require lining or the waste may need to be transported in special containers. Federal, State, and local laws limit weight that can be carried on roads (depending on type of truck and characteristics of road).	Relatively cost-effective, plenty of competition available. Truck hauling is typically the only option to haul materials short distances. Not cost-effective for hauling large volumes/weights of materials long distances.	Except for maybe the US Ecology - Michigan location, eliminated for hauling of radiologically-impacted materials to off-site disposal facilities because of long distances.

MATCH E

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[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
MATCH E	MATCH E					
Removal	Transportation (hauling of waste material)	Rail	Effective for hauling of waste materials over long distances or heavy volumes locally.	Difficult to implement. Would require truck-to-rail transfer and lease of nearby rail spur or extension of a rail spur onto the Site. Construction of new spur on-site would require land purchase or lease and coordination with local agencies and the railroad. Rate of waste transport via rail would be dependent on length of rail spur, number of switches provided by the railroad per week, and availability of specialty railcars for waste transport.	Cost-effective for hauling large volumes/weights long distances.	None.
	Disposal	Off-site disposal in a licensed facility	Can effectively remove the source of contamination to limit contaminant mobility and volume at the affected area and reduce related exposures.	Logistically more difficult to implement if a rail spur is not on-site. Will require construction of an on-site rail spur and crossing across St. Charles Rock Rd or a truck-to-rail transloading facility at a nearby rented rail spur. Depending on disposal facility selected, RIM may need to be staged and blending prior to loading into trucks or railcars.	High costs.	Risk of accidents associated with truck and rail transportation. Significant amount of greenhouse gases emitted during transportation to disposal facility.
	Storm Water Management	Implement Best Management Practices to route runon around working areas.	Effective in the short-term and long-term.	Easily implementable. Relies on use of conventional construction equipment and materials.	Low capital and O&M cost.	Would be implemented as part of RA and O&M.
		Implement Best Management Practices to minimize waste exposure to direct precipitation.	Would be effective during excavation if the RIM was being removed.	Easily implementable. Relies on use of conventional construction equipment and materials.	Moderate O&M cost.	Would be implemented as part of RA.
		Implement Best Management Practices to collect, detain, treat, and release runoff.	Effective during excavation while the RIM is being removed.	Easily implementable. Relies on use of conventional construction equipment and materials.	Moderate capital and O&M cost.	Would be implemented as part of RA.

Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
Nuisance Control Technologies	Bird Nuisance Mitigation	Implement Best Management Practices	Effective means to minimize waste exposure opportunity for birds.	Can be implemented as part of an excavation program.	Low-moderate cost, depending on size of waste area to be covered.	Potentually effective.
		Erect wire or monofilament grids over exposed refuse.	May be effective deterrent with adequate grid spacing and pole placement.	Can be implemented with parallel spacings of between 10 and 50 feet. Line height can be 10-15 feet above the starting grade for Areas 1 and 2 if scrapers are used to strip overburden. Line length depends on strength of the wire/filament used and available space for poles and pole anchors. Should be able to implement with conventional wire, poles, construction equipment, and labor.	Cost dependent on wire/monofilament used, grid spacing, and height. Moderate capital cost if parallel spacings >15 feet and pole height <15 feet.	More effective if combined with visual and/or auditory deterrents.
		Use of visual deterrents such as predator birds or effigies of predator birds	May be effective short-term in one position, but long-term (greater than several months) effectiveness will require frequent repositioning.	Can be implemented with commercially-available effigies of predator birds mounted on poles and/or onsite buildings.	Low capital and O&M cost.	More effective if combined with auditory deterrents and/or overhead wire grid.
		Use of auditory "frightening" devices such as pyrotechnics, screamer whistles, and bird distress calls.	May be effective short-term in one position, but long-term (greater than several months) effectiveness will require frequent repositioning and altering of timing of activation.	Can be implemented with commercially-available sound devices that can be mobilized to new locations.	Low capital and O&M cost.	More effective if combined with visual deterrents and/or overhead wire grid.
	Fugitive Dust/Odor Control	Implement Best Management Practices	Effective for minimizing dust on exposed surfaces, but little effect with respect to odor.	Easily implementable using conventional materials, but depending on construction schedule requirements, may be difficult to constantly move tarps to minimize exposed surfaces.	Low to moderate cost, depending on size of waste area to be covered.	Would be implemented in areas where MSD is exposed.

MATCH G

MATCH G

[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	SCREENING COMMENTS
MATCH G	MATCH G					
Nuisance Control Technologies	Fugitive Dust/Odor Control	Water spray/mist, foam, or other agents	Water effective for fugitive dust, particularly on roads, little effectiveness for odor. Foam would be effective for minimizing dust and odor on excavated surfaces and staged waste.	Sprayed water or mist could runoff sloped excavation.	Water: low cost. Foam: moderate cost.	Foam covering of exposed waste in excavation and staged material would assist with bird mitigation. For alternatives where recently-filled materials from the North Quarry portion of the Bridgeton Landfill in the southeast area of Area 1 need to be excavated and stockpiled to access RIM, foaming of surfaces of open excavations and stockpiles might be desirable to address odors.
		Enclose waste sorting/ loading within temporary structure	Effective for addressing fugitive dust and odor associated with excavated RIM staged for off-site disposal, not effective for open excavations.	Easily implemented with standard construction equipment and personnel. Would require an approximate 4-acre open area on the West Lake Landfill Site that is not located on fill. Long lead time from placement of order to delivery on-site. Would require ventilation exhaust air treatment for odor control.	Very high capital and O&M costs.	Would eliminate precipitation on as well as odor to the public from excavated RIM staged for off-site disposal and eliminate bird nuisance concerns associated with staged RIM.

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[1] Indicates that General Response Action or remedial technology is component of presumptive remedy for CERCLA municipal landfill sites (USEPA, 1993)

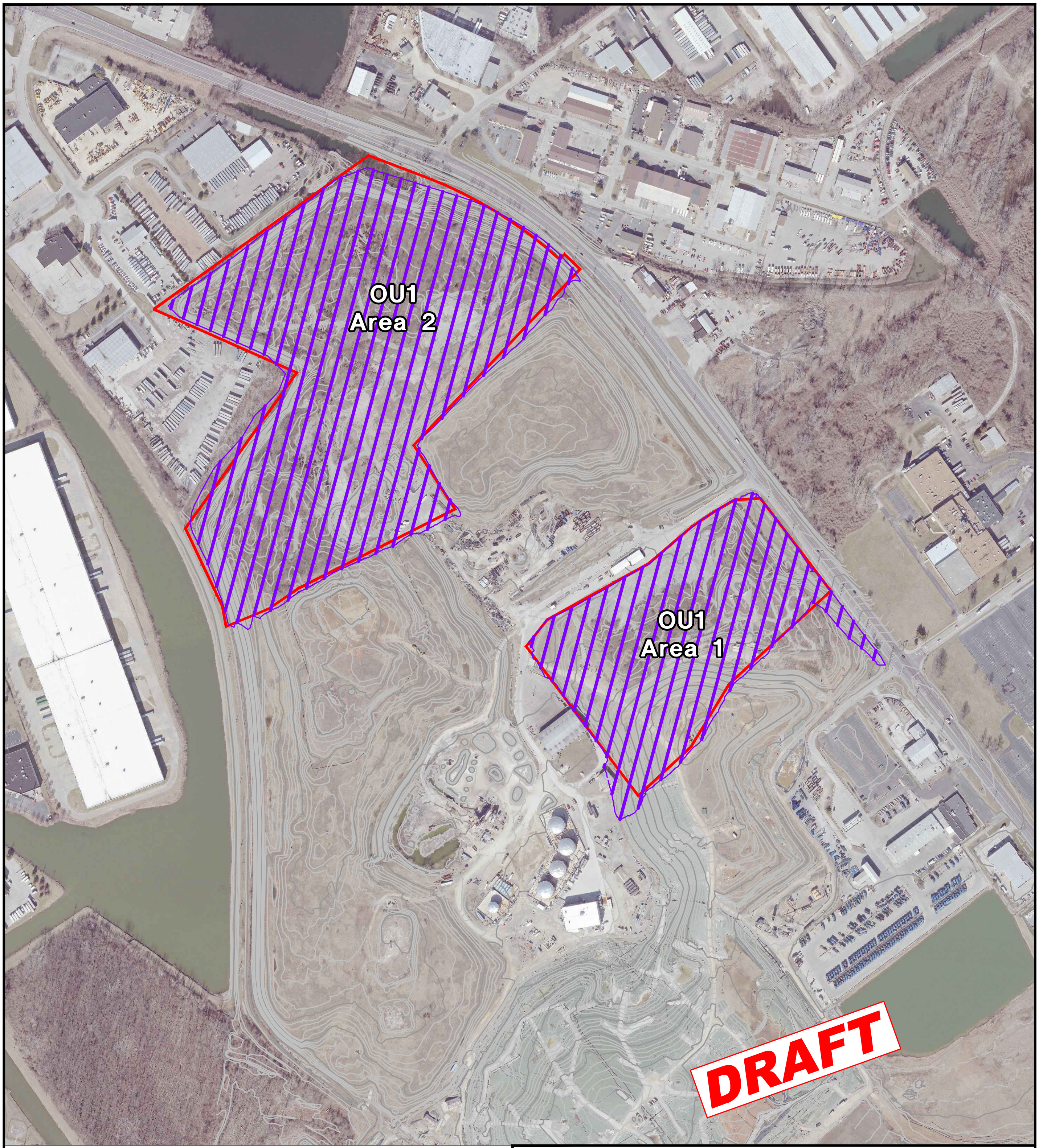
[2] Treatment technology or remedial technology specified in Technology Reference Guide for Radioactively Contaminated Media, EPA 402-R-07-004, October 2007.

