November 12, 2019 **VIA Electronic Mail**

Mr. Justin Barker
Remedial Project Manager
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, KS 66219

RE: Submittal of Draft Final OU-3 Remedial Investigation/Feasibility Study Work Plan
West Lake Landfill Operable Unit 3, Bridgeton, Missouri

Dear Mr. Barker:

On June 5, 2019, Trihydro Corporation (Trihydro) submitted a Draft OU-3 Remedial Investigation/ Feasibility Study Work Plan on behalf of Bridgeton Landfill, LLC, Cotter Corporation (N.S.L.), and the United States Department of Energy (Respondents) for the West Lake Landfill site located in Bridgeton, Missouri. The Respondents received USEPA comments the Work Plan on September 12, 2019. Enclosed please find the Draft Final OU-3 Work Plan, Sampling and Analysis Plan (including the Quality Assurance Project Plan and Field Sampling Plan) and the Health and Safety Plan (including the current OU-1 Radiation Safety Plan), which have been revised to address the agency comments. These documents are being submitted in accordance with the requirements of Section VIII, Paragraph 44 of the West Lake Landfill OU-3 Administrative Settlement Agreement and Order on Consent (ASAOC) for Remedial Investigation/ Feasibility Study (RI/FS), Docket No. CERCLA-07-2018-0259, and the Statement of Work (SOW) thereto.

Trihydro will be transmitting the Draft Final Work Plan documents to the USEPA electronically. If you have any questions or encounter issues downloading the documents, please contact Ms. Allison Riffel at Trihydro at 303-494-1172.

Sincerely,
Trihydro Corporation

Allison M. Riffel

Allison Riffel, P.E.
Project Manager

Gary Risse
Project Principal

40557227

63N-001-001

pdfc: Lynn Juett – EPA Region 7
Tom Mahler – EPA Region 7
Alyse Stoy – EPA Region 7
Ryan Seabaugh – MDNR
Victoria Warren
Scott Sklenar – Exelon Corporation
Jeffery Murl – DOE-LM
Dana Sincox – Bridgeton Landfill, LLC
Erin Fanning – Bridgeton Landfill, LLC
Paul Rosasco – Engineering Management Support, Inc.
Cynthia Teel – Lathrop Gage LLP
Bill Beck – Lathrop Gage LLP
Stephanie Feingold – Morgan Lewis & Bockius LLP
John McGahren – Morgan Lewis & Bockius LLP
Steven Miller – U.S. Department of Energy
Philip Dupre – U.S. Department of Justice
Dan Feezor – Feezor Engineering
Ralph Golia – AMO Environmental Decisions

DRAFT FINAL

VOLUME 1

REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

SITE WIDE GROUNDWATER (OPERABLE UNIT 03)

WEST LAKE LANDFILL SITE

BRIDGETON, MISSOURI

November 12, 2019

Project #: 63N-001-001

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

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List of Acronyms

3-D	Three dimensional
ACL	Alternate Concentrations Levels
AOA	Air Operations Area
ARAR	Applicable or Relevant and Appropriate Requirement
ASAOC	Administrative Settlement Agreement and Order on Consent
AVS	Acid Volatile Sulfides
B&M	Burns & McDonnell
BMP	Best Management Practices
bgs	below ground surface
bmp	below measuring surface
BRA	Baseline Risk Assessment
BRAWP	Baseline Risk Assessment Work Plan
CaCO3	Calcium Carbonate
C&D	Construction & Demolition
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Regulations
CME	Central Mine Equipment
cm/s	centimeters per second
cfs	cubic feet per second
COPC	Constituents of Potential Concern
CSM	Conceptual Site Model
CSR	Code of State Regulations
CWA	Clean Water Act

List of Acronyms (cont.)

DDT	4,4'-dichlorodiphenyltrichloroethane
DL	Data Logger
DQO	Data Quality Objective
DO	Dissolved Oxygen
DOE	Department of Energy
EDD	Electronic Data Deliverable
EMSI	Engineering Management Support, Inc.
EME	USEPA Metadata Editor
USEPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
FAA	Federal Aviation Administration
F&VD	Foth & Van Dyke
FGDC	Federal Geographic Data Committee
FS	Feasibility Study
FSP	Field Sampling Plan
ft	feet
ft/day	feet per day
ft^2/day	square feet per day
ft/year	feet per year
gpd	gallons per day
gpm	gallons per minute
GPS	Global Positioning System
GWPS	Groundwater Protection Standards

List of Acronyms (cont.)

HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
IDW	Investigation Derived Waste
ITRC	Interstate Technology Regulatory Council
JTU	Jackson Turbidity Units
kPa	kilopascal
LBSR	Leached Barium Sulfate Residue
LCS	Leachate Collection Sump
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering District
mg/L	milligram per liter
mgd	million gallons per day
MNA	Monitored Natural Attenuation
msl	mean sea level
MSWLF	Municipal Solid Waste Landfill
NAD83	North American Datum 1983
NAVD88	North American Vertical Datum 1988
NCC	Non-combustible Cover
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

List of Acronyms (cont.)

NRC	United States Nuclear Regulatory Commission
NTU	Nephelometric Turbidity Units
OM&M	Operation, Maintenance, and Monitoring
ONMSS	Office of Nuclear Material Safety and Safeguards
ORAU	Oak Ridge Associated Universities
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
RSMo	Missouri Revised Statutes
PCB	Polychlorinated Biphenyl
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PID	Photoionization detector
PPE	Personal Protective Equipment
PMP	Project Management Plan
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
redox	oxidation-reduction
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIA	Remedial Investigation Addendum

List of Acronyms (cont.)

RIM	Radiologically Impacted Materials
RL	Reporting Limit
RMC	Radiation Management Corporation
ROD	Record of Decision
ROW	Right of Way
RQD	Rock quality designation
RSL	Regional Screening Levels
RSMo	Revised Statutes of Missouri
RSP	Radiation Safety Plan
SAP	Sampling and Analysis Plan
Sch	Schedule
SDWA	Federal Safe Drinking Water Act
SEM	Simultaneously Extracted Metals
SLAPS	St. Louis Airport Site
SMART	Specific, Measurable, Attainable, Relevant, and Timely
SOP	Standard Operating Procedure
SOW	Statement of Work
SP	Spontaneous Potential
SSR	Subsurface Reaction
SU	Standard Units
SVOC	Semi-Volatile Organic Compound
TBC	To Be Considered
TDS	Total Dissolved Solids

List of Acronyms (cont.)

T&E	Threatened and Endangered
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UAO	Unilateral Administrative Order
µg/L	microgram per liter
UPL	Upper Prediction Limit
USC	United States Code
USACE	United States Army Corp of Engineers
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WMC	Water Management Consultants

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Work Plan) has been prepared by Trihydro Corporation (Trihydro) on behalf of Bridgeton Landfill, LLC, Cotter Corporation (N.S.L.), and the United States Department of Energy (DOE) (collectively Respondents), for site-wide groundwater (Operable Unit 3 or OU-3), at the West Lake Landfill site (site). The site is located at 13570 St. Charles Rock Road, Bridgeton, Missouri (Figure 1-1). The Work Plan was prepared at the request of the United States Environmental Protection Agency (USEPA) in accordance with requirements outlined in the Final RI/FS OU-3 Statement of Work (SOW) dated September 21, 2018, included as Appendix B in the Administrative Settlement Agreement and Order on Consent (ASAOC) dated February 6, 2019 (USEPA 2019a).

The site was added to the Superfund National Priorities List (NPL) in 1990 and consists of three Operable Units (OUs) including former industrial and municipal waste cells and groundwater. The site layout is shown on Figure 1-2. Operable Unit 1 (OU-1) includes former waste disposal areas Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2) where radiologically impacted materials (RIM) have been identified (USEPA ID#MOD079900932). Operable Unit 2 (OU-2) has no known areas identified as having been impacted with RIM and includes the Closed Demolition Landfill, Inactive Sanitary Landfill, and the North and South Quarry portions of the Bridgeton Landfill (also referred to as the Former Active Sanitary Landfill). The Missouri Department of Natural Resources (MDNR) is responsible for overseeing activities at the Bridgeton Landfill and Closed Demolition Landfill portions of OU-2, in contrast to the remedial actions for the Inactive Sanitary Landfill which are being addressed under USEPA Superfund authority. OU-3 includes groundwater beneath and associated with the entire approximately 200-acre site and is the focus of this RI/FS.

1.1 PURPOSE AND SCOPE

The purpose of this Work Plan is to outline the proposed methodology to sufficiently characterize the nature and extent of hazardous substance impacts to groundwater resulting from site activities and the associated potential risk posed to human health and the environment. This Work Plan has been prepared in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Regulations (CFR) Part 300 (USEPA 2011a), as well as the USEPA guidance including but not limited to: *Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.3-01 (USEPA 1988); *Guidance for Data Usability in Risk Assessment*, OSWER Directive No. 9285.7-09A (USEPA 1992a); *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER Directive No. 9200.4-18 (USEPA 1997a); *Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA*, OSWER Directive No. 9200.4-23 (USEPA 1997b); *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 No. 9200.4-35P (USEPA 2000); *Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA sites*, OSWER Directive No. 9283.1-14 (USEPA 2001a); *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 3, Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium*," USEPA/600/R-10/093 (USEPA 2010); *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*, (USEPA 2014a); and *Groundwater Statistics Tool*, (USEPA 2014b), OSWER 9283.1-46.

Groundwater investigations have previously been conducted at the site for OU-1 and OU-2 under USEPA and MDNR oversight. Routine groundwater monitoring for the North and South Quarries of the Bridgeton Landfill is ongoing and is under MDNR oversight. The United States Geological Survey (USGS) and USEPA evaluated the possible origin of radium in groundwater based on groundwater monitoring completed between 2012 through 2014 (USGS 2015). This study concluded the existing data set was not adequate to sufficiently characterize the nature and extent of constituents of potential concern (COPCs) present in groundwater. The objectives of this RI/FS, as outlined in the SOW are:

- To refine the current understanding of the site hydrogeologic system.
- To evaluate background groundwater quality near the site.
- To determine the extent of groundwater impacts occurring at and near the site.
- To provide predictive tools to evaluate potential future impacts.
- To identify potential groundwater remedies that may be implemented based on the information collected at the site, as applicable or deemed necessary.

To meet these objectives, the OU-3 RI/FS is designed to determine the horizontal and vertical distribution of landfill contaminants/leachate effects and COPCs in the subsurface at and/or near the site.

1.2 REQUIRED CONTENTS OF THE REPORT

As outlined in the SOW, this Work Plan provides a project description, a summary of site historical information, and a site setting overview, and outlines the general technical approach to achieve the RI/FS objectives. The approach uses and builds upon the findings of previous groundwater data, studies, sampling plans, quality plans, and associated reports to establish and support a robust RI process for characterization of groundwater for both radiological and non-radiological parameters at the site. This groundwater-specific OU-3 Work Plan contains a Sampling and Analysis Plan (SAP) composed of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP), included as Volume 2. A Health and Safety Plan (HASP), which includes a Radiation Safety Plan (RSP), has also been developed to support the overall planning process and is included as Volume 3. This Work Plan includes a history of investigative, regulatory, and response actions (Section 2); a preliminary well summary (Sections 2 and 3); a discussion of the nature and extent of impacts (Section 3); and a preliminary OU-3 study boundary defined by the area of investigation (Section 5).

The following items are required as part of this effort:

- Propose a scope of investigative and analytical activities required to meet the project objectives.
- Perform sampling, analysis, and review of data sets to adequately scope the project and develop project plans.
- Develop preliminary remedial action objectives (RAOs).
- Develop understanding and presentation of current and future risk posed by COPCs to human health and the environment.
- Develop potential methods and approach for scoping the groundwater modeling.
- Identify potential Applicable or Relevant and Appropriate Requirements (ARARs) associated with the location and contaminants of the site and the potential for response actions.

1.3 REPORT ORGANIZATION

This Work Plan is being submitted in general accordance with OSWER Directive No. 9355.3-01 and contains the following sections (USEPA 1988):

- Section 2 – Site Background and Setting
- Section 3 – Initial Evaluation and Conceptual Site Model
- Section 4 – RI/FS Work Plan Rationale
- Section 5 –Site Characterization
- Section 6 – Data Management and Evaluation
- Section 7 – Baseline Risk Assessment and RI Report
- Section 8 – Feasibility Study
- Section 9 – RI/FS Reporting
- Section 10 – Project Management Plan
- Section 11 – References

2.0 SITE BACKGROUND AND SETTING

This section presents a brief description of the site, including the location, an overview of past and current operations, and a discussion of activities occurring adjacent to the site. Detailed descriptions of the site were included in documents submitted to USEPA under the OU-1 and OU-2 RI/FS process. Numerous investigations were previously conducted by Radiation Management Corporation (RMC), Burns & McDonnell (B&M), the U.S. Nuclear Regulatory Commission (NRC), Golder Associates (Golder), McLaren/Hart Environmental Engineering Corporation (McLaren/Hart), Water Management Consultants, Inc. (WMC), Engineering Management Support, Inc (EMSI), Herst & Associates, Inc. (H&A), and Feezor Engineering, Inc. (Feezor). Relevant data from each effort pertinent to OU-3 is summarized herein.

2.1 PHYSICAL SETTING

The site is 212 acres and is located on the east side of the Missouri River within the western portion of the St. Louis metropolitan area in northwestern St. Louis County (Figure 1-1 and Figure 1-2). The site address is 13570 St. Charles Rock Road, which is located approximately one mile north of the intersection of Interstate 70 and Interstate 270, within the City of Bridgeton, Missouri. The site includes six identified historical waste disposal areas, or units, including Area 1, Area 2, the Closed Demolition Landfill, the Inactive Sanitary Landfill, and the North Quarry and South Quarry Portions of the Bridgeton Landfill. A solid waste transfer station and an asphalt batch plant currently operate on the site (Figure 2-1). A six-foot-high chain-link fence with a three-strand barbed wire canopy encloses most of the property. The main access gate is located on the northeastern boundary and a secondary access gate is located on the southwestern boundary of the landfill property.

Current ownership of the properties included in the definition of the site is depicted on Figure 2-2. The landfill property is bordered by Crossroads Industrial Park to the northwest and St. Charles Rock Road (State Highway 180) to the north and east; Taussig Road, commercial facilities (including the Republic Services, Inc. hauling company facility), and agricultural land are located to the southeast; and Old St. Charles Rock Road and the Earth City Industrial Park (Earth City) stormwater/ flood control pond are located to the south and west and north. The Earth City commercial/industrial complex continues to the west and north of the flood control pond and extends 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. Terrisan Reste mobile home park, located to the southeast, approximately 0.7 miles from Area 1 and 1.1 miles from Area 2 is the nearest residential area to the site. The Spanish Village residential subdivision is located to the south of the site near the intersection of St. Charles Rock Road and I-270, approximately 1 mile from Area 1 and 1.25 miles from Area 2 (EMSI 2018a).

The property on the west side of Area 2 was previously referred to as the Ford Property in the OU-1 RI (EMSI 2000) because it was previously owned by Ford Motor Credit, Inc (Ford). Most of the Ford Property was sold to Crossroad Properties, LLC in 1998 and has since been developed into the Crossroads Industrial Park. Ford initially retained ownership of a 1.78-acre parcel located immediately adjacent to the west of Area 2 (Figure 2-1). Ownership of this 1.78-acre parcel was subsequently transferred to Rock Road Industries, Inc., now Bridgeton Landfill, LLC, to provide a buffer between the landfill and adjacent property, and therefore this parcel has been identified as the "Buffer Zone." Crossroad Properties, LLC initially developed all the former Ford property with the exception of Lot 2A2, a 3.58-acre parcel located immediately north of the Buffer Zone. Lot 2A2 was subsequently developed by AAA Trailer, the owner of much of the property immediately to the north of the Buffer Zone and Area 2, although Lot 2A2 is still owned by Crossroad Properties, LLC. Property to the north and northeast of the landfill, across St. Charles Rock Road, is moderately developed with commercial, retail and manufacturing operations (EMSI 2018a). Zoning for the parcels that make up the landfill property and surrounding parcels is depicted on Figure 2-3.

The West Lake Landfill Superfund NPL Site consists of the various parcels that comprise the landfill property (on-property) and adjacent properties (off-property) where radionuclides were historically identified in the soil. OU-1 includes on-property Areas 1 and 2, and the adjacent off-property Buffer Zone and Parcels B and C of Lot 2A2 of the Crossroads Industrial Park (Figure 2-1). These off-property areas were not used for waste disposal but have been identified as containing radionuclides in soil as a result of transport by surficial processes from OU-1 (EMSI 2018a). OU-2 consists of the remaining portions of the landfill property. These areas are shown on Figure 2-1 and discussed in more detail in Section 2.2.

2.2 SITE HISTORY

Historically, the on-property portions of the site have been divided into five areas:

- Area 1
- Area 2
- Closed Demolition Landfill
- Inactive Sanitary Landfill
- Former Active Sanitary Landfill or the Bridgeton Landfill

These areas are discussed below in further detail. OU-1 includes Area 1, Area 2, the Buffer Zone, and Crossroads Properties LLC Lot 2A2. The Bridgeton Landfill, the Closed Demolition Landfill, and the Inactive Sanitary Landfill are all part of OU-2 (Figure 2-1).

The West Lake Landfill contains multiple areas of differing past operations. The landfill property was originally 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. The South Quarry Pit was excavated to a maximum depth of 240 feet below ground surface (ft bgs) and had a bottom elevation of approximately 240 feet (ft) above mean sea level (msl) (H&A 2005; Golder 1996).

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 (H&A 2005). The landfill became permitted for use as a sanitary landfill in 1952. USEPA 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" (USEPA 1989a). USEPA also reported that historical aerial photography from 1953 indicates use of a landfill had commenced (USEPA 1989a). Mine spoils from quarrying operations were deposited on adjacent land immediately to the west of the quarry (H&A 2005). Portions of the quarried areas and adjacent areas were subsequently used for landfilling municipal refuse, industrial solid wastes, and construction & demolition (C&D) debris. USEPA has reported that liquid wastes and sludges were also disposed of at the landfill (USEPA 1989a). 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 2-1).

Due in part to the fact that the disposal of solid and liquid waste at the site predated state and federal regulations for landfills, there is uncertainty regarding the specific site activities and disposal practices conducted onsite. Specifically, based upon a review of historical aerial photographs as documented in the Aerial Photographic Analysis of the West Lake Landfill Site (USEPA 1989a), "deep" pits, lagoons, and other site features related to past on-site disposal practices have been identified in several historical aerial photographs for years pre-dating the arrival of radionuclides from the Latty Avenue Site (EMSI 2018a).

2.2.1 LANDFILL PERMIT HISTORY

The following sections describing the landfill history are taken from the *Remedial Investigation Addendum, West Lake Landfill, Operable Unit 1* (EMSI 2018a). MDNR permitted areas are shown on Figure 2-4. The early landfilling activities (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 landfill property where these activities occurred has been referred to as the "unregulated landfill." Waste disposal in St. Louis County was regulated solely by St. Louis County authorities until

1974, when the MDNR was formed (H&A 2005). Landfill activities conducted in 1974 and afterwards were subject to a permit from MDNR.

In 1974, MDNR identified six waste disposal areas shown on Figure 2-4. MDNR Areas 1, 2, 5, and 6 were subsequently permitted for waste disposal. MDNR Areas 2 and 4, which included the majority of OU-1 Area 1 and the majority of OU-1 Area 2, were not permitted and were therefore closed in 1974 (H&A 2005). The areas subsequently permitted by MDNR for waste disposal are referred to as the "regulated landfill." These areas are further discussed below.

On August 27, 1974, MDNR granted authorization for a sanitary landfill on 25 acres in the area now identified as the Inactive Sanitary Landfill. MDNR subsequently issued a permit (No. 118903) for this area on January 27, 1976 (H&A 2005). MDNR also issued a permit (No. 218903) for operation of a solid waste disposal area for a demolition landfill on 27 acres of land that included a large portion of the area subsequently identified as the Closed Demolition Landfill. The Closed Demolition Landfill was constructed over an area that had previously been used for disposal of sanitary waste. This permit also included the eastern portion of Area 2, the eastern portion of the Inactive Sanitary Landfill, and the western portion of Area 1. On May 23, 1978, permit No. 118903 was modified to include an additional 3.5 acres within the area of the Inactive Sanitary Landfill. On August 27, 1980, MDNR issued a permit (No. 118908) for operation of a sanitary landfill on 6 acres located in the area now identified as the Inactive Sanitary Landfill. On September 18, 1984, MDNR issued a permit (No. 218912) for operation of a demolition landfill on 22 acres in the area now identified as the Closed Demolition Landfill.

On January 22, 1979, MDNR issued a permit (No. 118906) for operation of a sanitary landfill on 13 acres in the portion of the property described as the North Quarry of the Bridgeton Landfill (H&A 2005). A subsequent permit (No. 118909) was issued August 20, 1981 to allow for expansion of the North Quarry landfill. On November 11, 1985, MDNR issued permit No. 118912, which allowed for a 33-acre expansion of sanitary landfill operations into the South Quarry area and continued waste placement in the North Quarry, thereby superseding prior permits No. 118909 and 118906. Permit No. 118912 covers a 52-acre area that encompasses the North Quarry and South Quarry, which together comprise what is currently identified as the Bridgeton Landfill. Placement of waste material in the North and South Quarry areas ceased in 2004. No active landfilling has occurred since 2004, although ongoing activities pursuant to orders from the state Attorney General's Office, USEPA Region 7 and MDNR related to maintenance and monitoring of the Bridgeton Landfill continue to be conducted. Routine groundwater monitoring for the North and South Quarries of the Bridgeton Landfill is currently conducted under this permit.

2.2.2 WEST LAKE LANDFILL RADIOLOGICAL AREA 1

Area 1, which encompasses approximately 17.6 acres, is located immediately to the southwest of the landfill entrance (Figure 2-1). This area was part of the unregulated landfill operations conducted up through 1974, although the southwestern portion of what is currently identified as Area 1 was historically included under permit No. 218903. Pursuant to a Materials Management Plan (EMSI 2006) approved by MDNR, inert fill material (e.g., clean materials as defined in 10 CSR 80-2.010(11), such as uncontaminated soil, concrete, asphaltic concrete, brick, or inert solids) was placed over portions of Area 1 between 2006 and 2008.