Figure 4-4

Evaluation of Remediation Technologies and Process Options

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

🟥 OU-1 AREA BOUNDARY

▨ Extent of Cover

FROM FEEZER ENGINEERING 2011

Figure 5-1

Extent of ROD - Selected Remedy Landfill Cover

West Lake Landfill OU-1 Final Feasibility Study

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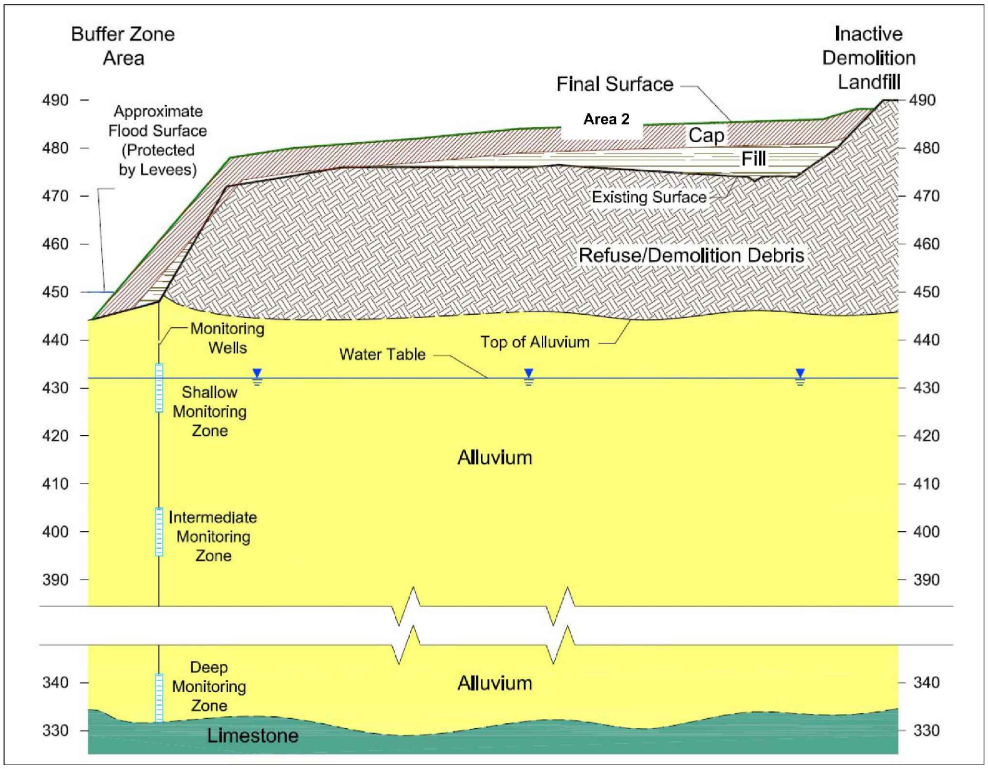
M:\clients\EMSI\westlake\2016\Final-FS\Section-5\WL-Fig-5-1-Extent-ROD.dwg 4/14/2015



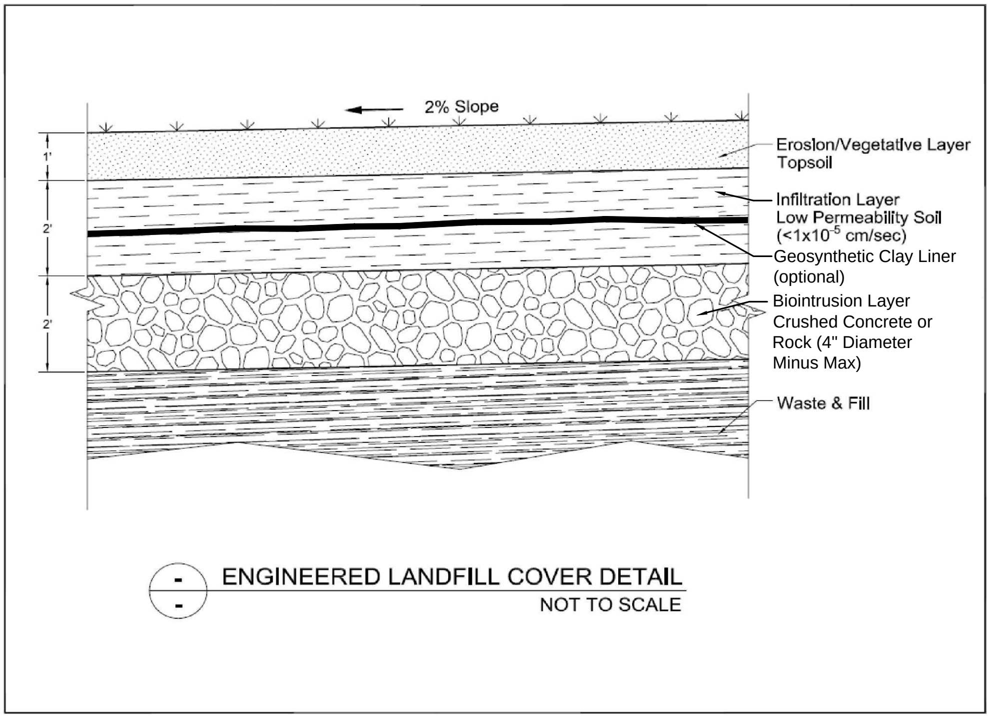


Figure 5-2

Conceptual Cross-Section of the ROD Remedy

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-5\WL-Fig-5-2-Concept-Xsec.dwg plotted: 12/15/2016

Figure 5-3

Potential Material Stockpile Areas

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FROM FEEZER ENGINEERING 2011

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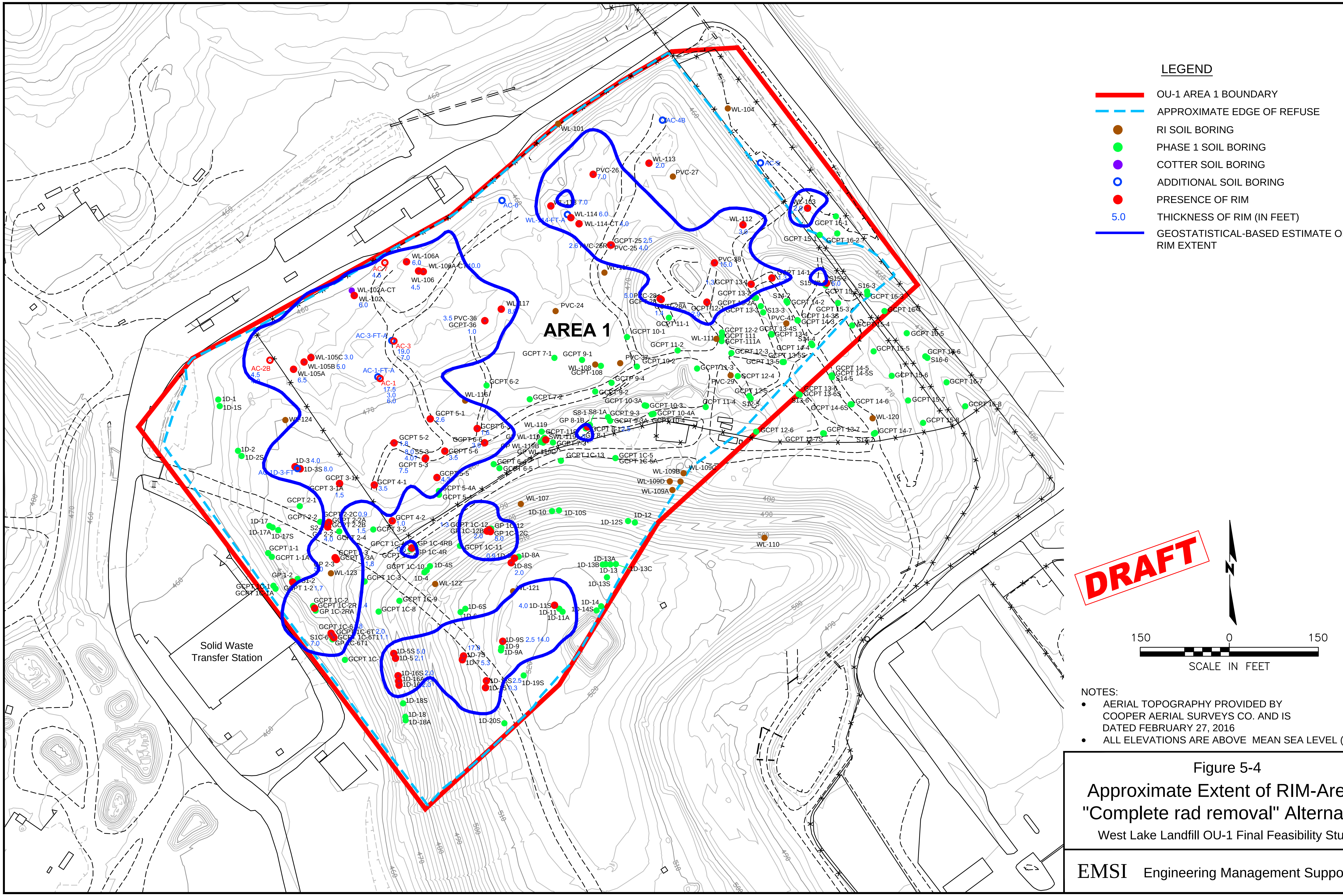


LEGEND

🟥 OU-1 AREA 1 BOUNDARY
- - APPROXIMATE EDGE OF REFUSE
● RI SOIL BORING
● PHASE 1 SOIL BORING
● COTTER SOIL BORING
○ ADDITIONAL SOIL BORING
● PRESENCE OF RIM
5.0 THICKNESS OF RIM (IN FEET)
— GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED FEBRUARY 27, 2016
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

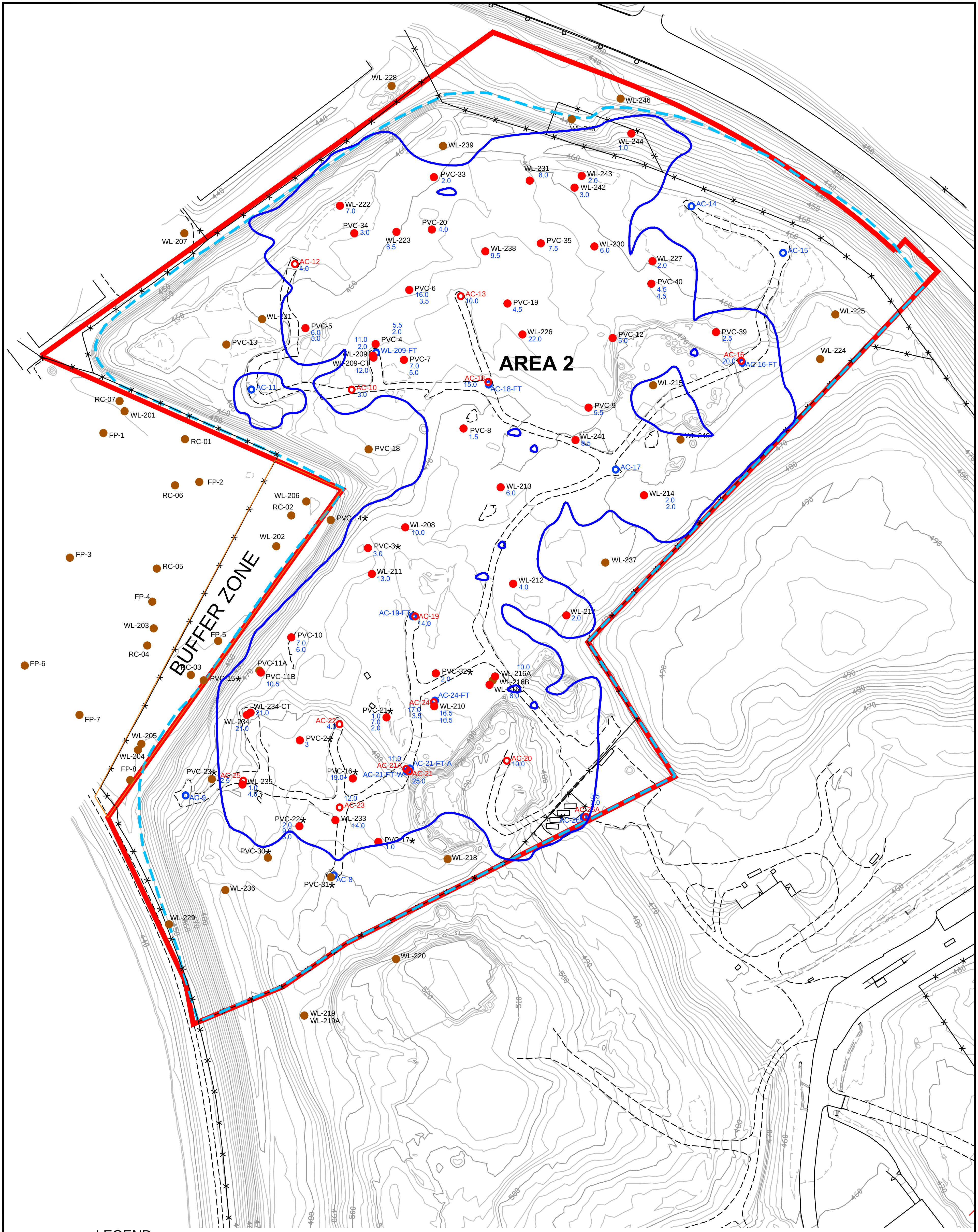
Figure 5-4

Approximate Extent of RIM-Area 1 "Complete rad removal" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-5\FIG-5-4_5-5-Extent-RIM.dwg



LEGEND

🟥	OU-1 AREA 2 BOUNDARY
- - -	APPROXIMATE EDGE OF REFUSE
*	LOCATION APPROXIMATE-NO SURVEY DATA AVAILABLE
●	RI SOIL BORING
●	COTTER SOIL BORING
○	ADDITIONAL SOIL BORING
●	PRESENCE OF RIM
5.0	THICKNESS OF RIM (IN FEET)
—	GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

DRAFT

NOTES:
- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED FEBRUARY 27, 2016
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

N

200 0 200

SCALE IN FEET

Figure 5-5

Approximate Extent of RIM-Area 2 "Complete rad removal" Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

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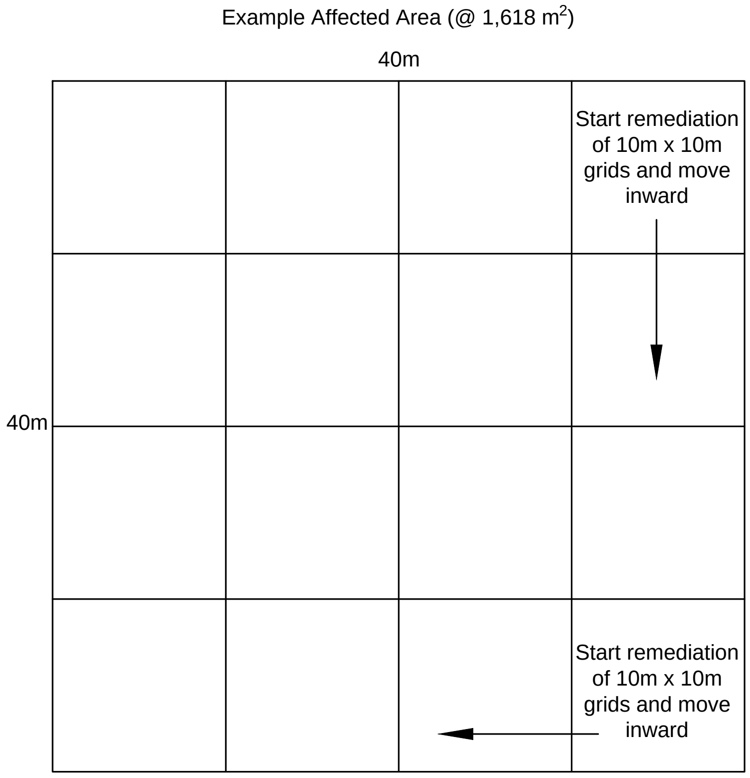
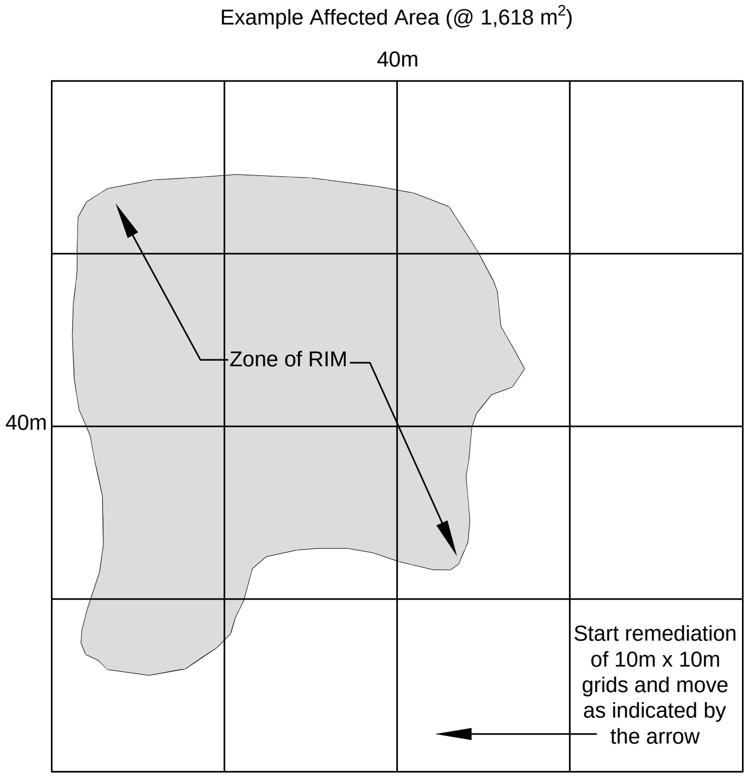


The soil would be excavated from the boundary inward, allowing movement of the hauling equipment closer to the excavator to try to increase efficiency and prevent the spread of contamination.