Remnants of an asphalt entrance road and parking area are located on the northwestern border of Area 1 to the south of the landfill office building. An abandoned underground diesel tank is also located beneath the asphalt-paved area, as evidenced by the presence of a fuel dispenser in Area 1. The tank is no longer in use but has not been removed because it is within the boundaries of Area 1 (current presence confirmed by site personnel). No information has been located regarding the date of installation of the underground tank, when it ceased to be used, or its abandonment; however, based on review of aerial photography in Appendix A, a pump likely associated with the underground tank was visible in aerial photography as early as October 8, 1980. A truck is visible in May 9, 1985 imagery adjacent to the pump as if it is in the process of refueling. This pump remains visible at least through the aerial photography taken on September 20, 2004.

Based on review of aerial photography, the road and parking area appear to have been constructed sometime between August 20, 1978 and May 25, 1979. Parked vehicles can be seen on aerial photographs through May 9, 1985 but are no longer visible on the April 1990 aerial photograph. As can be seen in aerial photographs included in Appendix A, a drainage structure is visible on the northwest side of Area 1 between June 17, 1981 and May 14, 1984 as shown on Figure 2-5. Between May 9, 1985 and June 18, 1990 an additional drainage structure is visible in aerial photographs on the northeast side of Area 1. A guard house or similar structure was constructed on the southwest corner of Area 1 between May 25, 1979 and December 2, 1979. It remains visible in aerial photographs through April 16, 1996.

The results of the site investigations indicated that RIM was present in the area of the road, parking area, and underground tank; however, no information is available as to whether the construction of the road and parking area or the installation of the underground tank resulted in disturbance or relocation of RIM. Prior to 2013, the remaining portions of Area 1 were mainly covered with grass, shrubs, and trees. In 2013, 2014, and 2015, vegetation was cleared along the alignments of numerous access roads and road base material was placed along these roads to support additional drilling activities. In 2016, approximately 2.6 acres in the northern portion of Area 1 were cleared of vegetation and covered with road base material as part of construction of a non-combustible cover (NCC) over areas where RIM was present at the ground surface (EMSI 2016) pursuant to a unilateral administrative order (UAO) for removal action issued by USEPA (USEPA 2015a). NCC consisted of a minimum of 8-inches of road base material placed over a geotextile placed on the existing ground surface following the removal of existing vegetation using a brush hog. The extent of the NCC was based on the extent of surface RIM defined in the 2000 RI report, additional overland gamma surveying, and collection and analysis of surface soil samples. Small and medium-sized trees and shrubs still cover the northern, eastern and southwestern portions of Area 1. The southwestern portion of Area 1 was covered beneath the above-grade portion of the North Quarry portion of the Bridgeton Landfill in approximately 2002-2003.

2.2.3 WEST LAKE LANDFILL RADIOLOGICAL AREA 2

Radiological Area 2, which encompasses approximately 41.8 acres, is located in the northwestern part of the landfill property. Landfilling activities are first visible in the footprint of Area 2 between June 14, 1962 and April 10, 1964, based on a review of historical aerial photographs. Area 2 was also part of the unregulated landfill operations conducted up through 1974, although a small part of the eastern portion of Area 2 was also included within permit No. 218903 (Figure 2-4). Pursuant to a Materials Management Plan (EMSI 2006) approved by MDNR, inert fill material (e.g., clean materials, as that term is defined in 10 CSR 80-2.010(11), such as uncontaminated soil, concrete, asphaltic concrete, brick, or inert solids) was placed over portions of Area 2 between 2006 and 2008.

Review of the RMC 1982 report, NRC 1988 and 1989 reports, and review of aerial photographs indicates that a small building (referred to in the RMC and NRC reports as the Shuman building) was present in the northern portion of Area 2. This building first appears in the April 6, 1975 aerial photograph and is no longer present in the April 1990 aerial photograph. No information has been located as to the purpose or use of this building or why it was removed; however, the time of the presence of the building corresponds to the period of time when material stockpiles are visible on the surface of Area 2, and therefore its use may have been related to activities being conducted by the West Lake Quarry, which were terminated in 1988. With the cessation of the use of the surface of Area 2, vegetation including grasses, shrubs, and trees began to grow in this area. During the 1994-1995 field investigations, only grasses, shrubs, and small tress were present in this area, but by 2015, this vegetation had grown into large trees and extensive brush cover.

Prior to 2015, large portions of this area were covered with grasses, native bushes, and trees, while other portions were unvegetated and covered with inert fill material consisting of soil, gravel, concrete rubble, and brick material. Miscellaneous debris consisting of concrete pipe, metal and automobile parts, discarded building materials, and other non-perishable materials were also present on the surface. During the 1994-1996 OU-1 RI field investigations, a number of small depressions, some of which seasonally contained ponded water and phreatophytes such as cattails, were scattered throughout Area 2, in large part due to the presence of small berms located along the top of the major landfill berm/slope along the northern, northeastern and western portions of Area 2, which are intended to contain runoff from Area 2. With the exception of the landfill slope adjacent to the Buffer Zone, the slopes of landfill berm were covered with a dense growth of trees, vines, and bushes.

In 2015, vegetation was cleared along the alignments of numerous access roads and road base material was placed along these roads to support additional drilling activities. In 2016, approximately 17.2 acres in the central portion of Area 2 were cleared of vegetation and covered with road base material as part of construction of an NCC over areas where RIM was present at the ground surface, pursuant to a UAO for removal action issued by USEPA (USEPA 2015a). NCC cover consisted of a minimum of 8 inches of road-base material place over a geotextile that was placed on the existing ground surface subsequent to removal of the vegetation using a brush hog. The extent of the NCC was based on the extent of surface RIM defined in the 2000 RI report, additional overland gamma surveying, and collection and analysis of surface soil samples (EMSI 2000). Vegetation, including large trees, was cleared from the southwestern portion of the landfill berm/slope adjacent to the Buffer Zone, and approximately 1.78 acres of the Buffer Zone was covered with rock, including construction of a large rock buttress in this area as part of the NCC construction for Area 2 (EMSI 2016). Large and medium-sized trees and shrubs still cover the northern, western, and southern portions of Area 2.

2.2.4 INACTIVE SANITARY LANDFILL AND CLOSED DEMOLITION LANDFILL OPERATIONS IN OU-2

The Inactive Sanitary Landfill is located to the southwest of the Closed Demolition Landfill. The operations performed in this area were also part of the unregulated landfill operations conducted up through 1974 that were subsequently regulated by MDNR and included within the scope of permit Nos. 118903, 218903, 118908, and 218912 (Figure 2-4). Based on the results of visual inspection and geologic logging of drill cuttings and core samples, municipal solid waste (MSW) is the primary waste disposed in the Inactive Sanitary Landfill (H&A 2005). Descriptions of waste included refuse, waste, and fill, but the descriptions did not distinguish between the type of waste placed in the Inactive Sanitary Landfill. The OU-1 RI Addendum (RIA) concluded there was no indication of industrial wastes within the Inactive Sanitary Landfill based on sampling results (EMSI 2018a).

A Closed Demolition Landfill is located in the north central part of the landfill property. The Closed Demolition Landfill is located on the southeast side of Area 2, between Area 2 and the landfill entrance road. Review of the permit history indicates that sanitary wastes were placed in MDNR Area 1 and Area 5 of Permit No. 218903 prior to placement of overlying C&D debris and wastes authorized under Permit 218903 on January 27, 1976 as shown on Figure 2-4.

Based on a review of aerial photography included in Appendix A, the first disturbance of the demolition landfill footprint is visible in the August 11, 1966 aerial photographs. By September 19, 1969, the entire demolition landfill footprint has been disturbed by landfilling activities. Filling within the demolition landfill footprint appears to cease between April 6, 1975 and April 12, 1976, based on aerial photographs. The time period prior to January 27, 1976 appears to correspond to pre-demolition landfilling activities. The active spreading of cover or cap material is visible through the May 9, 1976 photograph, and the surface is revegetating by August 20, 1978. Surface activities such as pathways, surface settling and impoundments, and grading are visible, but no major landfill activities are observed within the demolition landfill footprint until a new episode of light-toned filling is seen on the June 18, 1990 photograph. Activities on the demolition landfill appear to have ceased by the April 16, 1996 photograph.

2.2.5 BRIDGETON LANDFILL

The Bridgeton Landfill is located in the former North Quarry and South Quarry portions of the landfill property (Figure 2-1). Collectively, the North and South Quarry landfill areas make up the Former Sanitary Landfill, also known as the Bridgeton Landfill. The Bridgeton Landfill was referred to as the Former Active Landfill in the OU-2 Record of Decision (ROD). Waste disposal in the Bridgeton Landfill consisted primarily of MSW and commercial waste. Disposal of waste materials in the Bridgeton Landfill ceased in 2004 pursuant to an agreement with the City of St. Louis to reduce the potential for birds to interfere with operations at a new runway at the nearby Lambert-St. Louis International Airport (Lambert Field), the western end of which is located approximately 9,166 ft from the landfill. The Bridgeton Landfill is included within the scope of OU-2, and regulatory authority has been deferred to the MDNR, per the selected remedy under the OU-2 ROD.

Review of historical aerial photographs indicates that quarrying activities (removal of limestone) continued to be conducted in the North Quarry up through 1979. Based on the decrease in elevation of the quarry floor between 1969 and 1971, rock quarrying was being conducted in the southern portion of the North Quarry during this time frame. Some rock continued to be removed from this area during the period between 1971 and 1973; however, based on the change in the elevation of the quarry floor, the majority of the rock quarrying activity in the North Quarry shifted to the north during this period. Between 1973 and 1974 rock quarrying was occurring in the neck area located between the North and South Quarries. Between 1974 and 1975, quarrying occurred in the northern portion of the North Quarry. Between 1975 and 1977, the majority of rock quarrying occurred in the central and southern portions of the North Quarry. Between 1969 and 1977, the elevation of the base of the North Quarry decreased and indicates that the elevation of the floor of the North Quarry was lowered approximately 25 to 75 ft over this period. Because rock quarrying was occurring in the North Quarry area during this period and likely through 1979, placement of waste could not have occurred in North Quarry prior to 1979.

The first permit for placement of waste materials in the North Quarry portion of the Bridgeton Landfill (Permit No. 118906) was issued on January 22, 1979. Review of a May 1977 aerial photograph does not indicate any waste is present in the North Quarry area at that time, while review of a July 26, 1979 aerial photograph indicates waste placement is occurring in the North Quarry by this time. Based on the permit date and review of the historical aerial photographs, it seems likely that placement of waste in the North Quarry began in or around 1979. Landfilling continued in the North Quarry area until 1985 when the landfill underwent expansion to the southwest into the area described as the South Quarry Pit pursuant to an additional permit (No. 118912) issued by MDNR on November 18, 1985 (H&A 2005).

The North Quarry portion of the Bridgeton Landfill is located to the south of and adjacent to Area 1. The landfilling activities in the North Quarry portion of the Bridgeton Landfill included filling of the former North Quarry pit and above-grade landfilling over the top of the North Quarry pit that also extended outward beyond the edges of the former quarry pit. The above-grade portion of the North Quarry extends over, and overlaps, the southern portion of Area 1. Based on the date of Permit No. 118906 and review of historical aerial photographs, placement of waste in the North Quarry began in 1979 with initial waste placement occurring in the northeastern portion of the North Quarry area (nearest to St. Charles Rock Road) and subsequently progressing to the southwest (toward the South Quarry). By 1985, most of the northeastern part (e.g., the part adjacent to Area 1) of the below-grade (quarry) portion of the North Quarry had been filled with waste; however, waste disposal in the southwestern portion of the North Quarry (a.k.a., the "neck" area) continued through approximately 2002. Placement of waste in the above-ground portion of the North Quarry portion of the Bridgeton Landfill that extended over the southern portion of Area 1 occurred in approximately 2002 through 2004. Landfilling in the North Quarry ceased in 2004.

The South Quarry portion of the Bridgeton Landfill is adjacent to and southwest of the North Quarry. Historically, the quarrying operations extended from the North Quarry to the South Quarry, resulting in two quarry pits being connected via a narrow area referred to as the "neck". The South Quarry area is adjacent to the southernmost portion of the Inactive Sanitary Landfill. Landfilling in the South Quarry began in 1985 and ceased in 2004.

A subsurface reaction (SSR) was discovered in 2010 and is currently occurring in the South Quarry portion of the Bridgeton Landfill. It has been located in the southwestern portion of the South Quarry since 2013 and appears to be stationary. A heat extraction system was installed in the neck to prevent the migration of the SSR towards Area 1. Additional discussion of the SSR is provided in Section 3.1.5.7.3.

2.2.6 BUFFER ZONE AND LOT 2A2

The property located to the west of Area 2 was formerly owned by Ford and was referred to as the Ford property during performance of the 2000 OU-1 RI (EMSI 2000). Ford sold most of this property in 1997, and it was subsequently developed as the Crossroads Industrial Park between approximately 1998 through 2000. Most of the parcels associated with the Crossroads Industrial Park were subsequently sold at various times to individual owners; however, Crossroad Properties LLC retained ownership of Lot 2A2 Parcels B and C. Lot 2A2 is currently used for outdoor storage of trailer trucks by AAA Trailer, which operates on a facility located on Lot 2A1 immediately to the west of Lot 2A2.

The Buffer Zone – a portion of the former Ford property that was sold to Rock Road Industries on February 2, 2001 – is located between the Area 2 slope to the east and the Crossroads Industrial Park to the west (Figure 2-1). The Buffer Zone includes the area of radiologically impacted surface soils identified in the "Phase III Radiological Assessment" performed by Dames & Moore (D&M) for Ford Financial Services Group in 1991 (D&M 1991). Investigations conducted as part of the OU-1 RI identified the presence of radionuclides in surface soil on both the Buffer Zone and Lot 2A2. The OU-1 RIA concluded that the presence of radionuclides on these properties was likely a result of historical erosion of impacted soil from Area 2 (EMSI 2018a).

2.2.7 OTHER SIGNIFICANT FEATURES IN THE VICINITY OF THE SITE

The West Lake Landfill is located approximately 1.75 miles to the east-southeast of the Missouri River with portions of the site ranging from 1.4 to 2.0 miles from the river. The Earth City Industrial Park is located on the Missouri River floodplain to the west of the site. The Earth City Industrial Park is protected from flooding by a levee (Figure 1-2) and stormwater management system operated and maintained by the Earth City Flood Control and Levee District. The stormwater management system includes a series of stormwater detention ponds, one of which is located along the west side of the landfill property (Figure 1-2). Another stormwater detention pond is located across St. Charles Rock Road to the north of Area 2.

An area that occasionally accumulates stormwater is located near the northern portion of Area 2, on the south side of St. Charles Rock Road (Figure 1-2). Although this low area consisted of a pond during the time frame when the original OU-1 field investigations were conducted (1995-1997), and therefore was identified as the North Surface Water Body, over the years this area has become overgrown and silted in, and only contains water after storm events. In addition to overland flow from the north slope of Area 2, stormwater runoff from much of the West Lake Landfill area is conveyed to this area via the internal stormwater conveyance ditches and the perimeter stormwater conveyance structures and ditch located along the southwest side of St. Charles Rock Road. Inspection of the North Surface Water Body has not identified any outlet or pathway for discharge of water, and therefore, water that accumulates in this area appears to dissipate over time by evaporation and infiltration.

The site, at its closest point, is within approximately 8,450 ft of the end of runway 11 of Lambert St. Louis International Airport. The site is situated within the takeoff and approach routes for the airport. As discussed below in Section 2.3, the landfill is subject to a Negative Easement and Declaration of Restrictive Covenants Agreement between the City of St. Louis and Bridgeton Landfill, LLC (among other entities) that prohibits 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).

2.3 LAND USE RESTRICTIONS

The landfill property is subject to several controls on land use (Figure 2-6). An institutional control in the form of a "Declaration of Covenants and Restrictions" was recorded on June 30, 1997, and a supplemental "Declaration of Covenants and Restrictions" was recorded on January 20, 1998, prohibiting residential use and groundwater use on any of the landfill property and restricting construction of buildings and underground utilities and pipes within Areas 1 and 2. On October 31, 2016, the prior institutional controls were modified by a further supplemental "Declaration of Covenants and Restrictions" recorded against all of the OU-1 Areas (Areas 1 and 2 and the Buffer Zone) and the OU-2 landfill areas to include the OU-1 areas not included under the prior institutional controls, and to prohibit use of the premises for commercial and industrial purposes including but not limited to use as a storage yard, and to prohibit placement of water wells for agricultural purposes. These institutional controls cannot be terminated without the written approval of the current property owners, MDNR, and USEPA.

In addition, in 2005, the City of St. Louis entered into a 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 landfill was a hazardous wildlife attractant for the Lambert-St. Louis International Airport (City of St. Louis Airport Authority 2010).

The northwest end of the Lambert-St. Louis International Airport runway 11 is approximately 8,450 ft from the nearest point of the landfill mass (east corner of the South Quarry portion of the Bridgeton Landfill). The northwest end of runway 11 is approximately 9,350 ft from the nearest point of Area 1, and approximately 11,000 ft from the nearest point of Area 2. Therefore, portions of both the Bridgeton Landfill and Area 1 are located at distances that are less than the FAA siting guidance of a 10,000-foot separation radius between an airport's Air Operations Area (AOA) and a municipal solid waste landfill (MSWLF) (FAA 2007). In addition, the FAA recommends a distance of 5 miles between the farthest edge of an airport's AOA and any hazardous waste wildlife attractant (e.g., an active MSWLF), if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace. All portions of the site are within this 5-mile distance (EMSI 2018a).

2.4 HISTORY OF INVESTIGATIVE, REGULATORY, AND RESPONSE ACTIONS

Previous investigations, regulatory actions, and response actions conducted by local, state, federal or private parties that are related to this OU-3 RI are summarized on Table 2-1 and discussed in detail in the RIA (EMSI 2018a). A summary of the pertinent groundwater-specific OU-1, OU-2, and regional groundwater investigations is presented below. These reports have been used to develop the conceptual site model (CSM).

2.4.1 1986 HYDROGEOLOGIC INVESTIGATION

The 1986 hydrogeologic investigation was conducted to evaluate groundwater flow and to delineate the nature and extent of groundwater impacts (B&M 1986). The investigation did not take into consideration leachate collection, treatment, or monitoring at the North Quarry portion of the Bridgeton Landfill, which at the time was 180 ft below the Missouri River alluvium water table near the neck. The goal of the investigation was to establish a long-term monitoring network and background groundwater quality. The scope of work included soil sampling at 15 borings, soil engineering properties testing, piezometer installation for water levels and groundwater sampling, evaluation and gauging of 20 existing piezometers for a total of 35 periodic measurements, evaluation of groundwater head and flow at different alluvial horizons, and sampling for two rounds at 18 select piezometers/wells based on their horizontal and vertical spacing. Three casing volumes were bailed, and samples collected from 18 wells in December 1985 and May 1986 to evaluate seasonal variability. Samples were submitted to various laboratories for analysis of priority pollutants under 40 CFR Part 122, gross alpha and beta, and individual isotopes. Figures displaying the historical monitoring well networks are included in Appendix B.

The investigation concluded that the alluvium was the major aquifer in the vicinity, that it is generally unconfined, and in hydraulic communication with the Missouri River, with predominant regional flow within the alluvium towards the Missouri River. Regional groundwater flow evaluation is included as part of the OU-3 RI, and is expected to show a component of flow down the Missouri River Valley during normal conditions. The alluvium was mounded with downward vertical gradients in areas of localized recharge, and could be generally separated into two aquifers – an upper alluvial aquifer and a lower alluvial aquifer. Shallow and intermediate alluvial wells were combined as the upper alluvial aquifer, present from ground surface to approximately 65 ft bgs, or above 385 feet above mean sea level (ft msl). Deep alluvial wells were considered to monitor the lower aquifer, present from approximately 65 ft bgs to 120 ft bgs, or below 385 ft msl. Surface water monitoring point SMP-63 was located in the North Surface Water Body and was in apparent communication with groundwater but was accidentally destroyed prior to surveying. Horizonal gradients in the aquifers were determined to be small, and variable. The lower aquifer exhibited flatter hydraulic gradients than the upper aquifer. Hydraulic conductivity of the alluvium was found to range between 2.4×10^{-4} to 2.5×10^{-1} centimeters per second (cm/s). To understand hydraulic conductivity properly for this area, the OU-3 RI will take into account both the vertical and horizontal distribution of aquifer properties. Groundwater flow rates are a function of both hydraulic gradient and conductivity.

Methylene chloride was the only priority pollutant volatile organic compound (VOC) detected in background, upgradient, and downgradient wells, but was below standards in all of the samples. Bis (2-ethyhexyl) phthalate and phenol were detected below standards in D-92 at 477 micrograms per liter (ug/L) and 19 ug/L, respectively. Organics exhibited an irregular distribution in monitoring wells, so the landfill was identified as a possible source. Metals also were distributed irregularly with none in exceedance of state and federal standards and no significant differences observed between background, upgradient, and downgradient wells. No significant difference was observed between constituent concentrations in deep and shallow wells. Seasonality was observed between events with more constituents detected at higher concentrations during December 1985 than May 1986. Pesticides were detected at S-82, D-83, and S-84, but their source was not determined since pesticides were detected in what was then considered background, upgradient, and downgradient wells. Chlordane and 4,4’-dichlorodiphenyltrichloroethane (DDT) exceeded Health Risk Criteria at these locations. Presence of pesticides will be further evaluated after regional groundwater flow direction has been established. Gross alpha radiation exceeded drinking water standard at downgradient well S-82, and radium concentrations exceeded the drinking water standard at piezometers S-82 and D-83.

The investigation recommended short-term supplemental data investigation to evaluate seasonal variability in concentrations, potential impacts to fish in nearby surface water bodies to the north, the source of constituents in upgradient wells, and installation of an additional piezometer near D-89. Routine long-term monitoring was also recommended for a select list of constituents. These recommendations do not appear to have been implemented until a later date.