Example of Excavation Plan Logistics



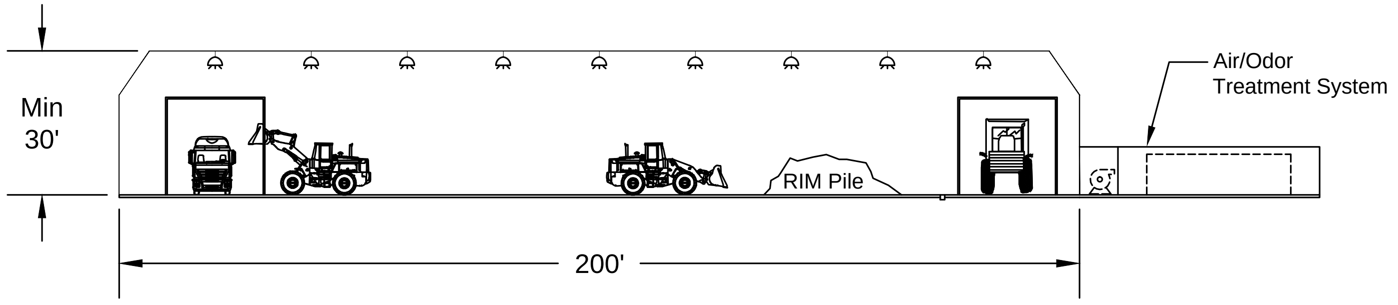
Continue Excavation Along Edges of RIM

Figure 5-6

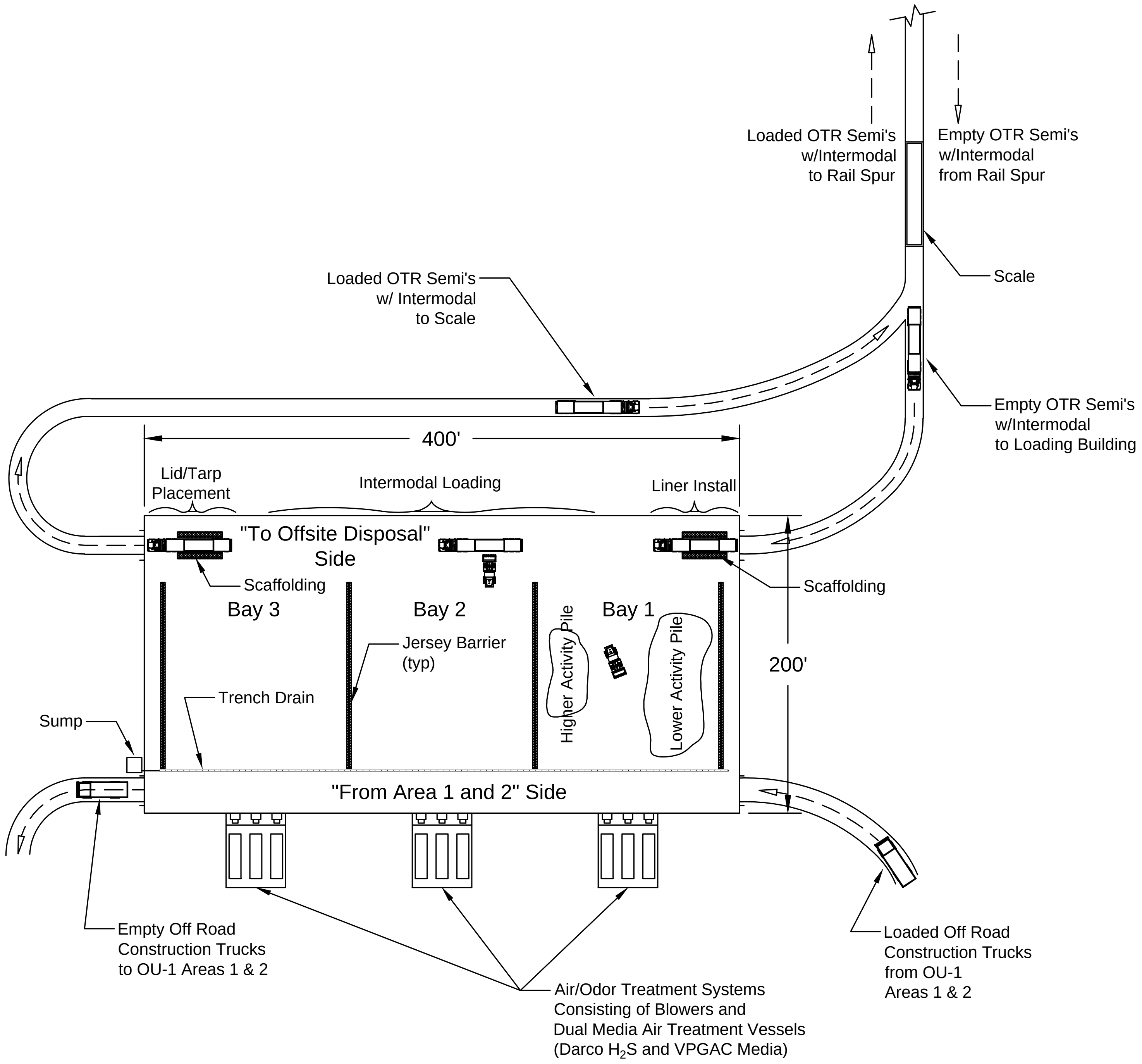
RIM Excavation Sequencing

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.

Figure 5-7

RIM Staging and Loading Building Layout

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

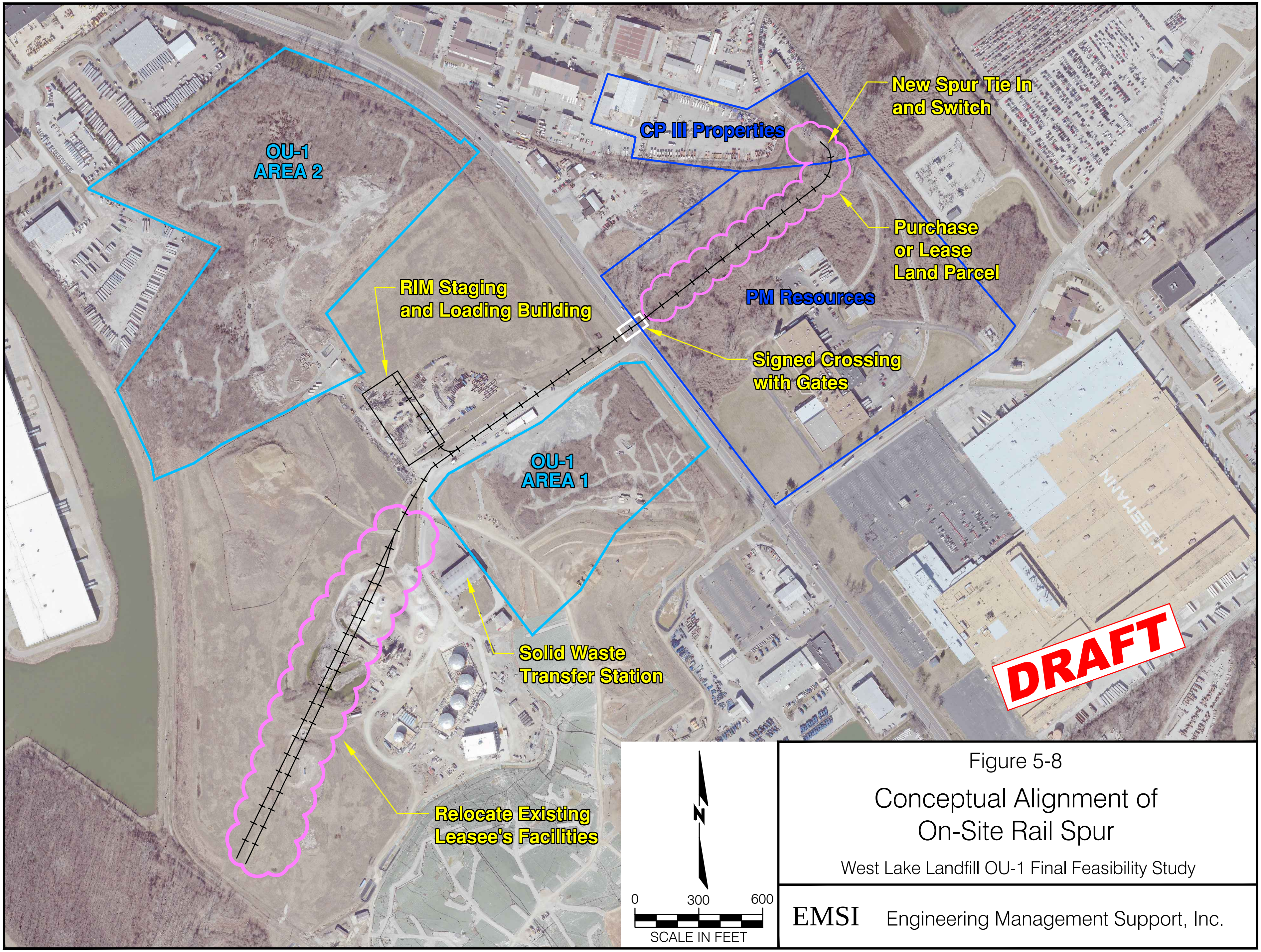


Figure 5-8

Conceptual Alignment of On-Site Rail Spur

West Lake Landfill OU-1 Final Feasibility Study

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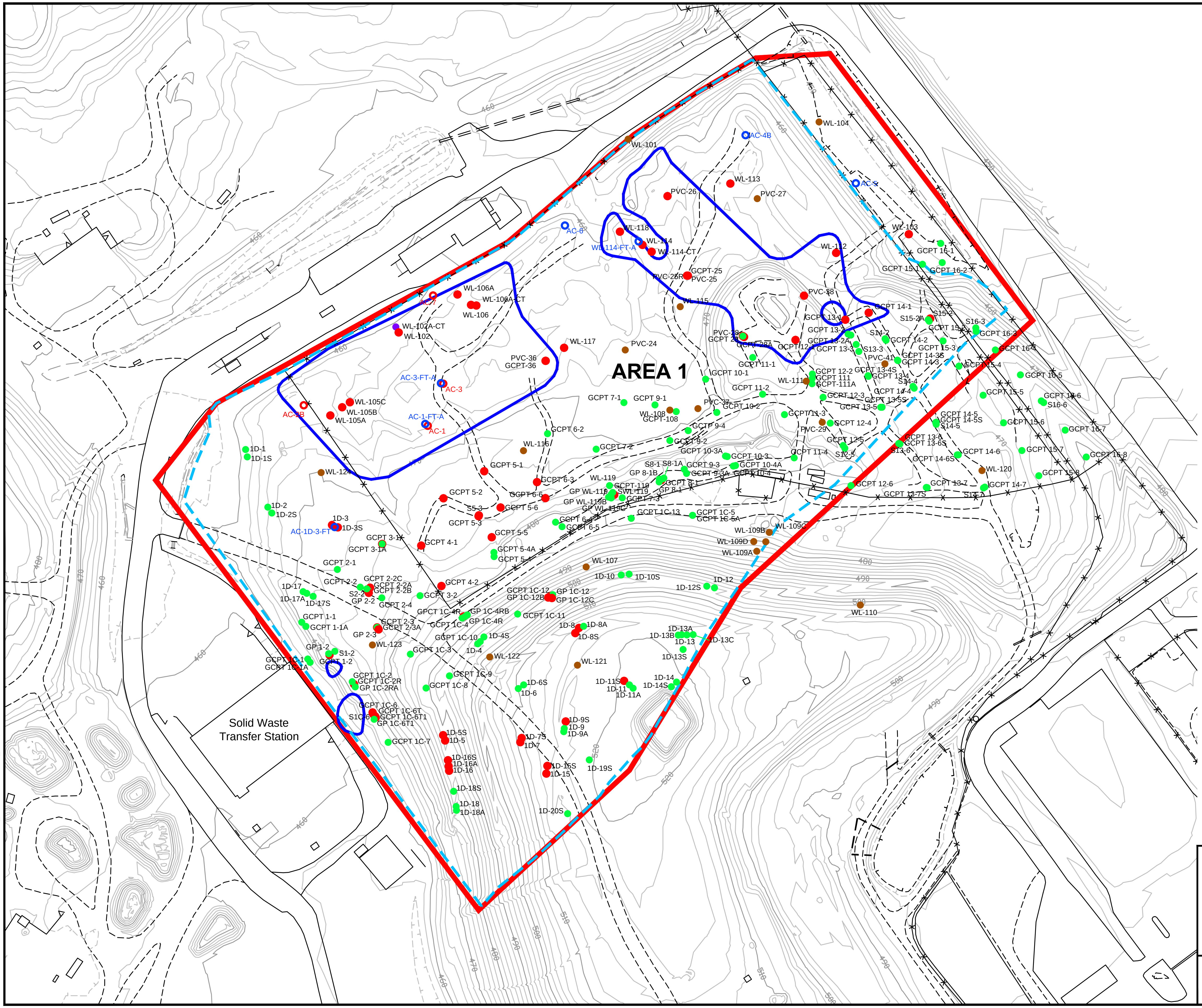