2.4.2 1989 SITE CHARACTERIZATION AND REMEDIAL ACTION CONCEPTS

The report by the Office of Nuclear Material Safety and Safeguards (ONMSS) evaluated previous site characterization of remedial actions and updated groundwater monitoring data (NRC 1989). Their report presented the results, environmental characteristics of the site, the extent and characteristics of the radioactive material, some considerations with regard to potential disposal of the materials, and some concepts of remedial measures. The investigation concluded contamination of water in the bedrock aquifer did not appear likely, due to the fairly impervious limestone and observed groundwater flow in most areas from the bedrock into the alluvium. The investigation also concluded radioactive material, as it then existed, did not pose an immediate health hazard. However, it also identified that there was a long-term potential for the RIM to pose a health problem without the proper construction of a soil cap.

2.4.3 1996 GROUNDWATER CONDITIONS REPORT WEST LAKE LANDFILL AREAS 1 & 2

A groundwater conditions investigation for Areas 1 and 2 was completed in 1996 and included grab groundwater sampling for gross alpha analysis, installation of 14 alluvial monitoring wells, development of existing and new wells, groundwater elevation monitoring, radiological and non-radiological groundwater sampling and analysis, and aquifer testing of 18 monitoring wells (McLaren/Hart 1996). Gross alpha samples were first collected from existing monitoring wells to evaluate whether groundwater was radiologically impacted and required specific investigation derived waste (IDW) handing during monitoring well re-development. All 31 wells sampled, after filtering 3 that failed initially, met the gross alpha concentrations of less than 15 picocuries per liter (pCi/L) acceptable for discharge directly to the Metropolitan St. Louis Sewer District.

A total of four wells were installed in Area 1, four wells were installed in Area 2, and six wells were installed on the Ford property. Large diameter holes were first drilled through landfill debris, logged using downhole gamma geophysical tools, then re-drilled using a smaller diameter auger rig, and completed as monitoring wells beneath the refuse. Newly completed wells were downhole gamma logged and developed, and 30 non-damaged existing wells were re-developed. A total of 44 wells were gauged and sampled for radiological and non-radiological COPCs after development (Appendix B). Constituents in the uranium-228, uranium-225, and thorium-232 decay series, eight priority pollutant metals, eleven VOCs, four semi-volatile organic compounds (SVOCs), and three pesticides were detected in groundwater.

2.4.4 1996 PHYSICAL CHARACTERIZATION TECHNICAL MEMORANDUM

The report was completed to review past investigations, describe the surface and subsurface features, and recommend a groundwater monitoring network for OU-2 (Golder 1996). Site characterization included a desk study and literature review; detailed geologic mapping of the exposed quarry walls; advancement of soil, bedrock, and solid waste borings;

soil and rock geotechnical testing; chemical analysis of soil; borehole geophysical logging; packer testing; piezometer/monitoring well construction; conversion of MW-1201 from open-borehole monitoring well to 2-inch cased well; installation of leachate risers in solid waste; developing and slug testing piezometers; gauging monitoring wells; and measuring surface water levels in site surface water bodies. This resulted in development of a conceptual site hydrogeologic model and groundwater monitoring network. The conceptual site hydrogeologic model evaluated the importance of the Bridgeton Landfill leachate collection system, which removed approximately 216,500 gallons of leachate per day during 1994. Leachate included surface water and groundwater that flowed into the Bridgeton Landfill. The groundwater monitoring network was designed, in part, to understand the influence of the leachate collection system.

A total of 49 single, paired, and clustered piezometers/monitoring wells were installed at 33 locations approximately 350 ft apart to characterize unconsolidated and bedrock materials. Screened intervals were selected based on contacts between strata. Leachate risers were also installed where USEPA inferred the presence of industrial and/or hazardous waste. Deep boreholes were continuously logged with some selected for geophysical logging and packer testing after drilling. Piezometers were then installed, surveyed, developed, and slug tested. Solid waste boreholes were completed as leachate risers.

Boreholes were reamed for geophysical testing, packer testing, and piezometer installation. Packer tests were conducted by selecting and isolating fractured/unfractured and porous/non-porous zones to provide a range of conductivities for each unit. Geotechnical sampling was also conducted on undisturbed Shelby tube unconsolidated samples, two disturbed unconsolidated samples, and two bedrock samples collected from the shale near the top of the Warsaw Formation. Open hole monitoring well MW-1201 was converted from a completion depth of 250 ft bgs to a piezometer PZ-1201-SS to a depth of 148.5 ft bgs. Staff gauges were installed in Earth City Industrial Park stormwater retention pond southwest of the leachate retention pond and monitored monthly coincident with water level gauging. Wells were developed by surging, bailing, and air lifting. Wells were then slug tested. Monthly groundwater levels and surface water levels were collected. Precipitation data was collected daily during well installation, averaged monthly, and compared to Lambert Field totals with good correlation, so Lambert Field data were used thereafter. Geologic mapping of the exposed St. Louis Formation in the limestone quarry walls was conducted to correlate large scale features to those identified in rock cores and evaluated seepage from the quarry walls into the pit. The St. Louis Formation was divided into five sub-units, as discussed below in Section 3.1.3.1.4.

A monitoring network of 24 monitoring wells/piezometers, 2 surface water points, 2 sediment sampling points, and 8 leachate sampling points in OU-2, and 28 monitoring wells/piezometers in OU-1, resulting in a total of 54 separate sampling locations across the site, was proposed based on the conceptual site hydrogeologic model. These were considered sufficient for site characterization, risk assessment, and remedy evaluation. Results of the investigation are discussed in Section 3.

2.4.5 1997 SITE CHARACTERIZATION SUMMARY REPORT OU-1

This report was submitted as an interim evaluation to assist in the development of the baseline risk assessment for OU-1 (EMSI 1997). The report included a review of previous investigations; description of surface and subsurface features; and a summary of the nature, extent, and migration potential of contamination. An updated CSM was provided for radionuclides.

2.4.6 1997 WEST LAKE LANDFILL OU-2 RI/FS SITE CHARACTERIZATION SUMMARY REPORT

Site characterization activities were conducted as part of the OU-2 RI/FS (WMC 1997). They reviewed previous investigative activities, described the nature and extent of surface and subsurface impacts, and evaluated transport mechanisms through various media. The primary objectives were to collect additional data to better characterize the environment, chemical occurrence, migration pathways, and transport mechanisms. Two rounds of sampling were conducted in February-March 1997 and May-June 1997 in piezometers/wells at the 24 locations selected by Golder for the OU-2 monitoring network. A non-routine background groundwater sampling event was also conducted in December 1995 at piezometers PZ-300-AS, PZ-300-AD, and PZ-300-SS, and wells I-50 and S-80, prior to those wells being decommissioned for development of nearby properties.

Samples collected during monitoring events were submitted for analysis of metals, general parameters, radionuclides, VOCS, SVOCs, pesticides, and polychlorinated biphenyls (PCBs). Results of routine events were compared to results of the non-routine background event and separated into alluvial and bedrock samples. Deep Salem Formation groundwater monitoring results suggested impacts related to site activities were absent. Surface water and sediment quality was deemed free of impacts from OU-2.

A total of five leachate riser (prefix LR) sampling points were installed in the Inactive Sanitary Landfill to evaluate whether standing water visible in aerial photographs represented liquid waste disposal areas. Four of these leachate risers contained sufficient liquid thickness for sampling. Samples were also collected from four leachate risers (prefix LCS) in the Bridgeton Landfill for comparison. Samples were submitted for the same analyte suite as groundwater monitoring wells. Organic compound and radionuclide concentrations were similar for the Inactive Sanitary Landfill and the Bridgeton Landfill. Solvents were not detected in the Inactive Sanitary Landfill. The report concluded that the standing water seen in the aerial photographs was most likely ponded precipitation.

Soil samples from the screened intervals of 300 series piezometers, leachate risers LR-103 and LR-104, and soil gas boreholes were submitted for laboratory analysis of total organic carbon (TOC). Select samples were also submitted for analysis of VOCs, purgeable-range total petroleum hydrocarbons (TPH), and extractable-range TPH. VOC and TPH results suggested impacts were limited to an area west/southwest of the asphalt plant UST site near monitoring well MW-F2.

The OU-2 site characterization did not identify any hazardous substance source areas. The report suggested that groundwater quality in the Deep Salem Formation, Upper Salem Formation/St Louis Formation, and alluvial hydrogeologic units within and near OU-2 was similar to upgradient, background groundwater quality with the exception of a limited area in the alluvial aquifer. VOCs were detected infrequently at low concentrations. According to the 1997 study, landfill gas likely affected groundwater quality throughout the site.

2.4.7 2000 OU-1 REMEDIAL INVESTIGATION

The OU-1 RI report was submitted in April 2000 and presented the results of site characterization field activities (EMSI 2000). The OU-1 RIA was submitted as an addendum in 2018 and included the contents of the 2000 OU-1 RI report (EMSI 2018a). Further discussion of this report follows below, in connection with the 2018 OU-1 RIA discussion in Section 2.4.17.

2.4.8 2005 REVISED OU-2 REMEDIAL INVESTIGATION

The revised OU-2 RI presented the results of previous site characterization activities (H&A 2005). In particular, it focused on work done as part of the groundwater investigation and documented in the Physical Characterization Memorandum (see Section 2.4.4) that included aquifer testing, laboratory permeability testing, groundwater level monitoring, horizontal and vertical gradient evaluation, seasonal variability, influence of precipitation, surface water groundwater interaction, and leachate evaluation. Monthly groundwater level measurements were collected between June 1995 and July 1996 from piezometers near the Bridgeton Landfill.

The 2005 RI concluded it was likely that the relatively high permeability of the alluvium generally allowed rapid dissipation of recharge and prevented mounding, resulting in little apparent response to precipitation. In the Upper Salem Formation/St. Louis Formation precipitation response was noted and occurred within one to five days of a precipitation event. In the Deep Salem Formation, a relatively rapid response to precipitation (one day) was registered. In the Keokuk, response to a rainfall event was slight, as expected, given the presence of an overlying aquitard.

The 2005 RI report also included the results of groundwater sampling documented in the 1997 Site Characterization Summary Report and supplemental sampling completed at a list of selected alluvial wells in December 2003 and May 2004 to verify previous results. A detailed comparison of results against background was completed. The detailed groundwater quality assessment and source characterization did not identify any hazardous substance source areas and concluded that the leachate collection sumps in the Bridgeton Landfill maintained an inward hydraulic gradient. The OU-2 RI also concluded that groundwater quality in the alluvium and Deep Salem and Upper Salem Formation / St. Louis Formation hydrogeological units near and within OU-2 was similar to upgradient, background groundwater quality. Groundwater impacts were limited to iron, manganese, total dissolved solids (TDS), arsenic, chloride, TPH, benzene, vinyl chloride, and fluoride. Inorganic and conventional parameters were explained by variability in background concentrations. The OU-2 RI did not identify any surface water or sediment impacts.

2.4.9 2006 OU-2 FEASIBILITY STUDY

The OU-2 FS presented remedy considerations under the presumptive remedy approach based on the findings of the OU-2 RI (H&A 2006). The presumptive remedy of containment for CERCLA municipal landfill sites was outlined and approved in the OU-2 AOC and discussed in the USEPA approved Remedial Action Objectives Report. An MDNR-prescribed landfill cover with long-term monitoring and institutional controls was proposed as the final remedy for OU-2, but design was postponed until a decision was made for OU-1 so the final remedies could be coordinated.

2.4.10 2006 OU-1 FEASIBILITY STUDY

The OU-1 FS presented remedial action alternatives for Area 1 and Area 2 in OU-1 and the Buffer Zone/Crossroad Property (Ford Property) (EMSI 2006). Impacted soil in Area 1 and Area 2 is interspersed with and contained within an overall matrix of solid waste materials. Both Area 1 and 2 are part of larger areas of previously placed solid wastes within the 230-acre landfill complex. Consequently, the OU-1 FS concluded possible remedial actions for the RIM in Areas 1 and 2 could not be implemented without consideration of ongoing activities at the landfill and possible future landfill operations, closure activities, or remedial actions that may be implemented for other portions of the landfill. Selection and implementation of a remedy for OU-1 would involve coordination with the remedial action, if any, to be selected for OU-2. Of particular interest was the coordination of any grading, landfill cover, or drainage improvements that may be implemented for either of the OUs. The remedy for OU-1 was proposed as an upgraded landfill cover over OU-1 and removal of impacted soil from the Buffer Zone/Crossroad Property. No technical compatibility issues were anticipated with implementation of any cover designs for OU-2. Protection of public health would have been achieved through the installation of a Subtitle D-equivalent landfill cover, removal of impacted soils from the Buffer Zone/Crossroad Property, and the maintenance of the existing and additional land use covenants.

2.4.11 2008 OU-1 RECORD OF DECISION

The OU-1 ROD proposed a landfill cover, soil consolidation from the Buffer Zone/Crossroad Property to the containment area, groundwater monitoring, surface water runoff control, gas monitoring and control, institutional control, and long-term surveillance and maintenance as the major components of the selected remedy (USEPA 2008a). The OU-1 ROD was intended to provide the final remedies for source control and groundwater to complete CERCLA decision-making for the site. The OU-1 ROD concluded that isolated detections of a small number of constituents were not indicative of on-site contaminant plumes, radial migration, or other forms of contiguous impacts related to landfilling. It also concluded that there was no evidence of significant leaching and migration of radionuclides from Areas 1 and 2 to perched water or groundwater, but that the pathway should be addressed. It identified the primary transport mechanism in alluvial water from Area 2 to the northeast, since hydrologic divides created by the leachate collection system and Earth City flood control prevent migration elsewhere.

2.4.12 2008 OU-2 RECORD OF DECISION

The OU-2 ROD proposed containment using a landfill cover with appropriate closure and post-closure care requirements as the Selected Remedy (USEPA 2008b). This included groundwater monitoring and protection, surface water runoff control, gas monitoring and control, institutional controls, and long-term surveillance and monitoring. The Bridgeton Landfill has been pumping approximately 300 million gallons of leachate/groundwater per year since approximately1993 and will continue with said pumping through at least 2036. Groundwater and surface water analytical results from the OU-1 and OU-2 RI/FS projects combined indicated the constituents detected at the site in excess of USEPA maximum contaminant levels (MCLs) were chlorobenzene, benzene, dissolved and total lead, dissolved and total arsenic, and dissolved and total radium. The results generally showed sporadic and isolated detections of a small number of contaminants at relatively low concentration levels. These results were not necessarily indicative of on-site contaminant plumes, radial migration, or other forms of contiguous groundwater contamination attributable to the landfill units. The Selected Remedy for the Inactive Sanitary Landfill was to install a cover system consistent with relevant and appropriate Missouri requirements for sanitary landfill caps, including two feet of engineered materials meeting permeability and vegetation maintenance requirements, institutional controls, long term monitoring, and periodic reviews.

2.4.13 2011 SUPPLEMENTAL FEASIBILITY STUDY

The Supplemental FS for OU-1 was prepared to provide additional evaluation of a select group of potential remedial alternatives for OU-1 (EMSI 2011). The USEPA required that the Supplemental FS be performed to provide an engineering and cost analysis of the ROD-selected remedy, and to evaluate two new, additional remedial alternatives for removal of all material containing radionuclides at levels greater than those that would allow for unrestricted use of the radiologically-contaminated areas, one for on-site disposal and one for off-site disposal.

2.4.14 2012 TO 2014 GROUNDWATER MONITORING REPORTS

Between July 2012 and October 2013, four additional groundwater sampling events occurred at OU-1 at the request of the USEPA (EMSI 2012; EMSI 2013a; EMSI 2013b; and EMSI 2014). The USEPA requested that all available groundwater monitoring wells at the West Lake Landfill be included, and directed that samples obtained from the wells be analyzed for uranium, thorium, and radium radioisotopes (including Radium-226 and Radium-228), with all radioisotopes analyzed for both total (unfiltered samples) and dissolved (filtered samples) phases, plus total and dissolved phase trace metals, VOCs and SVOCs.

The results of the July 2012 sampling event supported the USEPA May 2008 ROD conclusion: namely, isolated and sporadic detections of a small number of radiological and conventional contaminants exist in site groundwater, but no contiguous plumes of radiological or conventional groundwater contaminants were present underneath the site or migrating from the site. With respect to radionuclides, uranium is not present in site groundwater above the USEPA MCL, and thorium is present only at low levels. Two forms of radium are present in site groundwater: Radium-226 and Radium-228. The report stated that the absence of any spatial relationship between the RIM locations and the radium exceedances indicates the Radium-226 and Radium-228 found in site groundwater are of natural origin. Seventy-six wells were sampled as part of this event.

Seventy-five wells were sampled during the April 2013 sampling event. Only one well (S-53) contained a calculated total uranium mass concentration that exceeded the USEPA MCL. Due to limited water in the well, it was sampled without purging and had a turbidity of approximately 524 NTU, indicating the sample contained a large fraction of suspended sediment. This well was dry during the July 2012 sampling event and was therefore not sampled. Additionally, this well was not included in either the OU-1 or the OU-2 RI/FS groundwater sampling programs. All other wells were below the USEPA MCL for uranium. Overall for thorium isotopes, only low levels (less than 1 pCi/L) were detected in the majority of the wells. The highest was found in S-53. A total of 19 of the 75 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels exceeding the USEPA MCL. Trace metals were also detected in wells. The most frequent were iron and manganese, which were detected in nearly all the monitoring wells. VOCs were detected in groundwater samples. The most common was benzene, which was reported to be present in 26 of the 75 wells. Benzene was detected in 11 wells at concentrations greater than the applicable water quality standard of 5 µg/L. The highest concentrations of benzene were found in wells located adjacent to the South Quarry portion of the Bridgeton Landfill.

Seventy-five wells were sampled during the July 2013 sampling event. None of the samples contained calculated total uranium mass concentration that exceed the USEPA MCL of 30 µg/L. Overall for thorium isotopes, only low levels (less than 1 pCi/L) were detected in the majority of the wells. The highest was found in S-53. A total of 25 of the 75 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels that exceeded the USEPA MCL. Trace metals were detected in wells. The most frequently detected were iron and manganese, which were detected in nearly all the monitoring wells. VOCs were detected in groundwater samples. The most common was benzene, which was reported to be present in 27 of the 75 wells. Benzene was detected in 13 wells at concentrations greater than the water quality standard of 5 µg/L. The highest concentrations of benzene were found in wells located adjacent to the South Quarry portion of the Bridgeton Landfill.

Eighty-four wells were sampled in the October 2013 sampling event. One well (PZ-211-SD) contained a calculated total uranium mass concentration (70.25 µg/L) that exceeded the USEPA MCL of 30 µg/L. Overall for thorium isotopes, only low levels (less than 1 pCi/L) were detected in the majority of the wells. The highest total thorium values were in bedrock monitoring wells PZ-211-SD and PZ-102-SS and in alluvial wells D-85, S-61, and MW-104. A total of 30 of the 84 monitoring wells contained total and dissolved fraction or total fraction only results for combined Radium-226 plus Radium-228 at levels that exceeded the USEPA MCL. The combined Radium-226 plus Radium-228 results from 14 of the 84 monitoring wells exceeded the USEPA MCL for both the total fraction and the dissolved fraction. Trace metals were detected in wells. The most frequently detected were iron and manganese, which were detected in nearly all the monitoring wells. VOCs were detected in groundwater samples. The most common was benzene, which was reported to be present in 36 of the 84 wells. Benzene was detected in 18 wells at concentrations greater than the water quality standard of 5 µg/L. The highest concentrations of benzene were found in wells located adjacent to the South Quarry portion of the Bridgeton Landfill.

2.4.15 2015 USGS BACKGROUND STUDY

At the direction of USEPA Region 7, the USGS reviewed data from the comprehensive groundwater sampling completed at the site between 2012 and 2014 and evaluated the source of combined radium in groundwater above the USEPA MCL (USGS 2015). The USGS background study included a review of regional historical data, occurrence and geochemistry of radionuclides in various aquifer systems, geochemistry of MSWLFs, and historical data for the site. Four general hypotheses for the origin of dissolved combined radium in groundwater above the USEPA MCL were presented:

- Leaching of radium from RIM
- Natural variability

- Leaching of radium from non-RIM wastes
- Mobilization of naturally occurring radium from aquifer solids due to leachate

Radionuclide data from 9 alluvial wells and 2 bedrock wells open to Mississippian-age rock within 5 miles of the site were combined with data from PZ-212-SS and PZ-212-SD (installed in 2013) and data from off-site wells south of the site to calculate background concentrations of dissolved and total combined radium in groundwater. The upper limits of background (95th percentile) for dissolved and total radium were 1.98 and 2.81 pCi/L for the alluvium, and 3.56 and 3.34 pCi/L for Mississippian-age bedrock. Ratios of total and dissolved Radium-228/Radium-226 ranged from 1.0 to 4.98 for the alluvium and 0.09 to 2.11 for the bedrock. The background dataset was limited with only 17 alluvial groundwater samples and 11 bedrock groundwater samples from Mississippian age bedrock.

Background data were compared to data from 83 monitoring wells sampled at least once during 2012 to 2014 site-wide groundwater monitoring. Chloride, bromide, and iodide were considered the primary indicators of landfill leachate due to naturally occurring sodium, sulfate, and boron present in samples collected from the nearby Champ Landfill expansion. Wells were scored and weighted based on concentrations of primary leachate indicators. Results suggested that 47 wells (37 alluvial and 10 bedrock) scattered across the site were affected by landfill leachate and given an L score greater than zero suggesting landfill materials are widespread. A total of 10 of these 47 wells had an L score of 0.5 and exhibited slight possible effects of landfill leachate. The eight alluvial wells with no leachate effects were each less than 45 ft deep (shallow or intermediate) and located on the western part of the site. Several constituents in groundwater had moderate to strong correlations with leachate effects related to a change in the geochemical conditions.

Average combined dissolved radium was above the USEPA MCL in 13 wells and positively correlated with landfill impacts with 11 wells having a leachate score greater than zero. On-site dissolved or total combined radium in groundwater was variable with concentrations generally lower in wells open to the Keokuk Limestone and higher in wells open to the deep alluvium. Each of the five alluvial wells with average dissolved combined radium above the USEPA MCL were deep wells with naturally anoxic and/or leachate-affected conditions. Average combined dissolved radium in groundwater above the USEPA in bedrock wells were generally located around the North and South Quarry areas of the Bridgeton Landfill.

The USGS concluded that although there was a strong positive correlation between leachate effects and the average combined dissolved radium detections above the USEPA MCL, it did not indicate that RIM was the source. The USGS' evaluation suggested that the likely origin of the radium in groundwater was a combination of the four potential sources. Contributing to the uncertainty in determining the origin of combined radium in groundwater was the small background dataset; the absence of samples/data at discrete depths from onsite leachate risers and leachate collection sumps; and the insufficient data on concentrations/ratios and phase associations of radium in aquifer materials, RIM, and in leachate from other MSWLFs.

2.4.16 2016 GROUNDWATER TECHNICAL REPORT

A technical evaluation of the OU-2 groundwater monitoring network was completed at the request of MDNR (Feezor 2016). The scope of the report was to evaluate groundwater quality at monitoring wells located near the Bridgeton Landfill's North and South Quarries which were not being sampled as a part of the facility's detection or assessment monitoring programs and the facility's then current groundwater monitoring well network. It included a detailed review of data collected from wells within approximately 350 ft of the landfill's waste boundary during quarterly monitoring events between fourth quarter 2015 and third quarter 2016, and the field and laboratory analytical results presented in the Physical Characterization Technical Memorandum (Golder 1996). The evaluation included a detailed hydrogeological review of the different zones and non-routine monitoring wells, and suggested modifications to the OU-2 routine monitoring network.

Several wells were identified as candidates for addition to the OU-2 monitoring well network. These included St. Louis/Upper Salem Formation wells PZ-102R-SS, PZ-113-SS, PZ-203-SS, and PZ-204-SS, and alluvial well I-68. Confirmatory sampling was proposed at wells with unconfirmed organic constituent detections, and or unconfirmed inorganic constituent exceedances of the MCL during third quarter 2016. Confirmatory sampling was proposed for St. Louis/Upper Salem Formation well PZ-116-SS, and alluvial wells D-3, D-85, I-4, I-73, PZ-112-AS, PZ-113-AS, PZ-113-AD, PZ-207-AS, S-5, and S-84. Additional sampling was proposed for wells with confirmed organic constituent detections and confirmed inorganic constituent exceedances of the MCL. Additional sampling was proposed at Salem Formation well MW-1204; St. Louis/Upper Salem Formation wells PZ-101-SS, PZ-103-SS, PZ-200-SS, PZ-202-SS, and PZ-204A-SS; and shallow alluvial well PZ-205-AS. These recommendations were implemented by the Bridgeton Landfill and have been considered during preparation of this Work Plan.

2.4.17 2018 OU-1 RI ADDENDUM

USEPA requested an OU-1 RIA, updated baseline risk assessment (BRA), and final FS in the OU-1 ASAOC as amended and associated SOW dated December 9, 2015 (USEPA 2015a). The OU-1 RIA updated the CSM based on additional data and various site characterization activities completed after submittal of the OU-1 RI in 2000 (EMSI 2000). The CSM presented in the OU-1 RIA serves as the basis for the CSM presented in this Work Plan. It identified the following data gaps (EMSI 2018a):

- Background groundwater quality

- Groundwater geochemistry
- Regional, site, and local hydraulic gradients
- Recharge and discharge points
- Leachate chemistry and occurrence
- Effect of leachate extraction on groundwater levels and hydraulic gradients
- Nature and extent of off-site contamination
- Adequacy of the groundwater monitoring network along the perimeters of Areas 1 and 2
- Hydraulic properties of the aquifer
- Effect of suspended sediment on groundwater quality
- Potential for vapor intrusion into on-site buildings
- Potential correlations between radium and geochemical indicators
- Evaluation of potential leaching of wastes

The OU-1 RIA included a discussion of the potential subsurface transport mechanisms and recommended additional groundwater investigations under the OU-3 RI/FS to address the data gaps (EMSI 2018a).

2.4.18 2018 OU-1 UPDATED BASELINE RISK ASSESSMENT

An updated BRA was prepared in conjunction with the OU-1 RIA by Auxier & Associates (Auxier 2018). The BRA consisted of a human health evaluation and screening level ecological risk assessment. The overall objectives were to evaluate whether radiological and chemical constituents detected in the environmental media at OU-1 pose lifetime cancer risks (LCRs) or non-cancer effects that exceed USEPA's regulatory threshold levels under current and anticipated future conditions if no remedial actions are taken and support decisions concerning risk management. The BRA identified radionuclides associated with uranium, actinium, and thorium decay series as well as 13 inorganic COPCs at OU-1. The OU-1 BRA concluded there were no current unacceptable risks to on-property or off-property human or ecological receptors.

2.4.19 2018 OU-1 FINAL FEASIBILITY STUDY

The Final Feasibility Study (FFS) for OU-1 was prepared to present further evaluation of potential remedial alternatives to address the presence of RIM contained within portions of some of the landfill units at the site (EMSI 2018b). The FFS provides further evaluation of the containment remedy with some modifications, and additional evaluations of a containment remedy alternative with an engineered cover designed to meet the Uranium Mill Tailings Radiation Control Act (UMTRCA) performance standards; a full excavation with off-site disposal alternative; a partial excavation alternative that would remove RIM containing either combined radium or combined thorium activities above 52.9 pCi/g and located within 16 feet of the 2005 topographic surface; a partial excavation alternative that would remove RIM containing either combined radium or combined thorium above 1,000 pCi/g regardless of depth; a risk based partial excavation alternative to remove RIM such that the remaining materials would be protective of industrial land uses (the reasonably anticipated future land use) without consideration of the presence of an engineered cover system; and a full excavation alternative with the option to re-dispose the excavated material in an on-site engineered cell. Of the seven remedial alternatives (excluding the No Action alternative), all meet the USEPA's criteria for protection of Human Health and the Environment, compliance with ARARs, long-term effectiveness and performance, reduction in toxicity, mobility or volume through treatment, short-term effectiveness, implementability, and cost.

2.4.20 2018 OU-1 RECORD OF DECISION AMENDMENT

The USEPA determined that further evaluation of remedial alternatives was warranted as a result of stakeholder and community concerns following the 2008 ROD (USEPA 2018a). Based on the results of those investigations and evaluations, the USEPA determined that a fundamental change to the 2008 ROD is appropriate. In summary, the Amended Remedy is based on the following:

- A better understanding of the volume, concentration and location of RIM at the site that may present an unacceptable risk
- New information regarding the potential for RIM to leach under certain circumstances
- Concern that should a subsurface heating event occur in OU-1, the heat could dry and desiccate a cap, providing a conduit for increased release of radon from the subsurface and potentially for the leaching of RIM
- A determination that implementation of the 2008 ROD could not be accomplished without disturbance of both putrescible waste and RIM

The USEPAs Amended Remedy includes:

- Excavation and stockpiling of overburden in OU-1 Radiological Areas 1 and 2 to access the RIM
- Excavation of RIM from the Areas 1 and 2 of OU-1 that contains combined radium or combined thorium activities greater than 52.9 pCi/g that is located generally within 12 feet of the 2005 topographic surface. Optimization of RIM removal above and below the 12-foot target depth (excavation as deep as 20 feet or as shallow as 8 feet) will be performed during the remedial design

- Excavation of RIM soil from the Buffer Zone and/or Lot 2A2 sufficient to reduce concentrations of radionuclides to background in order to allow for unlimited use and unrestricted exposure (UU/UE)
- Loading and transport of the RIM and radiologically impacted soil for disposal at an off-site permitted disposal facility
- Re-grading 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 over Areas 1 and 2 designed to meet the Resource Conservation and Recovery Act (RCRA) hazardous waste design criteria, municipal waste landfill regulations, and UMTRCA performance and longevity standards
- Design, installation, and maintenance of surface water runoff controls
- Groundwater performance monitoring
- Landfill gas and radon monitoring and control, in accordance with ARARs
- Institutional controls to prevent land uses that are inconsistent with a closed landfill containing radiological materials
- Long-term surveillance and maintenance of the landfill cover in Areas 1 and 2 and other remedial components

2.5 HISTORICAL DATASET

Each of the investigations summarized in the previous sections were reviewed in detail prior to and during preparation of this RI/FS Work Plan, and mined for relevant and pertinent information to begin addressing the following OU-3 data gaps identified in the SOW:

1. Adequacy, usability, and status of existing and abandoned on-site and near-site monitoring wells
2. Aquifer properties, including recharge/discharge rates and hydraulic conductivities
3. Regional and localized hydraulic gradients and flow directions between alluvial and shallow bedrock aquifers
4. Background groundwater quality of alluvial and shallow bedrock aquifers near the site
5. Occurrence and extent of groundwater contamination and landfill gas migration in groundwater
6. Groundwater geochemistry parameters, redox couples, and organic content
7. Effects of the Bridgeton Landfill, related infrastructure, and hydraulic characteristics of landfill material on the groundwater system
8. Vapor intrusion

9. Temporal variability in groundwater levels and flow direction
10. Temporal and spatial water elevation effects from relevant surface water features (Missouri River, streams, and surface water bodies) and storm events

A summary of existing data and approximate date ranges during which they were collected is included as Table 2-2. This dataset was compiled and considered in preparation of a preliminary CSM. Further evaluation of this dataset will be completed to refine the CSM as part of the OU-3 RI/FS data evaluation. The historical dataset will be evaluated using relevant USEPA guidance as listed on the USEPA *Resources for Project Planning that Use Existing Data* website to determine that the data are appropriate and of sufficient quality for the intended use pursuant to the OU-3 QAPP, which was prepared in accordance with USEPA Requirements for Quality Assurance Project Plans (USEPA 2001c; USEPA 2018b).

3.0 INITIAL EVALUATION AND CONCEPTUAL SITE MODEL

An evaluation of the existing dataset and review of the documents described in Section 2.0 were completed as part of the preparation of this Work Plan. This included compilation and review of available borehole logs, well construction details, field logs, analytical data, field measurements, aquifer testing data, and geochemistry data to refine the groundwater CSM and develop an OU-3 database. The data for each of these investigative periods was combined and collectively analyzed with respect to understanding conditions near the site. The preliminary CSM provides an understanding and summary of:

- The potential and known sources of groundwater impacts
- Potential release mechanisms
- Potential routes of migration, including any known or suspected preferential pathways
- Groundwater flow (vertical and horizontal)
- Missouri River and groundwater interaction
- Factors controlling contaminant distribution
- Potential human and environmental receptors

The CSM will be updated with additional data as the investigation progresses and will be presented in the Annual Hydrogeologic Investigation and Groundwater Characterization Reports and the OU-3 RI Report. Real-time data collected during field activities will be incorporated to reflect newly collected information in accordance with *Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model* (USEPA 2011b). The preliminary CSM is presented below.

3.1 PRELIMINARY CONCEPTUAL SITE MODEL

The preliminary CSM synthesizes the regional setting with site-specific geology, hydrology, hydrogeology, geochemistry, and ecology data. Existing demography, land, groundwater, and surface water data are discussed along with flora and fauna of the site and surrounding areas, threatened and endangered species, rare species, sensitive environmental areas, and critical habitats to identify potential human and ecological receptors. Potential surface, subsurface, atmospheric, and biotic migration pathways are also identified.

3.1.1 REGIONAL SETTING

The site is located near the confluence of the Missouri River and the Mississippi River, in the gently undulating Dissected Till Plains Physiographic Province ranging in elevation from approximately 440 to 700 ft msl. The site is close to the southernmost extent of Pleistocene glaciation, but morainal topography is absent and till is thin and dissected (Miller et al. 1974). Loess was deposited in upland areas during Pleistocene glaciation and alluvium was deposited in river valleys. Surface water runoff reaches the Missouri or Mississippi Rivers. Quaternary deposits are generally underlain by Pennsylvanian shale, limestone, clay, sandstone, siltstone, and coal, and Mississippian limestone (Harrison 1997). Regional and local geology and hydrogeology are described in the following subsections.

3.1.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

The geology of the region is described in detail on the *St. Louis 30' x 60' Quadrangle of Missouri and Illinois* and accompanying cross-sections (Harrison 1997). These cross sections are included as Appendix C. A regional stratigraphic column with detailed descriptions of bedrock present at the site is included as Table 3-1a. The stratigraphic sequence generally consists of strata deposited in shallow epicontinental seas.

3.1.2.1 REGIONAL GEOLOGY

Regional geology can generally be described as Precambrian igneous crystalline basement rock overlain by the cyclic deposition of Paleozoic sandstone, shale, limestone and dolomite belonging to the Illinois Basin (Table 3-1b). The basin consists of nearly three vertical miles of largely shallow water marine deposits that thicken to the east and toward the Ozark Dome to the southwest. As documented by the United States Army Corps of Engineers (USACE), the bedrock units are oriented nearly horizontal in the St. Louis area and dip less than 1 degree to the northeast as a result of uplift of the Ozark Dome (USACE 1998). Other regional structural features include the Cheltenham Syncline, the Dupo Anticline, and the Florissant Dome (McCracken 1965; Harrison 1997).

That shallowest units of the Illinois Basin near the site consist of Pennsylvanian and Mississippian age bedrock. The Pennsylvanian units consist primarily of siliciclastic deposits (i.e., shale, siltstone and sandstone), whereas the underlying Mississippian units consist primarily of fractured carbonate units (limestone and dolomite). Though bedrock units of Pennsylvanian age are present throughout the area, they were removed by erosion in the immediate vicinity of the site. Limestones, dolomites, and shales of the Mississippian System (Kinderhookian, Osagean, and Meramecian Series) are the dominant bedrock units at the site and are described in more detail in Section 3.1.3. The approximately 1,250 ft thick Mississippian System Series are all separated by non-distinct unconformities and are therefore defined by paleontology (Howe 1961).

Unconsolidated deposits of Quaternary age (Pleistocene to Holocene) unconformably overly the Paleozoic bedrock units of the Illinois Basin and generally occur in low-lying areas associated with the floodplains of the Missouri and Mississippi Rivers. Melt water from glaciers during the Pleistocene generated tremendous volumes of runoff, carrying immense quantities of sediment that had to be transported down the Missouri River. In response, the river carved a much deeper and wider channel than the river occupies today (MDNR 1997). These younger unconsolidated units consist of alluvial and terrace deposits of the Missouri River Alluvium and upland aeolian loess deposits. Fluvial alluvium dominates the Missouri and Mississippi River valleys, ranges up to 210 ft thick regionally and consists of gravel, sand, silt, and clay. Aeolian loess deposited during Pleistocene glaciation covers much of Missouri and Illinois overlying bedrock and forming the upland bluffs near the Missouri River valley. While the upland loess can range up to 215 ft regionally, the loess at the site is usually less than 40 ft thick but has been observed up to 80 ft thick in some areas generally consisting of 20 to 30 ft of pure silt overlying 20 to 49 feet of clay silt (Lutzen & Rockaway 1971; USACE 1998).

3.1.2.2 REGIONAL HYDROGEOLOGY

The Missouri River generally flows to the east through Missouri, flows to the north near the site, and is a tributary to the Mississippi River, which flows south along the eastern state boundary (Golder 1996). In 1974, of the 1,200 million gallons of water used daily in the St. Louis area 82 percent was pumped from the Mississippi River, 15 percent from the Missouri and Meramec Rivers, 2 percent from alluvial aquifers, and 1 percent from bedrock aquifers. Water withdrawn from surface water features required extensive treatment prior to use as potable water (Miller et al. 1974).

The major aquifers of the region are both the alluvial aquifers and the bedrock aquifers. Alluvial aquifers are generally present in the Missouri and Mississippi River valleys within saturated sands and gravels. Production of wells installed in the alluvium is dependent on sediment sorting, saturated thickness, connection to surface water, and infiltration (Miller et al. 1974). Alluvial aquifers are recharged by infiltration of surface water and precipitation, and upward movement of groundwater from underlying bedrock aquifers along the contact between bedrock and the base of the alluvium. Some wells installed in the alluvium yield over 2,600 gallons per minute (gpm).

Groundwater within bedrock is present within fractures, bedding planes, and solution cavities of limestone and dolomite, and within porous sandstones. The Warsaw Formation shale and the Maquoketa Shale are considered aquitards in the region. Economically feasible bedrock aquifers include the Ordovician St. Peters Sandstone, Roubidoux Formation, the Gunter Sandstone Member of the Gasconade Dolomite, and the Cambrian Potosi Dolomite. The uppermost of these, the St. Peters Sandstone, is encountered at approximately 1,450 ft below ground surface near the site and ranges from 60 to 165 ft thick with moderate reported yields between 10 and 140 gpm (Harrison 1997). The Roubidoux Formation is encountered at approximately 1,930 ft bgs and ranges from 110 to 170 ft thick

(Harrison 1997). Directly underlying the Roubidoux Formation is the Gasconade Dolomite. The basal unit of the Gasconade Dolomite is the Gunter Sandstone member that ranges between 25 and 30 ft thick. The Roubidoux Formation and Gunter Sandstone Member have yields between 10 and 300 gpm. The Potosi Dolomite is present at approximately 2,650 ft bgs with a thickness of approximately 200 ft and yields between 10 to 400 gpm.

Regional potentiometric surface maps for the alluvium and bedrock are shown on Figure 3-1. Predevelopment regional groundwater flow in the bedrock was generally toward the Missouri and Mississippi Rivers with a bedrock groundwater divide approximately 3.5 miles southeast of the site (Imes 1990). Regional groundwater flow in the alluvium appears to be a combination of base flow and underflow toward the Missouri River with a vector of approximately 45 degrees in the downstream direction (MDNR 1997; Emmett & Jeffery 1968). This flow direction near the site is variable with depth, precipitation, and river stage and is presently less understood. However, it will be characterized and evaluated during the implementation of this Work Plan.

3.1.2.3 REGIONAL GROUNDWATER QUALITY

Bedrock aquifers in the St. Louis area were described as not favorable for development of high-yield wells because these potable water wells typically have yields of less than 50 gpm and the deeper aquifers yield saline water (Miller et al. 1974). Regional groundwater quality is variable with calcium-magnesium-bicarbonate type water at low TDS and sodium chloride, sodium sulfate, or sodium bicarbonate type water depending on the source at high TDS. TDS generally ranges between 122 and 17,500 milligrams per liter (mg/L). Regional groundwater quality is affected by lithologic interrelations, permeability, structural features, residence time, distance traveled, flushing of entrapped saline connate water, and development (Miller et al. 1974). Compressional structural features such as anticlines and synclines can affect groundwater quality, with recharge occurring via secondary permeability of fractures and jointing in anticlines, and mineralized water traps in synclines (Miller et al. 1974).

The uppermost Post-Maquoketa bedrock aquifers are above the economically feasible aquifers. TDS in samples collected from wells in the Post-Maquoketa aquifers varied between 246 and 6,880 mg/L with low iron concentrations (<0.3 mg/L), high hardness (>180 mg/L), and relatively high fluoride concentrations (>1.4 mg/L in 50% of the samples) (Miller et al. 1974). Most potable water wells are located near the outcrops of Meramecian Series rocks and yield water of the calcium-magnesium-bicarbonate type. Water in northwestern St. Louis County has higher TDS generally of the sodium-chloride type with variable concentrations of calcium and sulfate. Chloride concentrations near the site are as high as 250 mg/L and could result from a lack of flushing of connate water or migration of mineralized water from deeper horizons or adjacent oil and gas rocks. High fluoride could result from solution of fluorite or saline water encroachment (Miller et al. 1974). Groundwater quality of the Ordovician, Cambrian, and Precambrian Systems is not evaluated in this CSM.

Missouri and Mississippi River alluvial aquifers have relatively well mixed and uniform concentrations of constituents but a wide variability of TDS. The water is of calcium-magnesium-bicarbonate type with localized high sulfate concentrations, high iron and manganese concentrations, and is very hard. High nitrate concentrations are likely due to impacts from surface waste (Miller et al. 1974).

3.1.2.4 REGIONAL SURFACE WATER RESOURCES AND QUALITY

The Mississippi and Missouri Rivers are a major reason for the growth and development of St. Louis and serve as commercial arteries for the nation. Combined flows historically averaged 112,000 million gallons per day (mgd) and provided 97 percent of the regional water use that includes industry, commerce, and recreation. They also provide means to dispose of waste and sewage. Missouri River flows are controlled upstream in the headwaters with a reservoir system reducing the flooding potential and maintaining navigable flows. Mississippi River flows are not controlled until they reach the locks and dams after the confluence with the Missouri River (Miller et al. 1974).

The Missouri and Mississippi Rivers provide an important supply of surface water to the area, with approximately 1 percent of the daily flow used for industry and commerce. These rivers also assimilate large quantities of municipal, industrial, and agricultural waste, which limits usage. Missouri River water in the St. Louis area is hard/moderately mineralized with calcium, magnesium, sodium, bicarbonate, and sulfate concentrations that control TDS and need treatment prior to use. Turbidity has trended downwards due to upstream dams but remains high, and needs reducing prior to use. Missouri River discharge is directly correlated with the chemistry showing a positive correlation with turbidity, and a negative correlation with hardness and alkalinity.

Chemical and physical characteristics of the Missouri River were averaged over the 20 years prior to 1970 from the Howard Bend Plant just upstream of the site (Miller et al. 1974). Temperature ranged from 0 degrees Celsius (°C) to 31°C with a mean of 14.5°C. Water was generally neutral to basic with a pH between 7.5 and 9.6 standard units (SU) and a mean of 8.1 SU. Alkalinity as calcium carbonate ($CaCO_3$) ranged from 53 to 294 mg/L with a mean of 150 mg/L. Hardness as $CaCO_3$ ranged between 83 and 366 mg/L with a mean of 206 mg/L. Turbidity ranged between 5 and 12,000 Jackson Turbidity Units (JTU) with a mean of 694 JTU. Annual average constituent summaries from 1951 through 1970 are included in Miller et al. 1974. These data are presented to provide context but are not incorporated into the OU-3 temporal boundary.