M:\clients\EMSI\westlake\2016\Final-FS\Section-5\FIG-5-9_5-10-Extent-RIM-52_9.dwg

LEGEND

▬ OU-1 AREA 1 BOUNDARY
- - APPROXIMATE EDGE OF REFUSE
● RI SOIL BORING
● PHASE 1 SOIL BORING
● COTTER SOIL BORING
○ ADDITIONAL SOIL BORING
● PRESENCE OF RIM
▬ GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

DRAFT

N

150 0 150
SCALE IN FEET

NOTES:
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- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

Figure 5-9

Approximate Extent of RIM-Area 1 52.9 pCi/g Partial Excavation Alternative

West Lake Landfill OU-1 Final Feasibility Study

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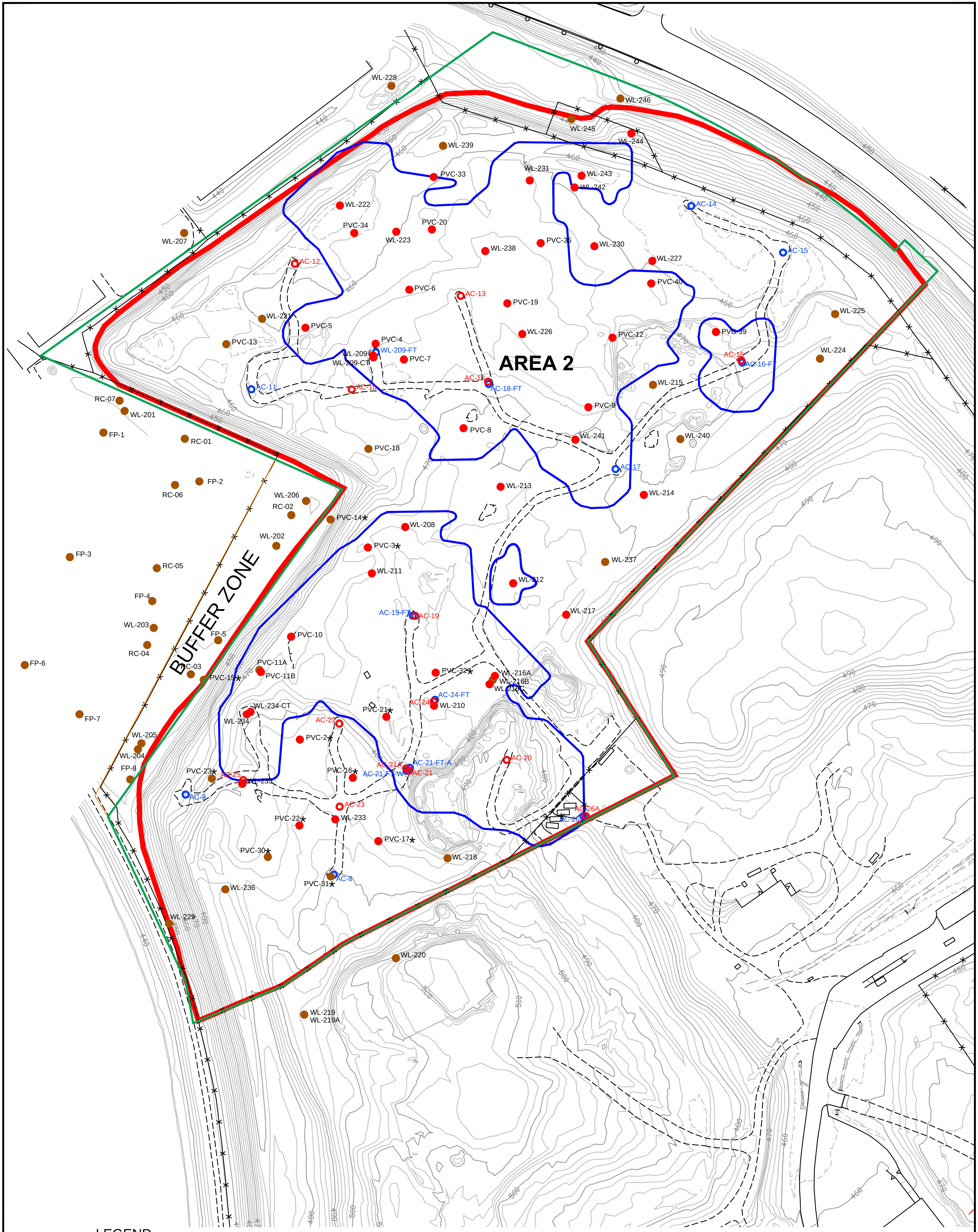

LEGEND

- 🟥 OU-1 AREA 2 BOUNDARY
- APPROXIMATE EDGE OF REFUSE
- * LOCATION APPROXIMATE-NO SURVEY DATA AVAILABLE
- ● RI SOIL BORING
- ● COTTER SOIL BORING
- ○ ADDITIONAL SOIL BORING
- ● PRESENCE OF RIM
- GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

NOTES:
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- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

200 0 200

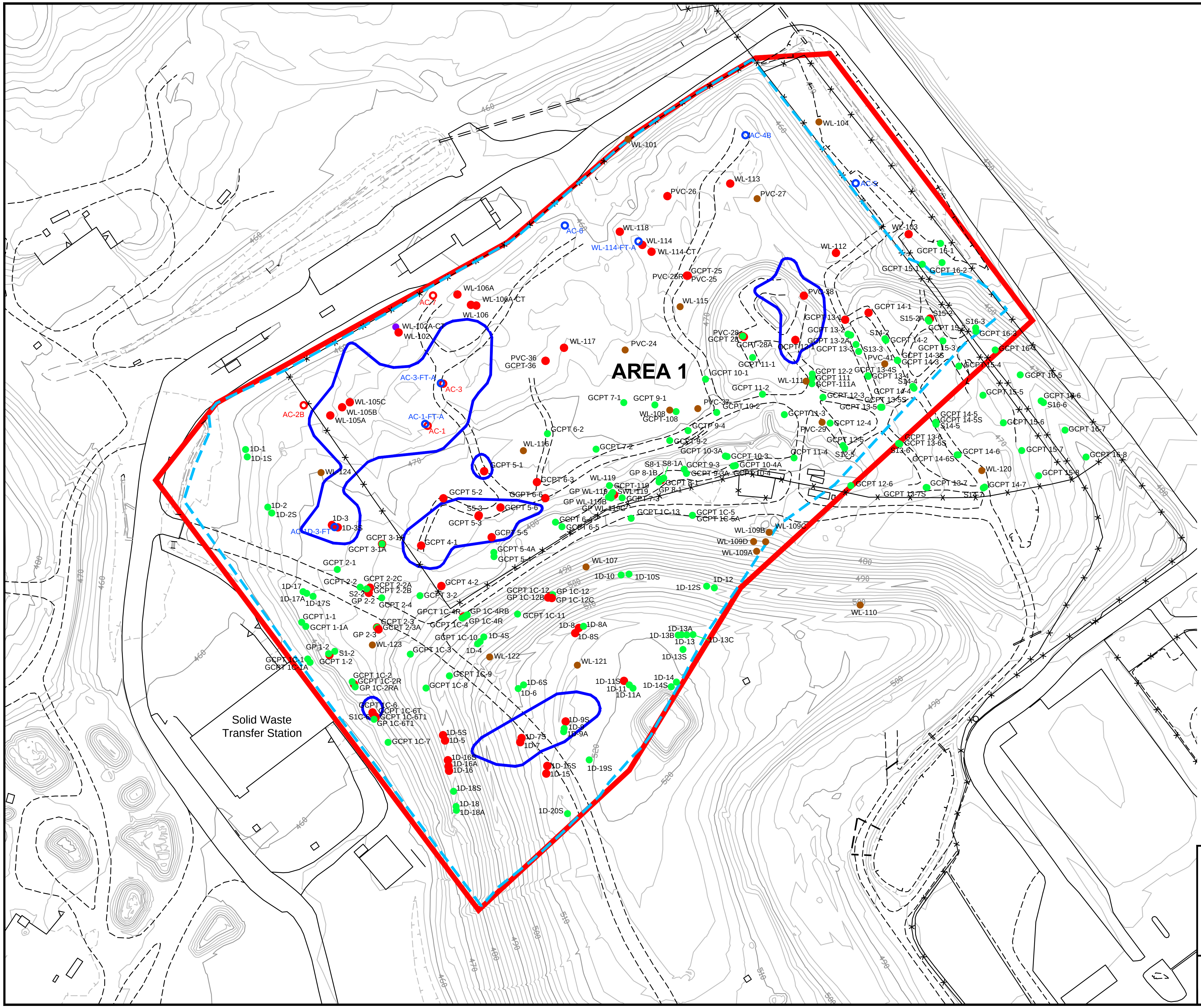
SCALE IN FEET

Figure 5-10

Approximate Extent of RIM-Area 2 52.9 pCi/g Partial Excavation Alternative

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.



LEGEND

🟥 OU-1 AREA 1 BOUNDARY

APPROXIMATE EDGE OF REFUSE

● RI SOIL BORING

● PHASE 1 SOIL BORING

● COTTER SOIL BORING

○ ADDITIONAL SOIL BORING

● PRESENCE OF RIM

GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

NOTES:

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- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

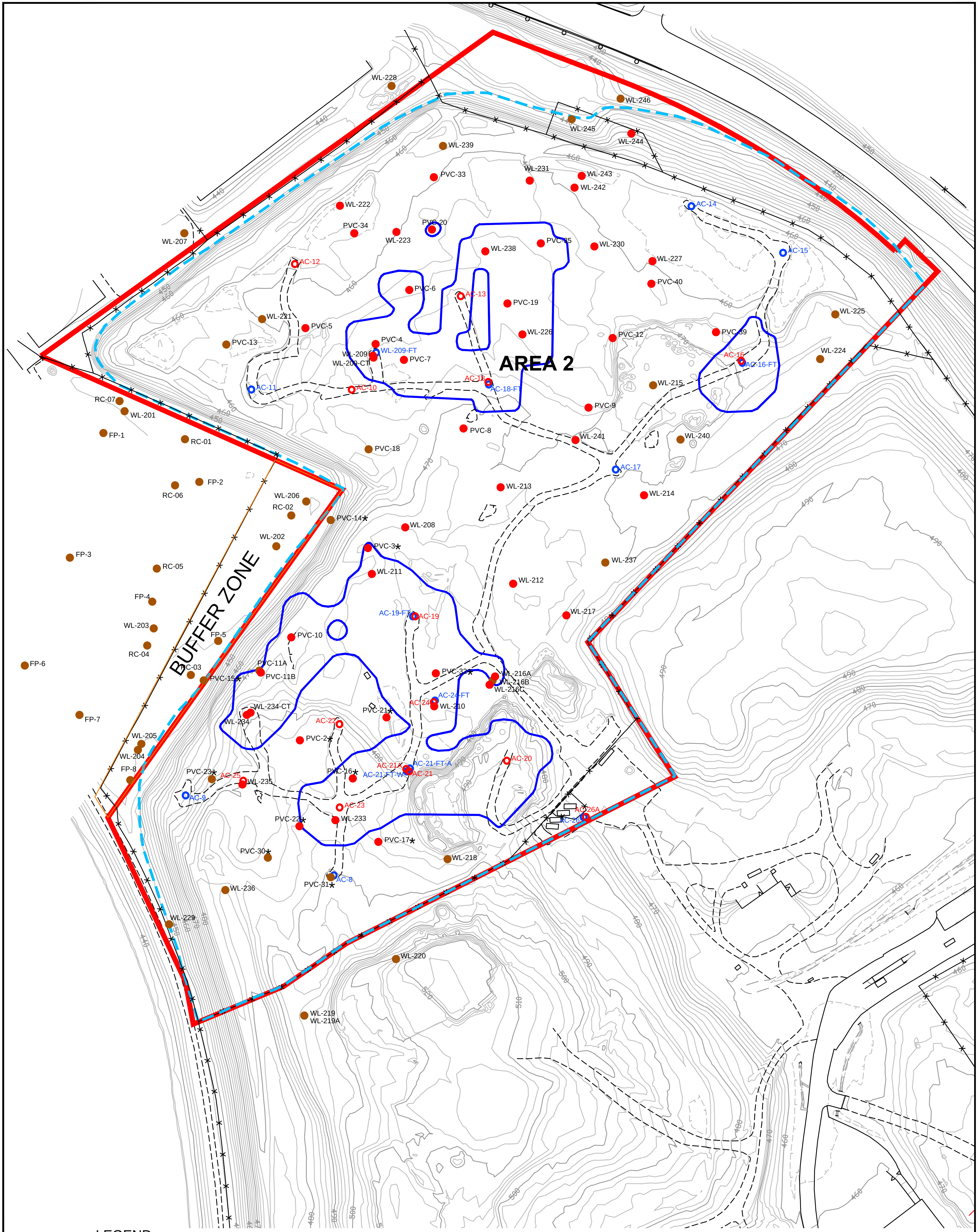
Figure 5-11

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\2016\Final-FS\Section-5\FIG-5-11_5-12-Extent-RIM-1000.dwg



LEGEND

▬	OU-1 AREA 2 BOUNDARY
- -	APPROXIMATE EDGE OF REFUSE
*	LOCATION APPROXIMATE-NO SURVEY DATA AVAILABLE
●	RI SOIL BORING
●	COTTER SOIL BORING
○	ADDITIONAL SOIL BORING
●	PRESENCE OF RIM
▬	GEOSTATISTICAL-BASED ESTIMATE OF RIM EXTENT

DRAFT

NOTES:
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- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

N

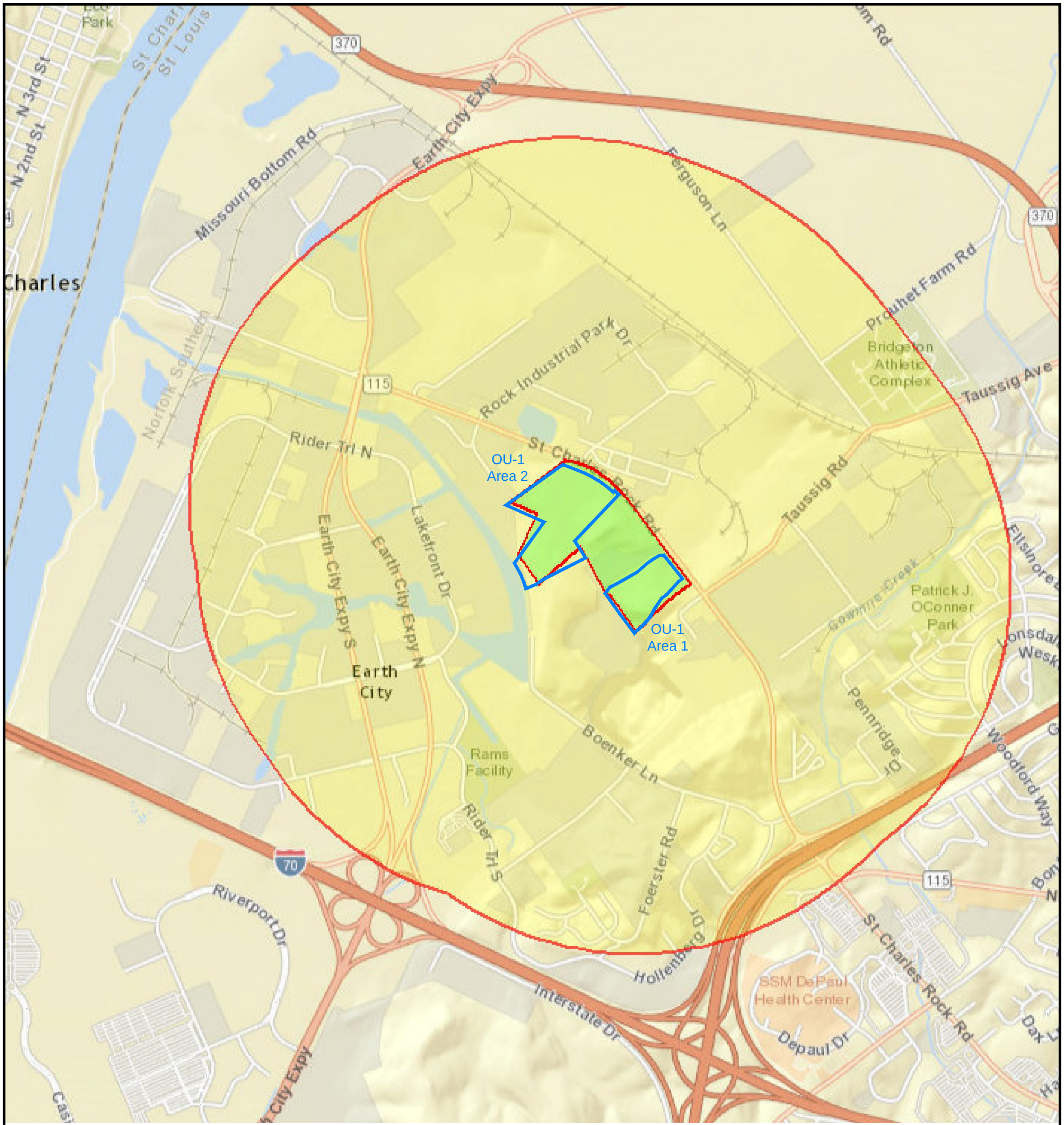
200 0 200
SCALE IN FEET

Figure 5-12

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.