3.1.3 LOCAL GEOLOGY

Local geology is generally described as Loess, Missouri River Alluvium, and limestone bedrock. Detailed characterization of the Quaternary alluvium and Mississippian bedrock has been conducted at the site through installation of boreholes and detailed descriptions of the South Quarry Pit. Updated geologic cross sections are shown on Figures 3-2 through 3-5. Cross sections were updated for this preliminary CSM based on a detailed review and evaluation of the borehole logs, hydrostratigraphy of the alluvium, and mapping of the South Quarry Pit. A cross section on the southern property boundary in bedrock was not prepared for the Work Plan. Additionally, this data evaluation review process included applying the environmental sequence stratigraphic analyses to update the data and its interpretation and presentation in general accordance with *Best Practices for Environmental Site Management: A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models* (USEPA 2017a). Available borehole data were digitized and classified based on maximum grain size and presence of fines. The hydrostratigraphic units were correlated in three-dimensional (3-D) space based on the depositional environment described in Section 3.1.2.1. The available borehole logs for monitoring wells and historical geologic cross sections are included in Appendices D and E, respectively.

3.1.3.1 BEDROCK

The bedrock units of hydrogeologic importance to the OU-3 RI/FS from oldest to youngest are: the Keokuk Formation (upper portion of the Osagean Series), the Warsaw Formation (lower portion of the Meramecian Series), the Salem Formation (middle portion of the Meramecian Series), and the St. Louis Limestone (middle portion of the Meramecian Series). Bedrock surface elevations of the Bridgeton Landfill are included in Appendix F. The St. Louis Formation was described in additional detail, mapped in the quarry, and subdivided into five units as documented in Appendix G (Golder 1996). Bedrock at the site is described in detail below.

3.1.3.1.1 KEOKUK FORMATION

The Keokuk Formation is generally described as a bluish-gray, medium to coarsely crystalline, medium bedded limestone with abundant light gray tripolitic chert layers and nodules, some finely-crystalline zones, and/or crinoidal zones (Spreng 1961; Thompson 1986). Brachiopods, horn corals, and bryozoans are abundant in the formation (Spreng 1961). Four boreholes at the site penetrate the Keokuk Formation at depths between 365 and 375 ft bgs on the eastern edge of the Bridgeton Landfill and at a depth of 345 ft bgs on the western edge of the Bridgeton Landfill.

The elevation of the top of the Keokuk Formation is shown in Appendix F and ranges from approximately 126 ft msl on the southeastern corner of the North Quarry and dips toward the west to approximately 116 ft msl on the western edge of the South Quarry (Golder 1996). The description of the Keokuk Formation at the site is consistent with the general description and is a fresh to slightly weathered, medium light gray, fine to coarsely crystalline, thin to medium bedded, medium strong to strong, fossiliferous limestone with argillaceous shaley partings, numerous light bluish gray chert layers 1-2 inches thick, chert nodules between 1 to 10 mm, and disseminated pyrite. Layers of moderately weathered, medium bedded, light olive gray, medium strong arenaceous dolomite and thinly laminated, dark greenish gray, silty claystone were noted. Styolitic chert nodules, silicified zones, highly weathered joints, weak rock, and porous open vugs containing calcite crystals were noted at the bottom of the boreholes. Joints observed in rock cores during drilling were generally horizontal and infrequent with less than 2 per foot and described as irregular and rough, with some described as smooth, bedded, or planar. Open vugs and pores were commonly encountered below approximately 100 ft msl (Golder 1996).

3.1.3.1.2 WARSAW FORMATION

The Warsaw Formation at the site can be divided into two distinct lithologic zones: an upper shale-dominated zone and lower limestone-dominated zone (Spreng 1961; USGS 1997). The conformable boundary between the Osagean Series Keokuk Formation and the Meramecian Warsaw Formation is easier to distinguish in the eastern part of Missouri where the clastic Warsaw limestone overlies pure Keokuk limestone but there is not a clearly defined faunal break (Thompson 1986). The Warsaw characteristically has geode beds underlying the Archimedes beds (Thompson 1986).

The Warsaw Formation is encountered at the site at approximately 245 ft bgs (240 ft msl elevation) to the east of the Bridgeton Landfill and at approximately 200 to 210 ft bgs (250 – 260 ft msl elevation) on the western side of the Bridgeton Landfill as shown on the bedrock surface elevation map in Appendix F. The elevation of the top of the Warsaw Formation is consistent with the basal elevation of the South Quarry Pit and suggests that quarrying terminated once encountering the formation. The total thickness of the Warsaw Formation at the site ranges from approximately 130 to 145 ft (Golder 1996).

The underlying upper Keokuk Formation grades upward into the lower portion of the Warsaw Formation at the site. The lower portion of the Warsaw Formation is generally described as an olive to dark gray, fresh, thinly to medium bedded, fine to very coarse crystalline, medium strong, vuggy, nodular, argillaceous, dolomitic, limestone with fossils, chert, and thinly bedded claystone and siltstone interbeds. The lower portion of the Warsaw Formation had a greater apparent thickness in wells PZ-106-KS and PZ-111-KS where it was encountered at approximately 295 to 300 ft bgs with a thickness of approximately 45 to 50 ft, than in wells PZ-100-KS and PZ-104-KS where it transitioned to silty claystone and clayey siltstone of the upper portion at approximately 350 ft bgs with a thickness of approximately 10 ft.

The upper portion of the Warsaw Formation is regionally described as a yellowish brown to olive black, fresh to highly weathered, thinly bedded, very fine grained, weak clayey siltstone, silty claystone, or fissile shale with fine pyrite crystals and calcite infilled veins interbedded with silty limestone and/or dolomitic limestone (EMSI 2000). The uppermost portion of the Warsaw Formation was characterized with an olive to medium dark gray, fresh, thinly to thickly bedded, fine grained, weak to medium strong siltstone or claystone reported to range from approximately 2.5 to

10 ft thick. However, based on observations at nearby off-site private wells, the thickness of upper zone at the site could be significantly thicker. The Warsaw Formation in general has a high rock quality designation (RQD) and very few fractures that were jointed, irregular or planar, and rough or smooth (Golder 1996). As discussed in Section 3.1.5.2, the Warsaw Formation is considered an aquitard between the Salem and Keokuk Formations.

3.1.3.1.3 SALEM FORMATION

The Salem Formation consists predominantly of fossiliferous calcarenite (a limestone with more than 50 percent transported sand-size carbonate grains) that ranges regionally from 70 to 180 feet thick (Thompson 1986; Harrison 1997). A distinct "cannonball" or "bulls-eye" chert zone is present near the top of the limestone with 4 to 6-inch diameter, concentrically banded, spherical nodules and is often overlain by a thin shale (Thompson 1986). The remainder of the unit is highly variable with interbeds of fine-grained limestone, sandstone, chert and evaporites (Harrison 1997). The Salem Formation is commonly quarried in the region (Thompson 1986).

As shown on the bedrock surface elevation map in Appendix F, the Salem Formation is encountered at the site at a depth of approximately 165 ft bgs (320 ft msl) on the eastern edge of the Bridgeton Landfill and between approximately 115 to 135 ft bgs on the western edge of the Bridgeton Landfill (328 to 340 ft msl) with a thickness of approximately 67 to 83 ft. It is described as a very light to medium dark gray, fresh, medium to coarse grained, thinly to thickly bedded, medium strong, fossiliferous, arenaceous, and bioclastic calcarenite with some iron oxide staining, chert zones and nodules, and some cross bedded layers. RQD was generally high in rock cores during drilling at the site with very few fractures in the lower portion of the formation (0 to 1 per foot) and up to 2 fractures per foot in the upper portion of the formation. The Salem Formation was exposed in the bottom parts of the North and South Quarry Pits.

3.1.3.1.4 ST. LOUIS LIMESTONE

The St. Louis Limestone represents the first-encountered bedrock at the site and is described as a gray, lithographic to finely crystalline, medium to massively bedded limestone that ranges from 100 to over 250 feet thick that is quarried for cement manufacture and aggregate. The unit is highly variable with interbeds of dolomite, cherty limestone, fossiliferous limestone, and evaporites. Minor thin beds of shale are present throughout the formation (Harrison 1997). Limestone breccia with a shale matrix is common in the lower part of the formation. Chert is uncommon, but where present is fragmented and brown. Parts of the limestone are dolomitic. Lithostrontionella castelnaui and Lithostrotion proliferun are diagnostic compound corals (Spreng 1961).

The St. Louis Formation has been well characterized at the site via rock cores and geologic mapping of the exposed South Quarry Pit walls and is encountered at depths between 14 to 52 ft bgs (425 to 450 ft msl) in the eastern portion of the site and at depths between 20 and 110 ft bgs (379 to 442 ft msl) in the western portion of the site (Appendix F). The variability in depth and elevation is due to erosion by the Missouri River. The St. Louis Formation ranges in thickness from approximately 65 to 130 ft and was previously separated into six different sub-units from oldest to youngest as Lc, Lb, Ls, Ld, Bx, and Lx as described below (Golder 1996). An additional older unit Lc was identified during development of the preliminary CSM. These sub-units are described below:

- Lc – a fresh, thinly to thickly bedded, finely crystalline, medium strong, stylolitic, argillaceous limestone.
- Lb – A thinly bedded, microcrystalline to finely crystalline thinly to thickly bedded limestone.
- Ls – A massive, microcrystalline, medium strong, very argillaceous limestone with sheet like weathering that causes 0.2 to 0.4 feet thick slabs to separate parallel to the exposed face. Localized joints, fractures, and seeps were not noted.
- Ld – A thin (1 to 3 ft thick) thinly bedded to massive, medium strong to strong, slightly argillaceous limestone that is almost continuously exposed in the quarry and overlain by a 2-inch thick fine-grained stratigraphic marker bed.
- Bx – A massive, brecciated, finely crystalline matrix, medium strong, limestone that ranges between 10 and 22 feet thick.
- Lx – A thinly to thickly bedded fine to medium crystalline, coarsening upward, medium strong, stylolitic, fossiliferous (brachiopods, gastropods, and crinoids), limestone with iron oxide concretions, argillaceous stringers, and chert nodules.

The top of bedrock surface generally dips westward toward the Missouri River with two dominant topographic features: the quarried areas associated with the former North and South quarry pit operations and the scour surface associated with the natural eastern edge of the Missouri River floodplain. Additional detail on the structural features and hydrogeologic properties of these units is provided below.

3.1.3.1.5 STRUCTURAL FEATURES

Joints, cavities, infilled collapsed features, and groundwater seeps were mapped on five different sectors of the exposed St. Louis Formation on the South Quarry pit walls as shown in Appendix G (Golder 1996). Joints were mapped as follows:

- 12 joints were oriented 60 degrees east of north
- 4 joints were oriented at 20 degrees east of north

- 3 joints were oriented 70 degrees east of north
- 3 joints were oriented 80 degrees east of north
- 8 joints were oriented between 40 and 185 degrees east of north (40, 55, 62, 75, 98, 100, 120, 185)

Sectors 4 and 5 had the densest spacing of mapped joints with a total of 24. The face of Sector 1 was oriented at 60 degrees east of north, parallel to the most dominant set, and had only two joints mapped at an orientation of 20 degrees east of north. It is likely these joints were caused by regional structural geologic features including the Dupo Anticline and Florissant Dome. Infilled collapsed features where voids collapsed and were infilled with fine-grained sediments were also mapped on the exposed walls of the South Quarry Pit. Sector 1 had none, Sector 2 had four, Sector 3 had two, Sector 4 had five, and Sector 5 had three. The base of smaller structures generally terminated at the Bx/Ld contact, with larger structures propagating to the base of the Ls (Golder 1996).

Groundwater flow into the North and South Quarry portions of the Bridgeton Landfill during quarrying, landfilling, and leachate extraction activities is an important component of the CSM. The locations and flows of six seeps in the quarry were mapped and measured in 1989 by Laidlaw as documented in Appendix G. The total approximate flow of the six seeps into the quarry was approximately 1,110 gallons per hour. Of this total volume, groundwater appeared to contribute approximately 1,010 gallons per hour. Seep 2 was located on the north wall of the South Quarry pit (Sector 5) at an elevation of approximately 330 ft msl and contributed 500 gallons per hour of water. A total of 88 seeps were observed by Golder during mapping of the South Quarry pit walls. Most of these seeps were present within the Ld unit at the Bx/Ld contact. Seeps above the Ls contact suggest it is a less transmissive unit (Golder 1996).

A total of 14 cavities are indicated on the quarry wall maps included as Appendix G. Four cavities were mapped near the base of the Lx sub-unit in Sector 2 and Sector 3. Only one had an associated seep. Five cavities were mapped within the Bx sub-unit. Seeps were observed in two of these cavities. Two cavities were observed in the Ls sub-unit. One was associated with a vertical joint. Three cavities were observed in the Lb sub-unit.

3.1.3.2 UNCONSOLIDATED SEDIMENTS AND MATERIALS

Unconsolidated sediments at the site are primarily Missouri River Alluvium and aeolian loess. Missouri River Alluvium is present to the north and west of the edge of the alluvial valley (Figure 3-1). Loess forms the bluffs and hills to the east and south. Alluvium isopach maps are included in Appendix H.

3.1.3.2.1 ALLUVIUM

Alluvium at the site is variable in thickness ranging up to approximately 120 feet and is generally present above 330 ft bgs. Deposits consist primarily of sand and gravel interbedded with minor silt and clay present at shallower depths less than 25 ft bgs or above 430 ft msl and are interpreted to be deposited as glacial outwash, point bars, natural levees, filled channels, swamps, lakes, overbank deposits, and small channels. The depositional environment resulted in rapid termination of the alluvium both vertically and horizontally (B&M 1986). Fining upward sequences typical of fluvial depositional environments are present within an overall fining upward sequence. Historical cross sections are included in Appendix E.

Alluvial cross sections and interpretations were updated during preparation of this Work Plan based on USEPA guidance on environmental sequence stratigraphy to identify preferential flow and flux pathways. These updated cross section locations are shown with monitoring wells used to construct them on Figure 3-2 and cross sections are shown on Figure 3-3, Figure 3-4, and Figure 3-5. Alluvium is more uniform and correlatable at elevations between 400 ft msl and bedrock due to channel scour and regrading of sediment after deposition (B&M 1986; NRC 1989). Alluvium has historically been divided into three separate units based on the hydrostratigraphy. These units are apparent on the cross sections and are described in the following subsections.

Deep alluvium is present from approximately 330 ft msl to 385 ft msl, is roughly 55 feet thick, and consists of fining upward sequences of coarse gravel to coarse sand likely deposited as point bars during the rapid channel infill of the Missouri River Valley. Color ranges from gray to brownish and greenish gray, which is consistent with mineralogic descriptions of predominantly quartz with feldspar and some mafic minerals. Deep alluvium was generally documented as subrounded with little to no presence of fines.

Intermediate alluvium is present from approximately 385 ft msl to 415 ft msl and averages about 30 feet thick. It is less uniform than the deep alluvium consisting of fining upward point bar sequences of coarse gravel through fine sand with some overbank flood plain type deposits of silt and clay present at the edge of the alluvial valley. Color is generally described as gray, brown, dark gray, or olive gray and mineralogic descriptions are consistent with the deep alluvium.

Shallow alluvium is present above the intermediate alluvium from approximately 415 ft msl with variable thickness up to the top of the alluvium or where it has been disturbed by landfilling. The water table is generally present in the shallow alluvium. Shallow alluvium ranges predominantly from medium-grained sand to clay with lenses of gravel and coarse-grained sand. Sand in the shallow alluvium is generally described as gray and mostly quartz with some mafic minerals present. Silty clay is present above 430 ft msl (~ upper 10 ft), which was deposited during Missouri River floods as overbank deposits.

3.1.3.2.2 LOESS

The upland loess consists of windblown silt, clayey silt, and silty loam. Surficial loess generated during Pleistocene glaciation was transported from glacial melt-out drainages by westerly winds and redeposited near the site approximately 17,500 years ago (Heim 1961). The variable thickness is controlled by both surface erosion and bedrock topography and is generally thinner than floodplain alluvium. A soil profile of loess is included in Appendix I and is generally described as pure silt overlying clayey silt up to approximately 80 ft thick near the site. Loess is encountered from 13 to 22 ft thick on the eastern side of the Bridgeton Landfill at an elevation of approximately 460 ft msl. Loess is uncommon above the alluvium on the western side of the Bridgeton Landfill but is occasionally interbedded with the underlying alluvium within the alluvial valley shown on Figure 3-6.

3.1.3.2.3 SOILS

Surficial soils along the floodplain of the Missouri River generally consist of Blake-Eudora-Waldron association while the surficial soils on the bluffs east of the river are the Urban Land-Harvester-Fishpot association. The floodplain materials are described as nearly level, somewhat poorly drained to well drained, deep soils formed in alluvial sediment. The upland materials are urban land and nearly level to moderately steep, moderately well drained to somewhat poorly drained, deep soils formed in silty fill material, loess and alluvium which are formed on uplands, terraces, and bottom lands (EMSI 2018a).

Soils in the area of the site consist of the Freeburg-Ashton-Weller association, which are nearly level to gently sloping, somewhat poorly drained, deep soils formed in loess and alluvial sediment. The Freeburg silt loam is found on the terrace adjacent to the eastern site boundary, while the Ashton silt loam is found to the east and south of the South Quarry portion of the Bridgeton Landfill (including the landfill borrow area).

3.1.3.2.4 SOLID WASTE AND LANDFILL LINER

Solid waste present above the alluvium west of the alluvial divide in OU-1 was well characterized in the OU-1 RIA. It primarily includes municipal refuse, C&D fill, and associated soil cover. The depth and configuration of the landfill deposits varies between each of the various areas of prior landfilling activities. The amount of variation depends in part upon the pre-landfill topography and the effects of pre-landfill disturbances (e.g., mining activities), the amount of above-grade disposal that took place, and the type of waste materials disposed. Landfill debris thickness is variable between 5 to 56 feet, with an average thickness of 36 ft in Area 1 and 30 feet in Area 2 (McLaren/Hart 1996). No liner is present beneath the northwestern portion of landfill and waste may have been placed directly on the ground surface (NRC 1989). Areas 1 and 2 are both in this unlined above-ground former landfill.

Solid waste materials encountered in OU-2 were described as common municipal wastes such as paper, plastics, clothing, and C&D debris. Older wastes were predominantly wood, construction debris, and other charred materials (Golder 1996; WMC 1997). Old mine spoils overlain with silt were also encountered in OU-2 (Golder 1996). A layer of approximately 7 to 10 feet of compacted clay was placed beneath permitted portions of the Inactive Sanitary Landfill constructed after 1974 as a liner to prevent downward movement of leachate (NRC 1989). The lining and compaction process prior to 1974 is unknown.

3.1.4 LOCAL HYDROLOGY AND CLIMATE

The major hydrological feature of importance near the site is the Missouri River. The present Missouri River channel is approximately two miles west/northwest of the site and has a surface slope of approximately 0.00018 ft per foot (Golder 1996). The USGS stream gauge 06935965 at St. Charles Missouri is located approximately 1.5 miles northwest of the northwest corner of Area 2, as shown on Figure 3-7, and has a surveyed elevation of 413.47 ft msl North American Vertical Datum 1988 (NAVD88) and a drainage area of approximately 524,000 square miles. Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) gauge at Lambert Field are shown on Figure 3-8.

Daily Missouri River stage and flow data from October 1984 to present were downloaded from the USGS website. A hydrograph of the Missouri River elevation and daily precipitation is shown on Figure 3-8. Average flow in the Missouri River has been approximately 75,000 cubic feet per second (cfs) since October 1984 and generally ranges between approximately 25,000 cfs (420 ft msl) in December/January and 300,000 cfs (450 ft msl) in May/June. Peak flow within the historical record occurred on August 1, 1993 with a stage of 452.91 ft msl. The Missouri River is in direct communication with the Missouri River alluvium and the measured stage affects groundwater levels. The immediate impact of the Missouri River on regional and local horizontal and vertical groundwater gradients at the site is not well understood and will be characterized during this RI/FS.

The Earth City Levee system ponds are to the west and northwest of the site, as shown on Figure 1-2. A relief well network along the land side of the levee allows groundwater to gravity flow under natural pressure gradients to the ground surface and into the network of ponds as needed to maintain the integrity of the levee during a major flood. These gravity flow relief wells have a designed discharge capacity of 780 gpm. Water flows through the system of ditches, channels, and lakes to a fully automated pump station which maintains a constant water elevation. Water is pumped through a discharge structure installed in the levee to a stormwater discharge channel west of the levee. The Earth City Levee system is designed to exceed the 500-year flood level and ranges from 462.03 ft msl at the south end to 459.34 ft msl at the north end. Assuming a 500-year flood were to occur, the Missouri River would be three to seven feet below the top of the Earth City levee. Most of the landfill property boundary is outside the Missouri River

500-year floodplain, with the exception of low-lying areas, the Buffer Zone, and Lot 2A2 that are within the area protected by the Earth City Levee system. The interaction between the Earth City Levee system ponds and the site (if any) are not well understood at this time and will be characterized during this RI/FS.

Climate at the site is typical of the midwestern United States and has four distinct seasons ranging from mild winters to hot summers with high humidity (NRC 1989). Daily on-site precipitation data were collected and compared to Lambert Field with good correlation (Golder 1996). Precipitation data for Lambert Field are shown on Figure 3-8 and are included in Appendix J. Approximately 40 inches of precipitation falls annually at the site. Precipitation directly affects the Missouri River stage, infiltration, and localized recharge due to runoff from bluffs. Surface water drainage patterns are included in Appendix K.

3.1.5 LOCAL HYDROGEOLOGY

The site-specific aquifers consist of the Missouri River Alluvial Aquifer and the Post-Maquoketa and Ozark bedrock aquifers. Given the location of the site on the margin of the Missouri River Valley, a significant aquifer boundary occurs along the bedrock interface, between bedrock groundwater within St. Louis and Salem Formations (east side of the site and below the alluvium) and shallow groundwater within the Missouri River Alluvial Aquifer (west side of the site).