August 13, 2016

🟩 Digitized Polygon

🟨 Buffer Area

1:36,112

0 0.3 0.6 1.2 mi

0 0.5 1 2 km

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

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Figure 6-1

1 Mile Radius Buffer

West Lake Landfill OU-1 Final Feasibility Study

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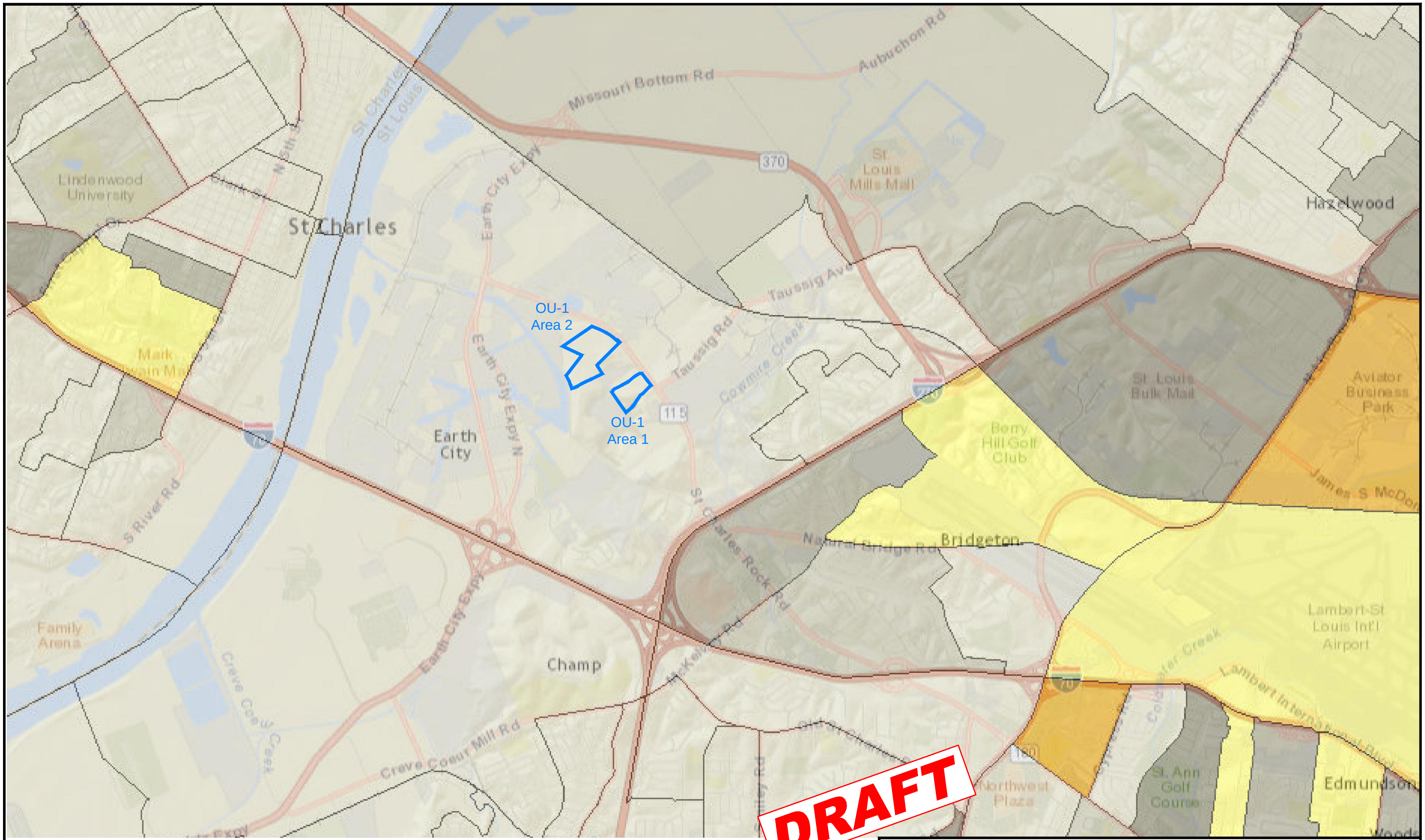
M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-1_1mile-Radius.dwg

M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-2_Demographic-Index.dwg



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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

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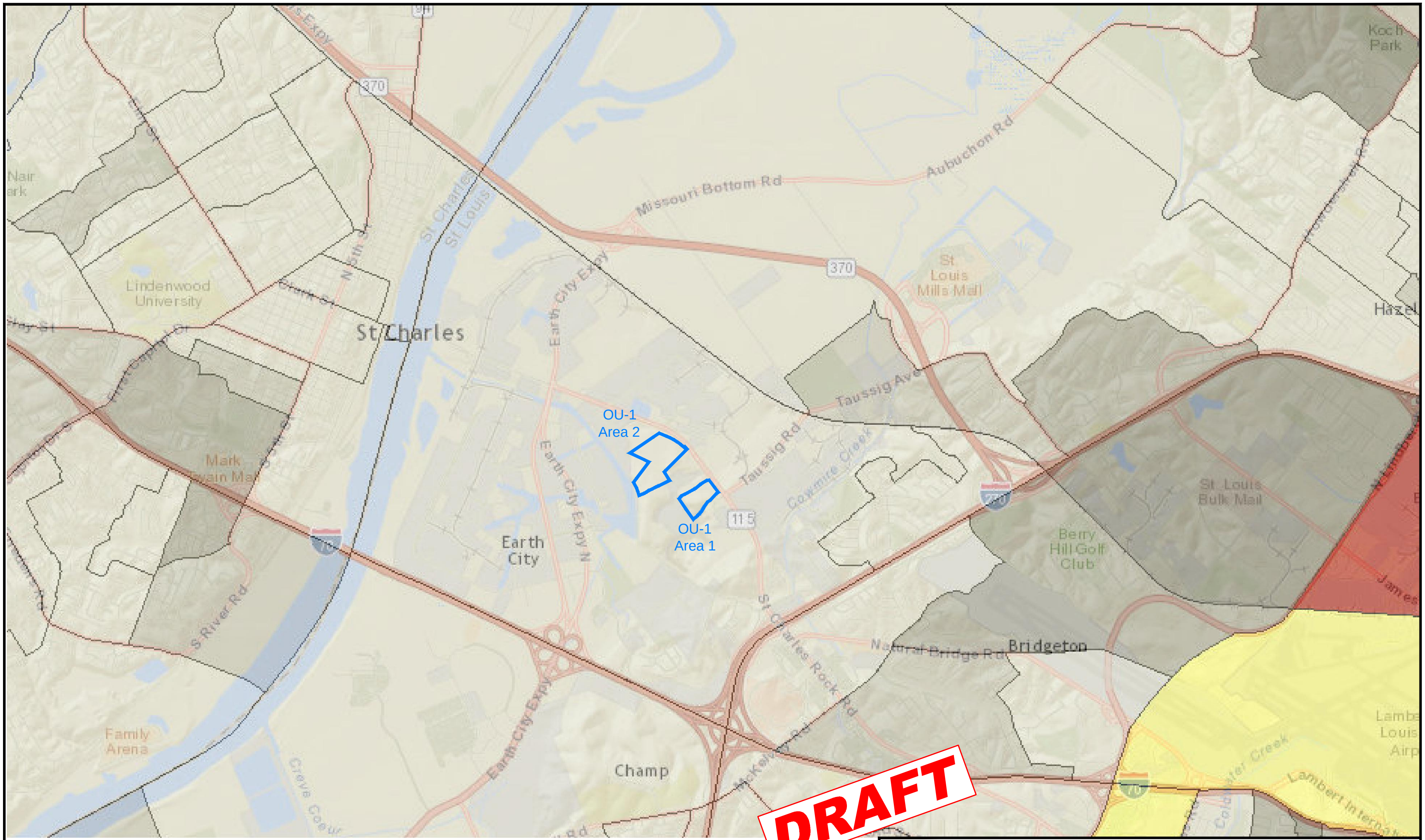
M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-3_Minority.dwg



August 13, 2016

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☐ 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),