The Missouri River Alluvial Aquifer is unconfined and occurs within highly-permeable alluvial sediments within the Missouri River Valley, which can be up to approximately 150 feet thick (MDNR 1997). The aquifer underlies the Missouri River floodplain, which is generally two to three miles wide in St. Louis County. The shallow aquifer is a very important and widely-used water source in Missouri and the hydraulic conductivity of the most permeable sand and gravel zones is likely on the order of 1,000 feet per day (ft/day). In many places, the upper 20 to 30 feet of alluvium consist of low-permeability materials.

In much of the central, eastern, and northern parts of St. Louis County, only the Mississippian-age limestones, including the St. Louis, Salem and Keokuk-Burlington limestones, produce usable quality water and are capable of yielding several gallons of water per minute (MDNR 1997). Collectively, these water-bearing units are referred to as the post-Maquoketa Aquifer, which is an independent, water-yielding unit on the northeast edge of the Ozark Plateau. The thick shale in the upper portion of the Warsaw Formation is generally impervious to groundwater flow and represents a lower confining unit within this portion of the post-Maquoketa Aquifer.

The underlying Ozark Aquifer generally occurs within Ordovician and older bedrock units within the Salem Plateau, which extends across central and southern Missouri (MDNR 1997). Though the Ozark Aquifer is undoubtedly the most important aquifer in the Salem Plateau and yields potable water in the southern and extreme western portion of St. Louis County, groundwater quality quickly deteriorates to the northeast and becomes too highly mineralized for use.

Over 130 monitoring wells and piezometers have previously been installed at, and near, the site. Wells are screened in the Keokuk Formation, the lower portion of the Salem Formation, the upper portion of the Salem Formation/St. Louis Formation, or the Missouri River Alluvium. Wells and piezometers have been monitored since 1979 to evaluate the groundwater quality near the site and the local hydrogeology. Current status and construction documentation of wells installed during prior site investigations is shown on Table 3-2 and Figure 3-9. The adequacy, usability, and status of existing and abandoned on-site and perimeter monitoring wells and associated data will be evaluated during this RI/FS. Details of this evaluation are discussed in Section 4.2.1.

Local hydrogeologic descriptions are consistent with the terminology of the local geology and are separated by consolidated and unconsolidated deposits. Monitoring well zones were reviewed during development of the preliminary CSM. Hydrostratigraphic zones of monitoring wells were reclassified based on the environmental sequence stratigraphy evaluation conducted during development of the preliminary CSM and elevation of the screened interval (Table 3-2). Important features that affect the local hydrogeology are the local geologic boundaries, the North and South Quarry Pits, and the various sources of recharge and discharge. Important sources of recharge and discharge include precipitation, the Missouri River, quarry dewatering, the Bridgeton Landfill leachate extraction system, and quarry wall seeps.

3.1.5.1 GROUNDWATER OCCURRENCE

The bedrock aquifers of interest at the site include the Salem Formation and the St. Louis Formation. The St. Louis and Salem Formations are both unconfined and the Warsaw Formation serves as a confining unit to the Keokuk Formation. The Keokuk Formation is isolated from the overlying St. Louis and Salem Formations as evidenced by water levels from wells screened in the different units and the lack of response in the Keokuk Formation to localized pumping in the overlying strata. Mississippian limestone at the site has low intergranular permeability when undisturbed and groundwater flow predominantly occurs through secondary porosity (NRC 1989). Secondary porosity of the Salem Formation and St. Louis Formation was likely enhanced by quarrying activities. Connectivity of the secondary porosity is not well understood and will be characterized during this RI/FS.

In general, bedrock aquifers within the Salem Plateau (representing approximately 46 percent of Missouri’s potable groundwater), which include the Ozark and post-Maquoketa aquifers, are recharged through precipitation. In addition, the surface and subsurface weathering of carbonates (limestones and dolostones) has created numerous karst groundwater-recharge features such as sinkholes and losing streams that allow very rapid movement of water from the surface into the subsurface. In areas where competent and unweathered bedrock (i.e., non-karst) is exposed at the surface (e.g., immediately east of the site), recharge from precipitation is minimal and almost all precipitation becomes runoff. The annual average precipitation for the area is about 40 inches per year (in/yr) and yearly recharge rates vary depending on local geology, vegetation, and surface features, and are estimated to range from a few inches to 14 in/yr (MDNR 1997).

The deep, intermediate, and shallow alluvial aquifers are of particular importance to the OU-3 RI/FS. They are separated as defined above based on the hydrostratigraphic properties of each unit. Groundwater is generally encountered near or immediately below the landfill base in the underlying alluvium. The absence of continuous confining units and small vertical gradients in clustered wells suggest groundwater in the alluvium is generally unconfined below fine-grained soils, but localized and temporary confining conditions occasionally exist when water levels rise above the base of fine-grained deposits in the shallow alluvium. In general, vertical gradients between clustered wells screened in the shallow, intermediate and deep zones within the alluvium are negligible, indicating these zones are in hydraulic communication and are part of a connected hydrostratigraphic zone. Based on previous characterization, the deep alluvium appears to behave as a single aquifer of relatively homogeneous high permeability that decreases near the bedrock valley walls and edge of the alluvium.

Recharge to the Missouri River Alluvial aquifer occurs by upward movement of groundwater from underlying bedrock near the margins of the alluvial floodplain, major river-aquifer interaction, gradual downward infiltration of water from precipitation, seepage from upland loess, and from downward infiltration of water from streams flowing across the alluvium (Miller et al. 1974; USGS 1986; MDNR 1997). Streams and underflow are a major source of recharge and radial mounding is observed where they enter the floodplain. A filled oxbow lake is present in the alluvium along the southwest landfill boundary.

The potentiometric surface of bedrock aquifer units adjacent to the Missouri River is normally above the potentiometric surface of the alluvial aquifer. Therefore, under natural conditions, there is groundwater flow from bedrock into the alluvium. Water from the Missouri River generally recharges the alluvium under two conditions: (1) when the river is at flood stage and above the elevation of the potentiometric surface and (2) where high-yield pumping wells are constructed close enough to the river to induce direct recharge from the river to the well (Miller et al. 1974; MDNR 1997). The amount of recharge from precipitation and from streams flowing across the alluvium is largely dependent on the local permeability of the shallow alluvial materials, which can be variable.

There is a direct hydraulic communication between the stage of the Missouri River and groundwater levels in the alluvium, although there is a delayed response of several days between higher river stages and higher groundwater levels. Seasonal river stages are associated with the gradual rise in groundwater levels in early spring through summer and the gradual decline of water levels during the fall and winter months (MDNR 1997). Similarly, a strong correlation has been observed in site water levels in alluvial wells when compared with river stage and precipitation over time, as expected for an unconfined system. Increases in alluvial water levels are matched by increases in river stage and precipitation, as a result of recharge to the alluvium by river water and precipitation.

3.1.5.2 AQUIFER TESTING

Various aquifer tests have been conducted in select monitoring wells and boreholes at the site during previous site investigations. In-situ aquifer testing includes slug testing and packer testing. Available slug testing results are included as Table 3-3 and shown on Figure 3-10. Packer testing results are included as Table 3-4 and shown on Figure 3-11. Aquifer testing evaluations completed during previous site characterization are included as Appendix L and include results of ex-situ triaxial permeability laboratory testing results. Aquifer properties, including recharge/discharge rates and hydraulic conductivities, were identified as a data gap in the SOW. Additional characterization will be conducted during this RI/FS. Results of existing data are discussed below.

3.1.5.2.1 SLUG TESTING

Slug testing was conducted in completed monitoring wells installed in the Keokuk Formation, the Salem Formation, the Upper Salem Formation/St. Louis Formation, the deep alluvium, the intermediate alluvium, and the shallow alluvium during various stages of the OU-1 and OU-2 site characterization. A total of 77 slug tests were conducted by Golder and McLaren Hart (Golder 1996; McLaren/Hart 1996). Slug tests were generally conducted using a rising head test. A minimum, maximum, and geometric mean of slug tests by zone are presented on Table 3-3. Geometric means were calculated using one rising head slug test from each location; falling head slug tests were used if a rising head test was not conducted.

Hydraulic conductivity results for slug testing of the shallow alluvium ranges from 0.35 to 97 feet per day (ft/day) with a geometric mean of 8.9 ft/day; intermediate alluvium ranges from 0.39 to 189 ft/day with a geometric mean of 49 ft/day; and deep alluvium ranges from 4.6 to 251 ft/day with a geometric mean of 59 ft/day. Hydraulic conductivity results of slug testing in the alluvium are consistent with grain size trends and increase with depth. As shown on Figure 3-10, the lowest hydraulic conductivities in the alluvium are adjacent to the edge of the alluvium and are likely influenced by overbank deposits.

Hydraulic conductivity results for slug testing of the bedrock units are generally orders of magnitude lower than those of the alluvium, with the exception of PZ-202-SS, and are therefore presented with scientific notation. Well PZ-202-SS is located near one of the seeps discussed in Section 3.1.3.1.5 and therefore could intersect a highly transmissive fracture. Hydraulic conductivity of the St. Louis Formation ranges from 6.5 x 10^{-5} ft/day to 7.8 x 10^{0} ft/day with a geometric mean of 3.7 x 10^{-3} ft/day; the Salem Formation ranges from 2.4 x 10^{-4} ft/day to 4.2 x 10^{-2} ft/day with a geometric mean of 1.9 x 10^{-3} ft/day; the Keokuk Formation ranges from 1.7 x 10^{-3} ft/day to 1.1 x 10^{-2} ft/day with a geometric mean of 5.8 x 10^{-3} ft/day. Hydraulic conductivity results suggest a low intergranular permeability of the Mississippian limestone and that flow in competent rock at the site occurs primarily through secondary porosity such as fractures and solution cavities.

3.1.5.2.2 BOREHOLE PACKER TESTING

Single and straddle constant head injection packer testing was conducted as part of site characterization activities in 1995 and 1996 prior to construction of piezometers (Golder 1996). Single packer testing was conducted on intervals ranging from 10 to 93 ft. Straddle packer tests were generally conducted on 5-foot intervals. Intervals were selected for packer testing based on degree of fracturing and degree of porosity and isolated to provide a range of hydraulic conductivities. Results of borehole packer testing are presented on Table 3-4 and are plotted with fractures per foot on Figure 3-11.

Hydraulic conductivity from packer testing of the St. Louis Formation ranges from 1.0 x 10^{-3} ft/day to 1.2 x 10^{-2} ft/day with a geometric mean of 2.7 x 10^{-3} ft/day; the Salem Formation ranges from 1.6 x 10^{-4} ft/day to 7.2 x 10^{-2} ft/day with a geometric mean of 4.6 x 10^{-3} ft/day; the Warsaw Formation ranges from 7.3 x 10^{-4} ft/day to 1.6 x 10^{-1} ft/day with a geometric mean of 5.5 x 10^{-3} ft/day; the Keokuk Formation ranges from 2.2 x 10^{-3} ft/day to 1.2 x 10^{-1} ft/day with a geometric mean of 2.8 x 10^{-2} ft/day. The geometric means of packer tests are slightly higher than slug tests conducted in the Salem and Keokuk Formations. This is also the case for the St. Louis Formation if the highly transmissive feature encountered at well PZ-202-SS is not included in the geometric mean. These conclusions provide another line of evidence that flow in competent rock at the site occurs primarily through secondary porosity such as fractures and solution cavities.

3.1.5.2.3 GEOTECHNICAL TESTING

Geotechnical testing at the site was historically conducted using a triaxial permeability test method. Results are shown on Table 3-5. The mean vertical hydraulic conductivity of the two rock cores collected from the shale near the top of the Warsaw Formation (PZ-106-KS GTS-1 and PZ-106-KS GTS-2) was 6.4 x 10^{-7} ft/day suggesting it acts as a confining aquitard. Undisturbed samples near surface soils and loess had much higher conductivity values ranging from 5.7 x 10^{-4} ft /day to 8.5 x 10^{-1} ft /day.

3.1.5.2.4 AQUIFER PROPERTIES OF SOLID WASTE

The overburden depth of landfill materials in the North Quarry and South Quarry (about 180 feet and 275 feet, respectively) is much greater than landfill materials in OU-1 Area 1. Therefore, the hydraulic conductivities are expected to be much lower for landfill materials near the bottom of the former pits. Reported values of hydraulic conductivity of aged municipal waste vary with respect to overburden stress, such that an overburden stress of 500 kilopascals (kPa) is associated with a measured hydraulic conductivity in the range of $5x10^{-6}$ cm/s (Powrie et al. 2005; Reddy et al. 2009). The saturated landfill materials in the deepest portions of the Bridgeton Landfill may have approximately 500 to 600 kPa of overburden stress, which corresponds to an expected range of hydraulic conductivity on the order of $1x10^{-5}$ to $1x10^{-7}$ cm/s. Hydraulic properties of landfilled material remain a data gap to be addressed by this OU-3 RI/FS.

3.1.5.2.5 TRANSMISSIVITY

Transmissivity of the alluvium was calculated using the geometric mean of conductivity and the thickness of each hydrostratigraphic zone. Transmissivity of the shallow alluvium assumes an average ground surface elevation of 450 ft msl, resulting in a thickness of 35 feet and transmissivity of approximately 310 ft^2/day. Transmissivity of the intermediate alluvium is approximately 1,500 ft^2/day. Transmissivity of the deep alluvium is approximately 3,300 ft^2/day. These data confirm the deep alluvium is the most transmissive hydrostratigraphic zone at the site.

3.1.5.3 GROUNDWATER ELEVATIONS AND GRADIENTS

Water levels/groundwater elevations have been measured at the site since 1979. Historical data has been measured relative to several different datum, and thus required conversion to a single standard to make a meaningful evaluation of gradients at the site. Measuring point elevations and groundwater elevations were converted to NAVD88 based on the conversion in the OU-1 RIA and are included in Appendix M. The conversion from the site coordinate system to 1983 Missouri East State Plane and NAVD88 was completed by adding 40.97 feet to the northing, adding 320174.7 feet to the easting, and subtracting 0.402 feet from the elevation. Depth to water measurements or groundwater elevation data used to populate the database are also included in Appendix M. Potentiometric surface maps from previous OU-1 and OU-2 reports are included as Appendix N. Potentiometric surface maps were prepared during preparation of this Work Plan for October 1984 and April 1985, which were among the first comprehensive site-wide gauging events conducted post RIM placement to evaluate groundwater flow direction seasonally and are included as Figures 3-12 and 3-13, respectively. Potentiometric surface maps were also prepared for April 2013 and September 2013, which were among the most recent comprehensive site-wide gauging events and are included as Figures 3-14 and 3-15, respectively. Historical potentiometric surface maps will be updated as part of the RI/FS after an additional site-wide survey is conducted and existing data have been evaluated in accordance with Section 2.5. Groundwater elevations and gradients are discussed below.

3.1.5.3.1 GROUNDWATER ELEVATIONS

Depth to groundwater generally ranges from approximately 10 to 60 ft bgs and is dependent on the site topography. The water table in floodplain deposits is generally within 10 ft of ground surface. Hydrographs are included in Appendix O. Groundwater elevations are generally highest during spring or summer and are influenced by topography, the Missouri River stage, precipitation, surface run-on, infiltration, and groundwater/leachate extraction. Groundwater elevation fluctuations in the alluvium mimic the Missouri River stage, but are subdued and delayed. A groundwater mound is often observed near monitoring wells S-75, S-76, and I-73 where surface recharge occurs. Monitoring well I-50 is partially confined when the water table rises above shallow fine-grained material. Perched water has been observed in monitoring well S-80, two soil borings advanced in Area 1, and nine soil borings advanced in Area 2. Locations of perched water encountered during the RIA are included as Appendix P. The presence of perched water was not evaluated for OU-2 during preparation of this Work Plan. The temporal variability in groundwater levels and flow direction and effects of the Missouri River stage and precipitation were previously identified as data gaps and remain key objectives of the proposed RI/FS activities.

3.1.5.3.2 HYDRAULIC GRADIENTS

During normal flow conditions for the Missouri River, groundwater gradients in the Missouri River alluvium are towards the river with a vector of about 45 degrees in the downstream direction (MDNR 1997). Regionally observed gradients are typically gentle and on the order of 1 to 2 feet per mile. During temporary river flood stage, sustained high river stages or in the vicinity of high-yield alluvial pumping wells, groundwater gradient reversals can occur under losing conditions, where groundwater flow is away from the Missouri River (Miller et al. 1974). The average Missouri river stage at the USGS St. Charles stream gauge station 06935965 is approximately 430 feet msl (2000 to present), and depending on the year and season, the river stage generally fluctuates by as much as 10 vertical feet.

Groundwater in the alluvial aquifer in the vicinity of the site generally flows to the northwest. The current leachate collection system discussed in Section 3.1.5.7.2 is of significant hydrogeologic importance as it directly affects groundwater levels, hydraulic gradients, groundwater flow directions, groundwater flux, and the overall water balance between precipitation recharge and groundwater inflow and outflow from the site area. Additional details regarding the hydrogeology of the site and the effects of the leachate collection system on groundwater will be further evaluated as part of this RI/FS.

The water table across the site has a low horizontal gradient ranging between 0.0003 and 0.0005 feet per foot (ft/ft) in July 2013. This is consistent with the previously measured (1979) off-site gradient of 0.0006 ft/ft (B&M 1986). Groundwater elevation fluctuates seasonally in direct response to the Missouri River stage and precipitation amounts. Variable hydraulic gradients are induced by the Missouri River bedrock channel and influenced by river stage with groundwater superimposed mounds and depressions influencing shallow water table gradients as shown on potentiometric surface figures in Appendix N. As documented in previous reports, small scale changes in water table gradient and flow direction are observed due to recharge and infiltration with macro effects towards the Missouri River. Water levels in the deep alluvium appear to respond more rapidly to the Missouri River stage. A horizontal gradient beneath Area 1 to the south toward the Bridgeton Landfill and to west-southwest beneath Area 2 towards the Earth City flood control channel was documented in the OU-1 RI (McLaren/Hart 1996). This can be observed on Figure 3-13.

Observations of downward vertical gradients have been made near the bedrock valley walls (B&M 1986). A downward component of flow has also been observed in southeast near wells D-81 and D-89. Monthly measurements appear to have been adequately spaced to detect significant changes in water table elevations. Contour patterns and flow patterns are generally the same seasonally. Localized shallow mounding has been observed due to pumping from the North and South Quarries to drainage ditches, surface water infiltration, and storage ponds nearby. Mounding is also affected by variable permeability.

The bedrock aquifers in the St. Louis area are confined and bedrock wells are often flowing artesian, where the hydrostatic pressure in these aquifers raises the water level in the well above the ground surface (Miller et. al. 1974). During periods of no or low groundwater extraction, groundwater in bedrock (including the St. Louis, Salem, and Keokuk Formations) has a natural upward and horizontal gradient towards the alluvium and Missouri River, which is typical of a low valley groundwater discharge system. However, the effects of leachate pumping in the landfill are evident in the St. Louis and upper Salem Formations, where there is an observed strong correlation between bedrock water levels with pumping rates. Increased pumping results in lower water levels and greater downward gradients in the St. Louis and upper Salem Formations; decreased pumping results in the recovery of water levels to regional water levels and a natural upward gradient. Water levels for the deeper Keokuk-Burlington Formation indicate minimal influence from pumping, likely as a result of upper confinement from the overlying Warsaw Shale. The water levels in the Keokuk-Burlington Formation are significantly higher than the St. Louis and upper Salem Formations with consistent upward vertical gradients for all historical events. However, regional and localized hydraulic gradients and flow directions between alluvial and shallow bedrock aquifers are a data gap and will be evaluated in more detail as part of this RI/FS. Previous summaries of vertical gradients are included in Appendix Q. Historical potentiometric surface maps will be revised based on the updated hydrostratigraphic zone classifications and presented in the updated and refined CSM. Temporal and seasonal trends will be discussed in more detail in the refined CSM.

3.1.5.4 GROUNDWATER VELOCITY AND DISCHARGE

Horizontal groundwater velocities of the shallow, intermediate, and deep alluvium were approximated using the ranges of hydraulic conductivities from slug testing data, a regional hydraulic gradient of 0.0006 ft/ft, and an assumed effective porosity of 0.15 for the shallow alluvium and 0.2 for the intermediate and deep alluvium. Calculated groundwater velocities in the shallow alluvium range from 0.5 to 142 feet per year (ft/year) with a geometric mean of 13 ft/year; intermediate alluvium range from 0.43 to 208 ft/year with a geometric mean of 53 ft/year; and deep alluvium range from 5.0 to 274 ft/year with a geometric mean of 65 ft/year. Results suggest that horizontal flow in the alluvial aquifer is relatively uniform.

Horizontal groundwater velocities of the St. Louis Formation, Salem Formation, and Keokuk Formation were also approximated using the ranges of hydraulic conductivities from slug testing data, a regional hydraulic gradient of 0.003 ft/ft, and an assumed effective porosity of 0.008. Groundwater velocity results for groundwater velocities in the St Louis Formation ranges from 0.01 to 1,065 ft/year with a geometric mean of 0.51 ft/year; Salem Formation ranges from 0.034 to 5.7 ft/year with a geometric mean of 0.27 ft/year; and the Keokuk Formation ranges from 0.24 to 1.5 ft/year with a geometric mean of 0.80 ft/year. Groundwater velocities in the bedrock are generally lower than those in the alluvium. However, groundwater velocities in features such as fractures and solution cavities are likely much higher.

Groundwater discharge was estimated as part of the 1986 evaluation based on Darcy's Law using average permeabilities and flow rates for the upper (shallow and intermediate alluvium) and lower aquifers (deep alluvium). Results across the cross-sectional area on the northern and western perimeters were 500 gallons per day (gpd) in the shallow aquifer and 400,000 gpd in the deep aquifer. Eastward flow estimated at 43,000 gpd was pumped from filled quarry leachate collection system, treated, and discharged to sanitary sewer (B&M 1986). Additional evaluation of groundwater velocity and discharge will be conducted during the RI/FS based on results of additional aquifer testing and hydraulic gradient evaluations as discussed in Section 5.4.11 and Section 5.4.13.