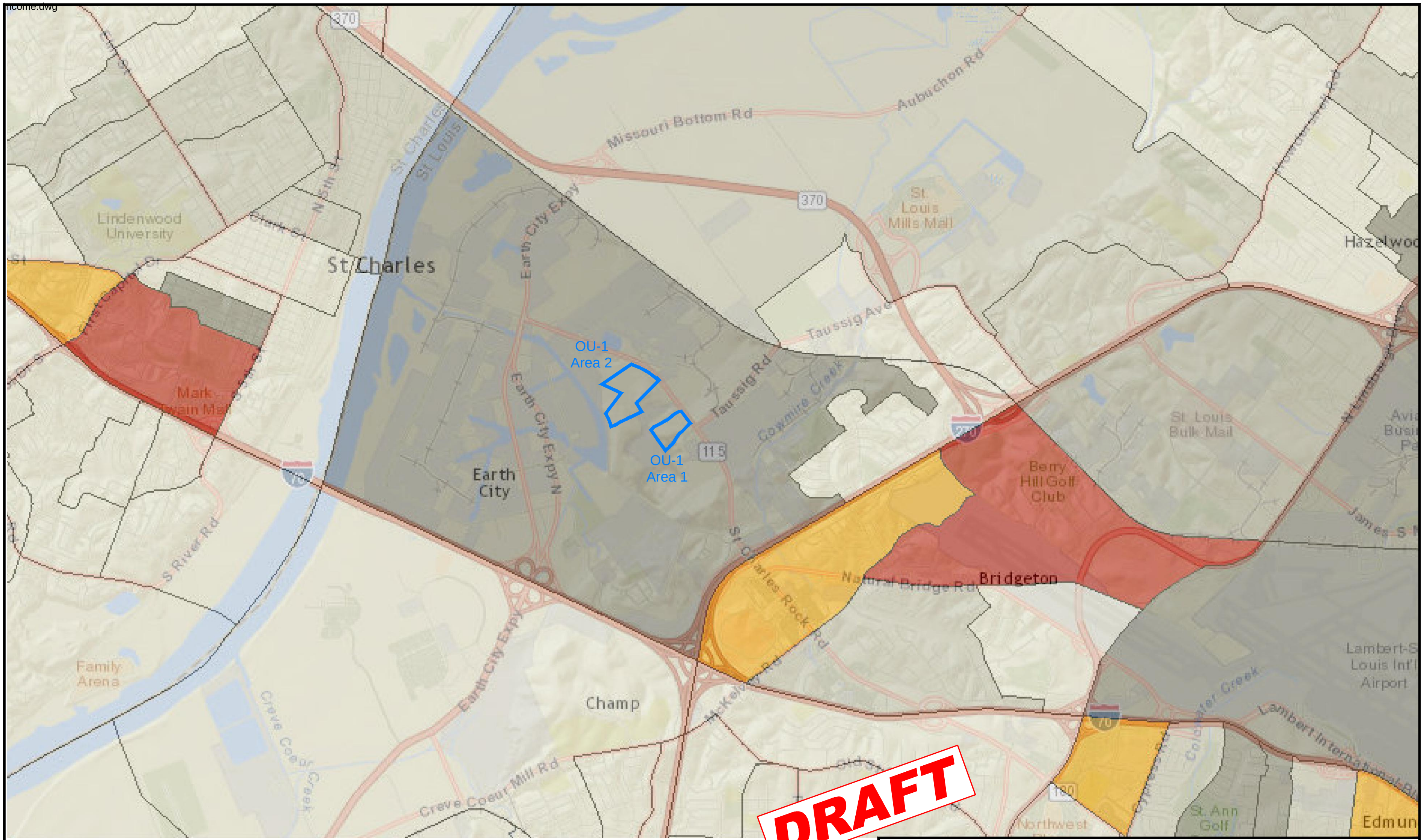
Figure 6-3

Minority
Population

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-4_Low ncome.dwg



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August 13, 2016

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- ☐ Data not available
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- ▨ 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

West Lake Landfill OU-1 Final Feasibility Study

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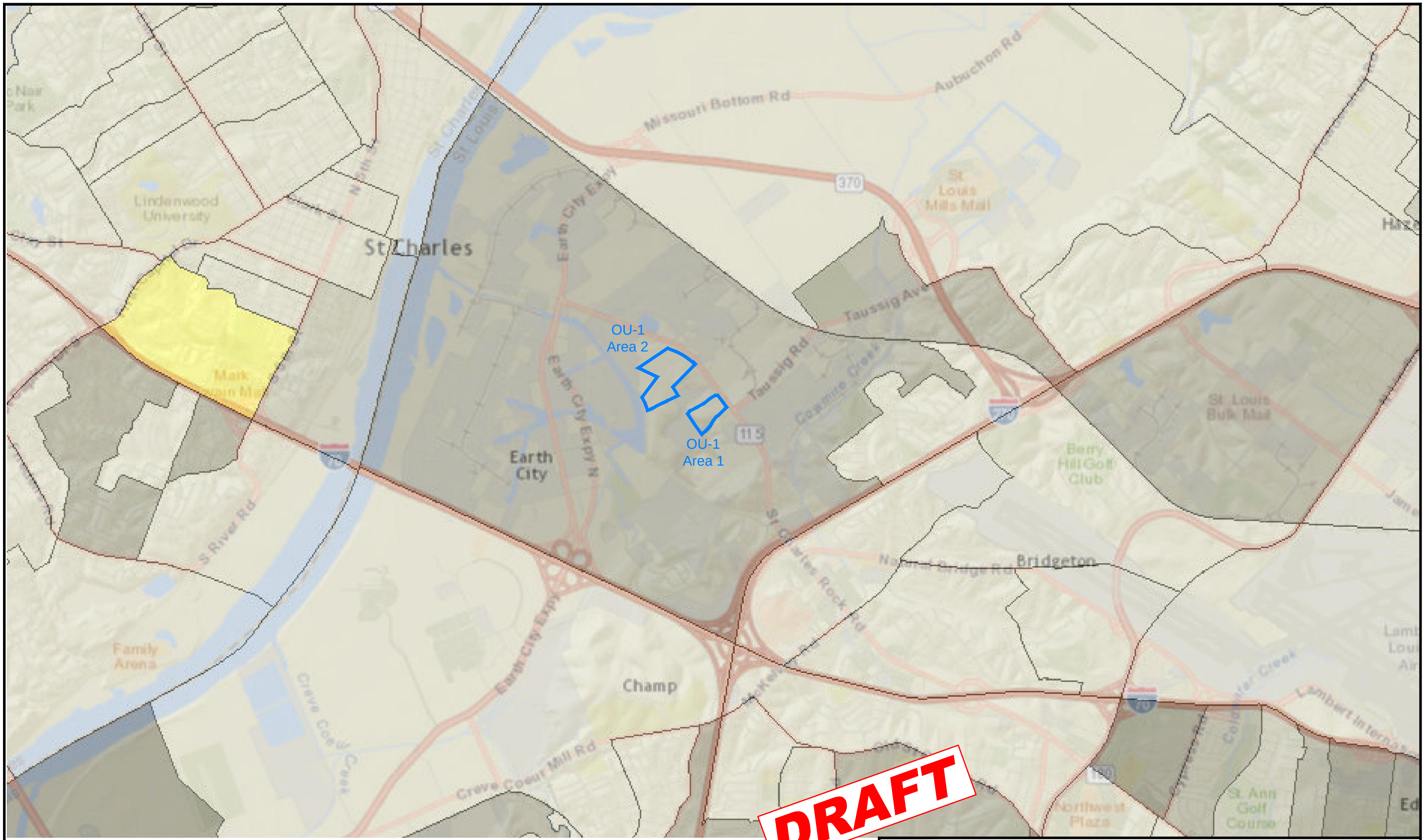
M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-5_Linguistically-Isolated.dwg



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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

West Lake Landfill OU-1 Final Feasibility Study

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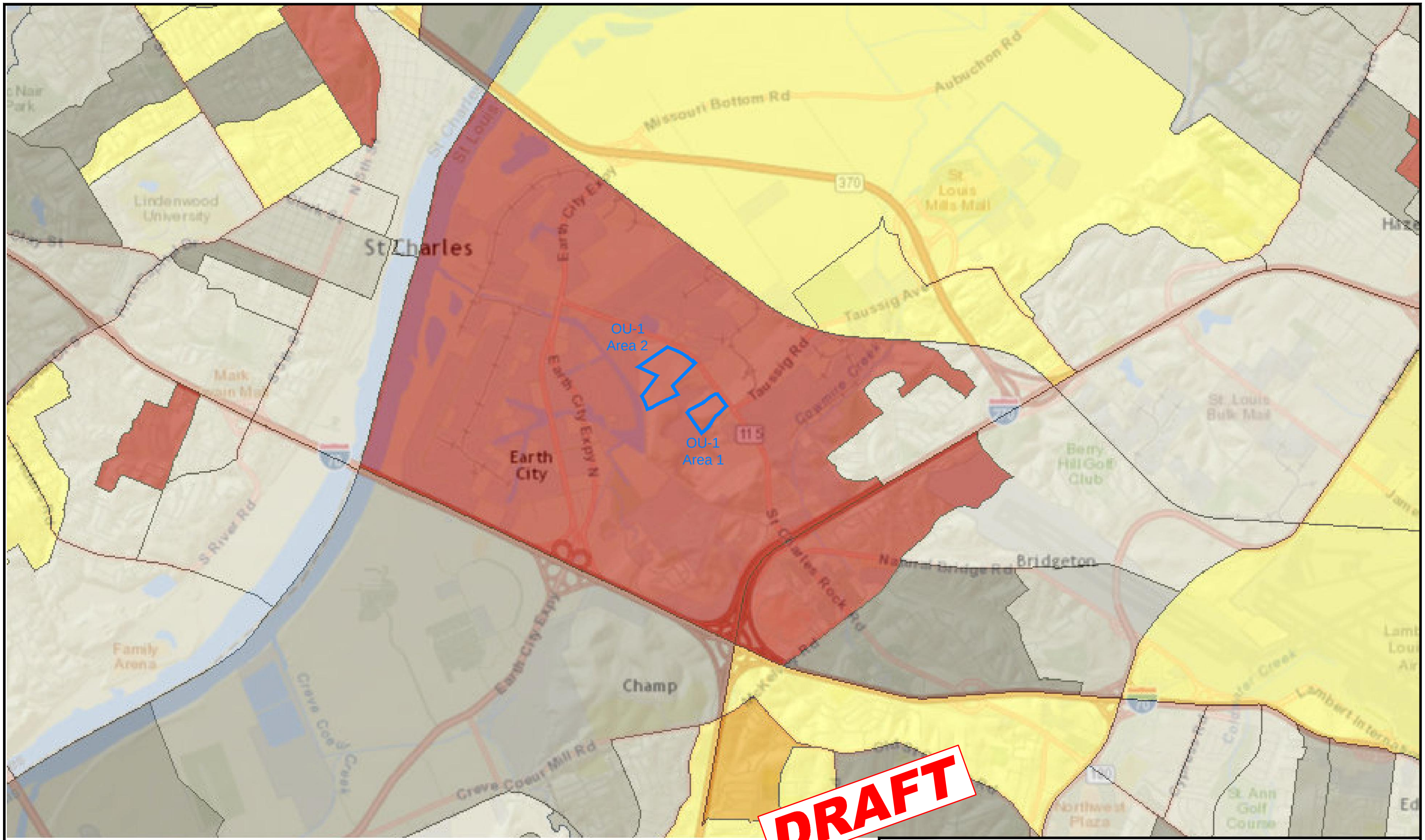
M:\clients\EMSI\westlake\2016\Final-FS\Section-6\FIG-6-6_Over-64.dwg



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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 6-6

Over 64

West Lake Landfill OU-1 Final Feasibility Study

EMSI Engineering Management Support, Inc.

APPENDICES