3.1.5.5 SURFACE WATER/GROUNDWATER INTERACTION

Staff gauges were previously installed at the site as part of OU-1 and OU-2 site characterization. Surface water elevations are shown on in Appendix K and locations are shown in Appendix B. The relationship between surface water and groundwater at the site is not fully understood. Additional staff gauges will be installed, and further characterization will be conducted during the RI/FS to address this data gap and is discussed in Section 5.4.15.

3.1.5.6 GROUNDWATER GEOCHEMISTRY

Understanding groundwater geochemistry at the site remains one of the most critical components of the CSM and was identified as a data gap by the USGS. Various factors can affect the oxidation-reduction (redox) conditions and groundwater pH, including the presence of landfill leachate and precipitation. The common geochemical redox conditions and species, and reactive minerals (Fe/Mn oxyhydroxides, clay minerals, and solid organic materials) typically associated with landfills, can influence radionuclide transport via exchange-adsorption/desorption and precipitation/co-precipitation or dissolution over time scales on the order of seconds to months.

High dissolved iron, low sulfate, and low uranium concentrations noted in prior site investigation activities suggested anoxic groundwater that is iron and possibly sulfate reducing exists beneath the site. Combined dissolved radium concentrations were significantly higher in wells exhibiting leachate impacts (USGS 2015). A preliminary evaluation of historical groundwater geochemistry parameters, redox couples, and organic content was completed prior to preparation of this proposed RI/FS scope of work. Existing figures from the USGS report and RIA are included as Appendix R.

3.1.5.7 EFFECTS OF THE QUARRY AND BRIDGETON LANDFILL

Quarrying in the North and South Quarry Pits of the Bridgeton Landfill began in 1939. Effects of quarry dewatering, the Bridgeton Landfill related infrastructure, and hydraulic characteristics of landfill material are also an important component of the CSM and are a data gap. Additional evaluation will be conducted during this RI/FS to address this data gap. A preliminary evaluation was, however, performed as part of this RI/FS Work Plan preparation, and effects of the quarry and the Bridgeton Landfill are discussed below.

3.1.5.7.1 QUARRY DEWATERING

Prior to landfilling in the North and South Quarry Pits, the open quarry required dewatering. Water would enter the quarry via direct precipitation, runoff, and through seeps. Seeps were mapped as part of a water balance conducted by Reitz & Jens, and a volumetric flow through the seeps were documented (Appendix E). Seeps were also mapped on the South Quarry Pit open faces during OU-2 site characterization (Appendix E). Quarry faces had 88 seeps observed. Many seeps were observed above the Bx/Ld contact and then within the Ld unit. Seeps were generally observed above the Ls unit of the St. Louis Formation, suggesting it might be less transmissive (Golder 1996). Attempts were made to seal the cavities and seeps in 1990, but those efforts appeared to be unsuccessful (F&VD 1990).

Leachate was observed to be migrating vertically through the alluvium into the South Quarry through more than 98 feet of limestone and entering the quarry at approximately 220 ft msl. Blasting activities performed during quarrying may have propagated fractures in the walls up to 30 ft horizontally beyond the quarry face. It is, however, unlikely the fractures would have extended beyond this point. Although unlikely, the noted leachate inflow may suggest landfill-related impacts extending into the limestone aquifer. While transport of leachate through solution channels in the limestone is also possible, quarry operators maintained the limestone is intact. Evidence of karst (solution) activity was limited on quarry walls with minor widening of joints and bedding planes near the bedrock surface (NRC 1989).

3.1.5.7.2 LEACHATE COLLECTION SYSTEM

The Bridgeton Landfill leachate collection system is of significant hydrogeological importance, since it is designed to remove (capture) surface water and groundwater flowing into the landfill and thus creates a sink to surrounding aquifers as illustrated by the historical potentiometric data. Leachate collection sumps are fitted with pumps designed to maintain a maximum of 30 ft leachate head from the base of the sump in accordance with permit conditions. During early operation, the Bridgeton Landfill historically pumped and discharged approximately 200,000 gpd (approximately 6 million gallons per month) of liquid to a lined and aerated leachate retention pond (WMC 1997). Groundwater was observed to flow inward from all sides of the Bridgeton Landfill towards the leachate collection sumps and a resulting groundwater divide was created in the alluvium, west of the quarries (Golder 1996). This can be seen on the potentiometric surface maps included as Appendix N.

The current leachate collection system was constructed at Bridgeton Landfill between April 2013 and August 2014. The 316 Tank was built first in April 2013. The 1 million-gallon aeration tanks were started in September 2013, and the associated building construction was started in December 2013. System start-up procedures began in June 2014, and the biological system startup/shakedown commenced in August 2014. The system includes five above ground storage tanks: one 316,000-gallon tank, and four 1 million-gallon tanks. The leachate system treatment train includes the following: solids removal, polymer addition/flocculation, pH adjustment, and biological treatment. Seven leachate collection sumps or LCS wells currently exist as shown in Appendix S; the wells have flow meters which monitor the amount of leachate extracted from each individual wellhead.

One totalizer flow meter and discrete flows from operating extraction wells currently measure the aggregate volume pumped by the leachate collection system active at Bridgeton Landfill; note that not all of the leachate collection sumps are currently operational. The current monthly amount of leachate generated during 2018 ranged from 1.8 to 3.3 million gallons (approximately 60,000 to 110,000 gpd). Additional measures to better quantify and understand the effects of the leachate extraction system are proposed in Section 5.4.16, which outlines measures intended to address this data gap.

3.1.5.7.3 SUBSURFACE REACTION

An SSR was discovered in December 2010 and is currently occurring in the South Quarry portion of the Bridgeton Landfill, resulting in elevated temperatures and accelerated decomposition of waste. The reaction appears to be occurring approximately 80 to 150 feet below the South Quarry landfill surface. An ethylene vinyl alcohol (EVOH) cover, landfill gas extraction wells, and temperature monitoring probes have been installed to address the SSR. Recent temperature, gas quality, and settlement monitoring observations suggest the primary heat front currently appears to be most active in the southern portion of the South Quarry. The heat front of the SSR appears to have migrated from an initial location in the eastern portion of the South Quarry in a counterclockwise direction to the north, then to the west, and, most recently, to the southern portion of the South Quarry. A heat extraction system has been installed and is currently operating in the neck area between the North and South Quarry portions of the Bridgeton Landfill, and additional temperature monitoring probes have been installed in the North Quarry between the neck area and Area 1 (EMSI 2018a).

3.1.6 NATURE AND EXTENT OF IMPACTS

A clear understanding of background alluvial and shallow bedrock aquifer water quality in the vicinity of the site remains undetermined and was identified as a significant data gap in the CSM. Analysis of available data relating to nature and extent of impacts is discussed below; this data will be substantially supplemented with the proposed RI/FS investigation activities. Potential on-site and off-site health and environmental effects posed by groundwater impacts will be evaluated upon completion of the field data gathering outlined in Section 6.2 of this RI/FS Work Plan. Additionally, potential surface water, sediment, and biotic impacts from OU-3 will be further evaluated as the RI/FS progresses.

3.1.6.1 NATURE AND EXTENT OF RIM

Radionuclides have been identified in soil interspersed with solid waste materials in portions of the landfill deposits in Area 1 and Area 2. Radionuclides were also previously detected in soil on the Buffer Zone and Crossroads Lot 2A2. The specific screening criteria approved by USEPA to define RIM at the site are:

- **7.9 pCi/g or higher** of combined Radium-226 plus Radium-228
- **7.9 pCi/g or higher** of combined Thorium-230 plus Thorium-232
- **54.5 pCi/g or higher** of combined uranium activity

Leached barium sulfate residue (LBSR) generated by Mallinckrodt Chemical Works (Mallinckrodt) during uranium processing for the Manhattan Engineering District (MED) was moved from the St. Louis Airport Site (SLAPS) to nearby 9200 Latty Avenue in Hazelwood, Missouri in 1966 (EMSI 2018). An NRC investigation conducted in 1976 reported that approximately 8,700 tons of leached barium sulfate residues, together with approximately 39,000 tons of soil removed from the top 12 to 18 inches of the Latty Avenue site, were transported to the West Lake Landfill over a three-month period from July 16 through October 9, 1973 (USEPA 2008a; NRC 1976; NRC 1988; RMC 1982).

The data and evaluations presented in the RIA identified RIM in multiple irregular volumes, some of which are partially at or near the surface, while others are located in the deeper portions of Area 1 and Area 2. The current distribution of RIM within the landfilled areas has been impacted by both natural and anthropogenic processes after the initial placement of the radiological materials. This includes more than 40 years of decomposition, consolidation, and differential settlement of the MSW. As a result, these irregular volumes of RIM consist of soils, putrescible wastes, and demolition wastes, which are often visually indistinguishable from the surrounding materials in the landfill, including both MSW and previously placed intermediate or final cover. RIM is irregularly interspersed within the overall larger matrix of MSW; not found in a thin, continuous layer as the NRC assumed. Additional detail on the nature and extent of RIM was provided in the RIA and is included as Appendix T.

3.1.6.2 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As summarized in the RIA, groundwater samples have been analyzed for radionuclides as part of the various OU-1 investigations. Most recently (2012-2013), groundwater samples intended for radionuclide analysis were collected at 85 monitoring wells. Radionuclides in the groundwater are discussed in terms of the isotopes of three elements: radium, thorium, and uranium. A detailed discussion of the nature and extent of these constituents was presented in the RIA. Figures showing their distribution are included as Appendix U. Radium has been detected in groundwater monitoring wells in most portions of the site, in both the bedrock and the alluvium. The USGS identified four general hypotheses for the origin of dissolved combined radium above the MCL in the groundwater including (USGS 2015):

- Leaching of radium from the RIM
- Radium values are within the range found in natural groundwater
- Leaching of radium from non-RIM wastes disposed at the site
- Mobilization of naturally-occurring radium from aquifer solids by some component of landfill leachate

The USGS further stated that other than the radium in groundwater samples being from the natural variation in groundwater, no single hypothesis can be invoked to explain all the occurrences of radium above the MCL. Furthermore, the available groundwater data are not adequate to provide definitive conclusions regarding the validity of any hypotheses. The fate and transport of radium is complicated by its natural occurrence and association with redox sensitive iron oxides (USGS 2015). Combined total Radium-226 and Radium-228 was detected above the USEPA MCL for all sampling dates between August 2012 and February 2014 in deep alluvial wells D-83, D-6, PZ-113-AD, and D-3, and Upper Salem/St. Louis Formation wells PZ-107-SS, PZ-115-SS, PZ-101-SS, PZ-102-SS and MW-1204. Ratios of Radium-228/Radium-226 are variable in these wells. Dissolved levels of thorium have not been detected at levels above the Gross Alpha MCL.

VOCS and trace metals have also been detected in site groundwater (Appendix U). Benzene has been detected in groundwater monitoring wells located near the South Quarry, the Inactive Sanitary Landfill and Area 1 (but not Area 2) at concentrations above its USEPA MCL of 5 µg/L. Chlorobenzene was detected in one well near the Inactive Sanitary Landfill and one well near Area 1 at concentrations above its USEPA MCL of 100 µg/L. Vinyl chloride has been detected during some, but not all sampling events in some wells near the Inactive Sanitary Landfill and Area 2. Arsenic has been detected in most of the site monitoring wells at concentrations above its USEPA MCL of 10 µg/L. Iron and manganese have been detected at concentrations above their respective secondary USEPA MCLs (300 and 50 µg/L, respectively) in most of the site monitoring wells. Chloride has also been detected in most of the site monitoring wells at concentrations above its MCL of 250 mg/L.

Occurrence and extent of groundwater contamination and landfill gas migration in groundwater is not delineated and is identified as a data gap. Additional evaluation of radionuclide and chemical occurrences in groundwater will be conducted as part of this OU-3 RI/FS.

3.1.7 POTENTIAL PATHWAYS OF CONTAMINANT MIGRATION/PRELIMINARY PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS

A Baseline Risk Assessment was prepared during each of the OU-1 and OU-2 RIs to evaluate the potential receptors, exposure routes, and potential risks that the site could pose to potential current and future workers at the site and the general public, including off-site residential areas. Potential receptors and pathways are presented below.

3.1.7.1 POTENTIAL RECEPTORS

Potential receptors associated with the site primarily include humans ingesting groundwater and/or ecological receptors ingesting sediment, surface water, or prey that have accumulated site-related constituents conveyed via the groundwater pathway. A preliminary CSM figure for OU-3 has been included as Figure 3-1 in the QAPP, which identifies potential receptors associated with OU-3. Additional potential receptors may be considered throughout the RI/FS process if data indicate that other exposure pathways are currently complete or could reasonably be complete in the future.

A potential exposure pathway is via potable or production water wells. Previous documentation of wells was compiled and reviewed as part of the planning process (Appendix V).

The RIA identified wells in proximity to the site – none of which are used for domestic consumption or community supplies. An inventory of existing and abandoned wells within 2 miles of the site will be conducted during this RI/FS. Information summarizing pertinent OU-3 area boundary features, general site physiography, hydrogeology, geology, and hydrology were summarized in Sections 2 and 3.

Potential ecological receptors are those that are expected to inhabit or use aquatic resources within the site or in areas where a complete exposure pathway exists. The land surrounding the site is largely developed and therefore provides limited overall habitat. The Missouri River provides habitat to both aquatic species and terrestrial species that may consume both food and water. At the conclusion of the RI, specific ecological receptors will be identified for potential exposure areas. No threatened and endangered (T&E) species have been noted to be present on site. Signs of wildlife noted during historical and recent site/vicinity inspections included deer tracks, rabbits, red-winged black birds, robins, crows, a great blue heron, and stool pellets containing fur suggesting a coyote or red fox (EMSI 1997). Bridgeton Landfill staff also report seeing coyotes, turkeys, racoons, skunks, and groundhogs.

3.1.7.2 EXPOSURE ROUTES AND PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS

Potential exposure routes include ingestion of groundwater, sediment, or surface water containing COPCs. Vapor intrusion was identified as a data gap in the SOW and is another potential exposure route for inhalation of radon gas, methane, or VOCs. A preliminary CSM figure for OU-3 has been included in the QAPP, which identifies potential exposure pathways associated with OU-3. Potential exposure routes and public health and environmental impacts will be further evaluated in this RI/FS when the existence, nature, and extent of off-site impacts are defined.

Due to the different behaviors of radium and radon in the environment, the Radium-226/Radon-222 activity ratios in natural water are not constant. Radon gas can leak and diffuse from rocks and sediment to the water, while the dissolution of Radium-226 in the rock/sediment to the water is a slower process. This causes higher Radon-222 concentrations than that of Radium-226 in the natural water. Additional factors also contribute to secular disequilibria between radium and radon, notably differences in the isotopes' half-lives and differences in the chemical behavior of multiple parent isotopes. While it is difficult to quantitatively predict radon activity concentrations in groundwater from radium, it is common for radon activity to exceed radium activity by multiple orders of magnitude (King et al. 1982; Moloney et al. 2011).

3.2 PRELIMINARY OU-3 STUDY AND MODEL BOUNDARIES

The preliminary extent of the OU-3 study area includes the area proposed for investigation as part of the OU-3 RI work plan as shown on Figure 3-16. This initial estimate of the study area will be refined during site characterization and as the OU-3 RI/FS progresses.

The preliminary groundwater modeling boundary is also shown on Figure 3-16. The proposed modeling boundary reflects the proposed modeling domain which extends beyond the study area to incorporate natural hydrogeologic and hydrologic flow boundaries. Additional details on the proposed model boundary are included in Section 6.2.1.

3.3 PRELIMINARY IDENTIFICATION OF RESPONSE OBJECTIVES AND GROUNDWATER REMEDIAL ACTION ALTERNATIVES

Preliminary response objectives are to prevent human and ecological receptors from ingesting groundwater or surface water with COPC concentrations in exceedance of chemical-specific ARARs. The following is a preliminary list of potential remedial action alternatives that may be considered, consistent with applicable Superfund/CERCLA protocols, after data has been collected and analyzed sufficiently.

3.3.1 NO ACTION

The No Action alternative is normally included and evaluated to determine what the threat would be, based on risk assessment, to human health and the environment. The No Action risk assessment provides a baseline for the comparison of other alternatives. The No Action alternative would not reduce or eliminate exposure to groundwater impacted by COPCs, therefore the response objectives would not be met if the groundwater is determined to be impacted. Regardless of the effectiveness of the No Action alternative, the NCP requires the alternative be carried through the detailed analysis of alternatives.

3.3.2 INSTITUTIONAL CONTROLS

Institutional controls provide limited action consisting of maintaining the existing perimeter site fencing/warning signs, regular maintenance, deed restrictions, deed notices, covenants, groundwater use restrictions, site activity use limitations, groundwater monitoring, and five-year reviews.

3.3.3 MONITORED NATURAL ATTENUATION

Monitored Natural Attenuation (MNA) generally consists of monitoring the rate at which natural processes are degrading COPCs. The monitoring typically includes a multiple lines of evidence type of approach that supplements COPC concentration data with geochemical and other data. Routine quarterly groundwater sampling of OU-3 will collect many useful data that will allow assessment of MNA under current site conditions. Geochemical conditions will be evaluated during quarterly sampling as well. This will include dissolved oxygen (DO), nitrate, and sulfate concentration, and also oxidation-reduction potential (ORP). Each of these can be used to determine the potential for oxidative or reductive biological and abiotic attenuation of certain COPCs.

3.3.4 GROUNDWATER EXTRACTION (HYDRAULIC CONTROL)/TREATMENT/DISPOSAL

Groundwater control can be achieved via pumping and pre-treatment on-site for off-site disposal to a publicly owned treatment works or other treatment facility. Depending upon the COPCs determined to be present, groundwater treatment alternatives may include air stripping (volatile organics), carbon adsorption (organics), chemical oxidation (organics), aerobic biodegradation (organics), chemical precipitation (metals), ion exchange (metals) or a combination of the above. Options preliminarily identified for disposal of treated groundwater include discharge to the sanitary sewer system which serves the site, and/or reinjection after treatment.

3.3.5 GROUNDWATER CONTAINMENT

A groundwater containment scenario would involve capping of the landfilled areas and potentially pumping of groundwater/leachate as necessary to create an inward groundwater gradient to prevent off-site migration of impacted groundwater. In addition, the effects of the OU-1 remedial action will need to be considered in the short and long term if a containment strategy is implemented.

3.3.6 IN-SITU TREATMENT

Groundwater can be treated in situ to facilitate the attenuation or degradation of dissolved COPCs in groundwater. Treatment of dissolved contaminants in situ requires an assessment of groundwater flow, COPC concentrations, and site geochemistry in order to develop a treatment method to break down the contaminants or reduce contaminant mobility. Depending on the COPCs present, options for in-situ treatment may include reactive barrier to attenuate the movement of COPCs in groundwater and/or injection of chemicals or other amendments to stabilize or enhance degradation of dissolved COPCs.

3.4 DATA NEEDS

The specific data needs and data gaps for the OU-3 RI activities are outlined in Section 4.0, and were based upon an evaluation of previous investigations; these specific data needs and data gaps were considered when developing the work plan rationale and the additional data acquisition program. The data needs identified for the OU-3 RI include:

- Identifying existing wells and proposing new borings/groundwater monitoring wells to define the physical and geochemical characteristics of the hydrogeologic system, including bedrock units.
- Identifying, sampling, and analyzing COPCs and other relevant parameters to assess background groundwater quality and potential downgradient landfill impacts (e.g., geochemical redox indicators, landfill leachate indicators, trace anions, tritium, wastewater organic compounds, and radionuclide isotopic analysis) upon groundwater quality.

These data will also support groundwater modeling and the completion of human health and ecological risk assessments needed to inform RI/FS decisions regarding potential remedy selection if needed. Discussions with the remedial project manager, the USEPA human health and ecological risk assessors, and the Respondents risk assessors will be necessary to identify data gaps and ensure that adequate data will be collected to meet the data needs for conducting the risk assessments and decision making.

Information from the OU-3 activities included in Section 5.0 to address the data needs and data gaps identified in Section 4.0 will be evaluated to identify data gaps that still exist and which will be further evaluated as an additional phase of the RI process. Data gaps could include sediment, sediment pore water, surface water, soil gas, indoor air, and/or additional groundwater quality data. Data needs and a plan to satisfy them will be outlined in additional work plans or addendums to this Work Plan.

3.5 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides the preliminary identification of potential OU-3 ARARs and other relevant guidance and criteria "to be considered" (TBC) for the site. The preliminary identification of potential ARARs and TBCs will continue throughout the OU-3 RI/FS process as more information is developed. In addition to the ARARs and TBCs described below, the work described in this RI/FS Work Plan will be completed in general accordance with the NCP (40 CFR Part 300).

A detailed discussion of ARARs was included in the OU-1 Final Feasibility Study (FFS) and modifications and an addendum to the approved FFS per the USEPA letter dated February 5, 2018, and the OU-1 ROD Amendment (EMSI 2018b; USEPA 2018a). Since OU-3 consists of the groundwater at or surrounding the West Lake Landfill site which includes OU-1 and OU-2, the previously identified ARARs were utilized as a starting point for identifying OU-3 ARARs. Potential chemical-specific and location-specific ARARs and TBCs were also identified based upon review of available site data. Potential action-specific ARARs and TBCs will be based on the remedial action alternatives to be developed in the OU-3 FS.

The ARARs and TBCs are divided into three categories: chemical-specific, action-specific, and location-specific, as described below:

- Chemical-Specific ARARs are typically health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, are expressed as numerical values. The values represent cleanup standards (e.g., the acceptable concentration of a chemical at the site). A list of preliminary Chemical Specific ARARs for OU-3 is presented in Table 3-6.

- Action-Specific ARARs are generally technology- or activity-based requirements or limitations on actions or conditions taken with respect to hazardous substances on the site. Action-specific ARARs do not typically determine the remedial alternative; however, the ARARs indicate how a selected alternative must be implemented or achieved. A list of preliminary Action Specific ARARs for OU-3 is presented in Table 3-7.

- Location-Specific ARARs are restrictions on the concentrations of hazardous substances or the conduct of activities in certain locations. A list of preliminary Location Specific ARARs is presented in Table 3-8.

4.0 RI/FS WORK PLAN RATIONALE

The objective of OU-3 site characterization is to collect sufficient data to address the data gaps listed in the SOW to:

- Refine the current understanding of the hydrogeologic system.
- Identify COPCs and their source(s) in groundwater.
- Characterize the current nature and extent of impacts to the hydrogeologic and hydrologic system.
- Predict the potential nature and extent of impacts to the hydrogeologic and hydrologic system.
- Evaluate exposure pathways to determine current and future human health and ecological risk.
- Evaluate remedies as necessary.

Rationale for the proposed OU-3 site characterization activities is provided below.

4.1 DATA QUALITY OBJECTIVE NEEDS

The data quality objective (DQO) process is designed to clarify the objectives of data collection, maximize efficiency during data collection, and develop the design for data collection. DQOs provide specificity to the framework in which data will be collected and the requirements that data needs to meet in order to meet the general objectives of the OU-3 RI/FS listed below:

- Identify and characterize sources of COPCs
- Determine the nature and extent of impacts to groundwater and surface water
- Develop a preliminary OU-3 boundary
- Develop an appropriate groundwater model
- Identify exposure pathways, evaluate current and future human health and ecological risks posed by the COPCs present at the site, and complete a risk assessment in accordance with USEPA guidance
- Determine the potential for vapor intrusion
- Develop and evaluate remedial alternatives for the site

The seven-step DQO process was completed for the OU-3 RI Work Plan consistent with USEPA's *Guidance on Systematic Planning Using the Data Quality Objective Process* using the nine data gaps identified in the ASAOC as the basis (USEPA 2006). The OU-3 RI scope of work was then developed based on the results of the DQO evaluation as summarized in Table 3-1 of the QAPP.

4.2 WORK PLAN RATIONALE

Nine data gaps were identified in the OU-3 ASAOC SOW. The proposed OU-3 RI approach to address the individual data gaps is discussed in the following subsections.

4.2.1 DATA USABILITY AND WELL INVENTORY

Over 100 monitoring wells were previously installed on-site and near-site to characterize impacts to groundwater. A portion of these wells were plugged/abandoned over time. There are currently 86 existing monitoring wells, which are located on-site or near-site. The existing wells have been sampled from 1979 to 2019. The adequacy and usability of data collected from these wells to characterize impacts needs evaluation for the parameters that will be utilized as part of the OU-3 studies.

The usability of historical data is important in understanding potential extent of impacts and transport. It is unknown whether additional validation efforts are necessary for the desired data set; however, it is likely that the more recent data have already been validated to meet the requirements of the OU-3 QAPP.

As part of the OU-3 investigation, these 86 existing wells are proposed as part of the overall OU-3 well network. The OU-3 well network will include the 86 existing wells and 64 proposed wells, resulting in a network of 150 wells. It is unknown whether the proposed OU-3 well network will ultimately be sufficient for evaluating nature and extent of site-related impacts and characterizing background groundwater conditions.

Additionally, there may be existing wells offsite that may provide useful hydrogeologic information, but an off-site well inventory has not been completed since 2018. There may be existing non-potable wells offsite within a two-mile radius which may be impacted by groundwater from the site. Sampling of these wells may be necessary to determine if groundwater has been impacted from the site. No drinking water wells were identified in 2018 within two miles of the site, but that may have changed over time.

The proposed approach to address the first OU-3 RI data gap includes the following scope of work:

- Installation of additional on-site, near-site, off-site, and background monitoring wells.
- Evaluation of the usability of existing data in accordance with USEPA guidance, and qualification or rejection from inclusion in the OU-3 database, if necessary.
- Completion of a detailed well inventory to evaluate usability of the currently installed wells identified as part of the OU-3 groundwater well network. Completion of well repairs or replacement of wells as needed.
- Compilation of local and regional monitoring well information within a 2-mile radius of the site using publicly available database information, including water levels, water quality data, well use, pumping rates, and well construction information. If necessary, well information will be requested from well owners. Results from the well inventory will be documented in the Well Inventory Summary Report.

After the first phase of site characterization for the OU-3 RI, the first data gap will be addressed. However, the well inventory may be revised over time as necessary to support the risk assessment and groundwater modeling efforts.

4.2.2 AQUIFER PROPERTIES

Aquifer properties including recharge/discharge rates and hydraulic conductivities were identified as a data gap in the OU-3 SOW. A detailed evaluation of the hydrostratigraphy was conducted in general accordance with USEPA guidance on environmental sequence stratigraphy during preparation of the preliminary CSM to evaluate how the depositional environment could affect contaminant fate and transport (USEPA 2017a). Existing slug testing and packer testing data were compiled and evaluated as discussed in Section 3.1.5.2. However, the existing dataset is inadequate to develop a groundwater flow and transport model. In general, a water-balance has not been completed to fully conceptualize the hydrology at the site.

In order to address this second data gap, aquifer property information will be collected to address both the geology and hydrogeology at the site as described below:

- Geology:
  - Alluvial boreholes will be advanced and logged continuously by visual inspection to obtain hydrostratigraphic data and expand the stratigraphy evaluation.
  - Rock boreholes will be continuously cored and logged using geophysical techniques prior to monitoring well installation.
  - Discontinuity data for rock boreholes will be entered into the OU-3 database and will be evaluated along with the existing dataset.

- Hydrogeology:
  - Pneumatic or traditional slug tests are proposed at all new monitoring wells and existing monitoring wells not previously tested to address this data gap. Packer tests are proposed at select intervals identified based on geophysical logging all new bedrock wells.
  - A multi-well pumping test will be conducted at a well with no COPC impacts. The pumping test is intended to provide additional necessary input parameters for a groundwater model after the initial phase of site characterization is complete.
  - Continuous water level monitoring will be conducted in a select network of monitoring wells and staff gauges and compared to precipitation data to evaluate recharge rates.
  - A pilot test using a hydraulic profiling tool (HPT) that collects vertical hydraulic conductivity is proposed in the Buffer Zone to evaluate whether it can be successfully deployed to supplement the hydraulic conductivity data.
  - Hydraulic properties, potentiometric surfaces, COPC concentrations, and hydrostratigraphic thicknesses will be used to calculate mass flux and discharge of COPCs and prepare a water balance.

4.2.3 REGIONAL AND LOCALIZED HYDRAULIC GRADIENTS

Regional and localized hydraulic gradients and flow directions within the alluvial and shallow bedrock aquifers were identified as the third data gap based on the limited information available from existing on-site and off-site wells. The influence of groundwater extraction, recharge, and communication with surface water has not been well characterized offsite. In order to address this third data gap, well installation, well gauging and sampling, and surface water gauging are proposed.

- New alluvial and bedrock well series are proposed to be installed to supplement the existing on-site well network. The proposed wells near the site will be screened within each water-bearing zone to evaluate vertical gradients; alluvial wells will be located within one borehole (nested) when possible and bedrock wells will be within single boreholes in close proximity to the alluvial well nest (clustered). The number of wells in the proposed well network was selected to provide horizontal gradient information near the site and offsite to the north, west, and east of the site. Wells are also proposed for installation away from the site (background wells), which will assist with interpretation of regional gradients. Water level and water quality information will be obtained from the proposed well network.
- Continuous water level monitoring is proposed at a select number of wells and all staff gauges in addition to routine manual water level and staff gauging to evaluate the temporal variability in areas near surface water or

groundwater extraction points. Information from off-site wells will also be compiled to supplement the evaluation of regional groundwater gradients.

- Staff gauges will be installed in surface water bodies and equipped with transducers for continuous data collection within the model boundary to provide information on potential effects of pumping and recharge, evaluate whether potential exposure pathways are complete, and provide calibration data for the groundwater model.

4.2.4 BACKGROUND GROUNDWATER CONDITIONS

Background groundwater conditions near the site in the alluvial and bedrock aquifers has not been established and should be established due to the presence of elevated concentrations of naturally-occurring radionuclides and other COPCs in groundwater. The USGS did not determine background Radium-226 and Radium-228 concentrations in groundwater due to a limited dataset, which included 17 alluvial samples from 14 alluvial wells and 11 bedrock samples from 6 bedrock wells. This is identified as an important data gap for the risk assessment and remedy decision-making (USGS 2015). Background radionuclide concentrations and ratios are an important component of evaluating the extent of potential impacts related to the site and identifying the source of radionuclides present in groundwater at the site. Nearby off-site sources may be contributing to groundwater quality within the study area, including leaking underground storage tank sites and the Champ Landfill.

In order to address the fourth data gap, new background wells are proposed in the alluvium and bedrock to expand the existing dataset used by the USGS and develop background values for the COPCs that are representative of the spatial variability of background data. Data will be collected at a spatial and temporal frequency sufficient to establish statistically significant background conditions. Radium-228/Radium-226 (Ra228/Ra226) ratios in groundwater and aquifer matrix materials along with geochemical conditions will be used to evaluate the relative contribution of natural and anthropogenic radium.

4.2.5 OCCURRENCE AND EXTENT OF GROUNDWATER IMPACTS

Radium has been detected in on-site groundwater. There is limited information currently available regarding the potential extent of site-related groundwater impacts (if present) due to the lack of comparable data from off-site wells. A new off-site well network is proposed to address this issue. The USGS identified four potential sources for radium in on-site groundwater but was unable to quantify the relative contribution of each source. Groundwater underlying the site and/or downgradient from the site may contain elevated inorganic and organic constituents. The present lack of understanding of the spatial distribution of groundwater impacts limits the ability to evaluate the site for potential receptors (present and future).

To address this fifth data gap, off-site wells will be installed for water level and water quality data collection, and to understand off-site groundwater conditions compared to on-site / near-site water quality data.

- New on-site, near-site, and off-site monitoring wells are proposed to evaluate the nature and extent of groundwater impacts respective to background in the alluvium and bedrock. Water level data from the current and proposed wells will be used to evaluate the current and future distribution of groundwater impacts (if present) and assess exposure pathways. Information related to surrounding properties will be reviewed and compiled to determine potential receptors or potentially affected properties.
- Samples will be collected from the Bridgeton Landfill leachate collection system and leachate risers. Additional regionally relevant MSWLF data will be collected to the extent they are available, to compare radium concentrations and ratios at similar sites. Existing and newly collected geochemical data will be used to evaluate the potential for radium to liberate from alluvial and bedrock aquifer matrix samples.
- Modeling of the hydrologic system is necessary to evaluate the potential future COPCs migration scenarios. Insufficient groundwater level and groundwater quality data is available near surface water bodies to evaluate sediment, sediment pore water, and surface water exposure pathways. Data gathered during implementation of the RI/FS will be used to better understand and quantify these pathways, as needed.

4.2.6 GROUNDWATER GEOCHEMISTRY

Multiple subsurface conditions typical of a landfill environment can result in alterations of naturally occurring geochemical parameters in surrounding groundwater. Different redox conditions, mineralogy, and organic content can attenuate or mobilize radionuclides via exchange, adsorption, desorption, precipitation, co-precipitation, and dissolution. The redox environment at the site may be reducing in the vicinity of leachate influence, but redox can also be aerobic within river valleys. The presence of available metals for sorption under certain pH levels and redox conditions can result in lower radionuclide concentrations in groundwater. Higher organic carbon content can lead to sorption onto aquifer matrix solids and lower groundwater concentrations. A better understanding of how radionuclide concentrations in groundwater at and near the site may be changing spatially due to these influences is warranted.

To address this sixth data gap, groundwater and aquifer matrix samples will be collected as follows:

- Redox measurements will be collected from the proposed well network (current and existing wells). These readings will be incorporated with the existing historical ORP and DO measurements and compiled into the OU-3 database.

- Groundwater samples will be submitted for a number of inorganic constituents to better understand the local and regional geochemical environment. New data will be incorporated into the OU-3 database and evaluated to understand how the groundwater geochemical conditions may affect the fate and transport of COPCs.
- Aquifer matrix samples will also be collected for cation/anion information, mineralogy and radionuclide concentrations to evaluate the potential for radionuclides to mobilize or attenuate from naturally occurring materials based on the geochemical conditions in groundwater.

4.2.7 EFFECTS OF THE BRIDGETON LANDFILL

The Bridgeton Landfill operated as a limestone quarry prior to landfilling activities. Water was extracted from the quarry during operations. Landfilled materials were placed in the North and South Quarry Portions of the Bridgeton Landfill. The hydraulic characteristics of the landfill materials may be affecting groundwater in several possible ways. Current Bridgeton Landfill infrastructure such as the leachate extraction system and landfill gas extraction system could play an important role in the fate and transport of COPCs in groundwater:

- Extraction of leachate may be providing some benefit to surrounding groundwater quality, or creating a measured level of hydraulic control.
- Landfill leachate may be entering groundwater and influencing groundwater quality.
- Leachate migration into groundwater near the site could potentially cause mobilization of naturally occurring radium in the surrounding soil or bedrock matrix due to chemical interaction with those aquifer matrices.

The potential for landfill gas migration has been evaluated onsite, but not offsite. If landfill gas is present off-site in groundwater, it may be affecting the redox conditions and impacting radionuclide groundwater concentrations.

To address the seventh data gap, water levels, pumping rates, groundwater quality, aquifer matrix radium concentrations, and leachate concentrations will be evaluated:

- Manual and continuous monitoring of water levels at select wells near the Bridgeton Landfill will be used to determine groundwater flow direction and gradients based on current conditions.
- Water level and leachate collection/pumping data will be input into the groundwater model to explore how existing infrastructure has potentially influenced the current nature and extent of groundwater impacts (if present). Flow monitoring from individual leachate collection sumps and seepage data will also be conducted to assist with preparation of site-wide water balance. The water balance will be completed using existing and new flow and existing seepage data to evaluate the potential contribution of groundwater to leachate generation.

- Temperature data for the heat extraction system will be compiled to evaluate the potential impact on the nature and extent of impacts.
- The contribution of radionuclide impacts leaching from RIM will be evaluated by collecting aquifer matrix and groundwater samples to calculate the Radium-228/Radium-226 ratio.
- Analysis of dissolved gases is proposed as part of the analyte suite to evaluate whether landfill gas is migrating offsite in groundwater. Analytical results of dissolved gases (methane and carbon dioxide) in groundwater will be used to determine if the potential exists for landfill gas to migrate upward from groundwater in off-site areas during the first phase of site characterization. An evaluation of the potential impact of the EVOH and landfill gas collection system on groundwater concentrations will be completed through comparison of dissolved phase gas concentrations onsite and offsite relative to these systems.
- To evaluate the potential that groundwater has been impacted by landfill gas, groundwater sample results will be reviewed for VOCs present in groundwater with or without elevated or increasing levels of leachate constituents/parameters (e.g chloride, electrical conductance, and often iron and manganese, or other easily transported constituents present at elevated levels in leachate). If VOCs are present without elevated or increasing levels of leachate parameters, this would be indicative of a landfill gas effect. Conversely, if VOCs are elevated and leachate constituents are elevated the likely source would be a leachate effect. Further, there are particular VOCs that are more frequently detected in landfill gas (e.g. benzene, chlorobenzene, 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, methylene chloride, tetrachloroethene, toluene, 1,1-trichloroethane, trichloroethene, and vinyl chloride). The large suite of constituents proposed for leachate and groundwater monitoring should be sufficient to differentiate the likely source(s) contributing to groundwater impact.

4.2.8 VAPOR INTRUSION

The potential for vapor intrusion into on-site or off-site structures has not been investigated. Perimeter landfill ambient air sampling is currently being conducted, but the indoor air pathway has not been evaluated for radon since the 1990s and has not been evaluated for methane or VOCs to date. The potential risk to indoor air at off-site properties has also not yet been evaluated due to the lack of off-site groundwater data. Additional data gaps may exist if off-site groundwater data indicate a potential for vapor intrusion, including the potential need for sub-slab, soil gas, and/or indoor air data.

To address the eighth data gap, on-site indoor air quality will be assessed through testing of occupied, enclosed on-site structures for radon, methane, and VOCs as part of the first phase of OU-3 RI activities. Off-site indoor air quality will be evaluated based on the results of the proposed groundwater sampling. Groundwater data will be used to estimate off-site indoor air quality. Further off-site testing will be recommended as part of an integrated additional phase of characterization if necessary, based on the results of the vapor screening evaluation.

4.2.9 GROUNDWATER AND SURFACE WATER TEMPORAL AND SPATIAL VARIABILITY

Previous investigations documented temporal variability in groundwater levels and flow direction. Groundwater elevations and flow direction may also be influenced by the elevations in nearby surface water bodies, including ponds and the Missouri River. The potential fluctuations in groundwater levels and flow directions in response to influences such as surface water, precipitation, and pumping need further assessment to evaluate the nature and extent of current and future groundwater impacts. Surface water features such as the Missouri River, impounded water, and other nearby surface water bodies could influence groundwater flow direction. Historical groundwater levels, surface water elevations from nearby staff gauges, and USGS data from the St. Charles Missouri River Gauge provide useful sources of data, but additional data tied to current groundwater conditions is needed.

To address the ninth data gap, groundwater and surface water level data will be collected from existing and proposed locations to evaluate both the temporal and spatial variability of groundwater elevations and flow direction. Continuous water level monitoring in a select network of wells, and monthly manual gauging will be implemented for remaining monitoring wells during the OU-3 site characterization activities. Staff gauges will be installed in nearby ponds and stormwater basins near the site and monitored continuously. Missouri River stage data will be downloaded from the USGS.

5.0 SITE CHARACTERIZATION

OU-3 site characterization activities are designed to supplement the existing dataset through the collection of additional data to sufficiently characterize the nature and extent of hazardous substance impacts to groundwater and their potential risk posed to human health and the environment. The resulting data will be used to address data gaps outlined in Section 4.0, refine the current understanding of the hydrogeologic system at the site, evaluate background groundwater quality, determine the extent of groundwater impacts, provide predictive tools/models to evaluate potential future impacts, and identify potential remedies as needed. The following tasks have been initiated and/or will be completed to address the data gaps outlined in Section 4.0 and meet the objectives of the RI/FS process:

- Compile quantitative data and information pertaining to existing surface water features, geology, hydrogeology, geochemistry, property access conditions, and the proximity of potential receptors to known or potential contaminants.
- Determine adequacy, usability and status of existing and abandoned site-associated monitoring wells and associated data. Install additional monitoring wells/piezometers, as needed.
- Collect continuous cores at select new locations (grain size, minerology, organic carbon content).
- Apply borehole geophysical methods in areas sufficiently far from the site to provide a more complete characterization of the alluvial aquifer and bedrock formations as necessary.
- Conduct aquifer testing in areas sufficiently far from the site to better understand flow characteristics and vertical hydrogeological aspects to minimize model boundary effects of estimated aquifer information.
- Gauge/sample wells periodically and measure certain groundwater and surface water levels continuously.
- Collect and analyze field data to assist in the evaluation of reasonable groundwater remedies.
- Determine background radionuclide and other contaminant concentrations in aquifers located at, and near, the site.
- Prepare a geologic modeling database and perform groundwater modeling.

Site characterization will follow best management practices (BMPs) including the USEPA Triad Approach, Interstate Technology Regulatory Council (ITRC) guidance on integrated site characterization, and ITRC guidance on characterization and remediation of fractured rock. These BMPs will be used to evaluate fate and transport processes and to develop a robust updated version of the CSM. Integrated site characterization will use systematic planning and dynamic work strategies under the Triad approach to evaluate real-time data and update the CSM for optimizing and streamlining additional characterization, monitoring, and Specific, Measurable, Attainable, Relevant, and Timely (SMART) remedy selection. The goal is to allow for a phased, iterative, flexible, and collaborative approach with

USEPA that supports changes in scope as new data become available, and adaptive characterization progresses. Samples will be collected and analyzed in accordance with this Work Plan, related documents, and appropriate USEPA methods and test procedures unless otherwise noted based on actual field conditions and/or when approved by USEPA. Site characterization will be conducted in accordance with the SAP. Tasks are summarized below.

5.1 SAMPLING AND ANALYSIS PLAN

The SAP consisting of the FSP and a QAPP has been prepared for the OU-3 RI/FS. This document is included in this submittal as Volume 2. Work conducted as part of the site characterization will follow the SAP. The SAP will include standard operating procedures (SOPs) and other relevant information needed to properly document and conduct the work in a safe and efficient manner to reach the goals of the project. Elements of the SAP are as follows:

5.1.1 FIELD SAMPLING PLAN

The FSP specifies and outlines necessary activities to collect and obtain additional field data. The plan explains the additional data required to adequately characterize subsurface conditions including, but not limited to, vertical/lateral flow, extent of COPCs, background levels of contaminants and naturally occurring materials to support evaluations conducted in the OU-3 BRA, and as warranted to support the evaluation of remedial technologies. The FSP states sampling objectives; sampling methods and necessary equipment; anticipated sample types, locations, and frequency; a field events schedule; and when deliverables will be submitted to the USEPA. General requirements regarding site access and related site control measures are clearly defined in the FSP.

5.1.2 QUALITY ASSURANCE PROJECT PLAN

The QAPP addresses the types of investigations and analysis to be conducted and includes the following discussions:

1. A project description summary (duplicated from this Work Plan).
2. A project organization chart illustrating the lines of responsibility of the personnel involved in the sampling and testing phases of the project.
3. DQOs in accordance with the seven step process.
4. Quality assurance objectives for data such as the required precision and accuracy, completeness of data, representativeness of data, comparability of data, and the intended use of collected data.
5. The type and frequency of calibration procedures for both field and laboratory instruments, internal quality control checks, and supporting quality assurance performance audits and system audits.

6. Preventative maintenance procedures and schedule, and corrective action procedures for field and laboratory instruments.
7. Specific procedures to assess data precision, representativeness, comparability, accuracy, and completeness of specific measurement parameters.
8. Data documentation, reporting, and tracking procedures.

5.2 COMPILE EXISTING DATA

Publicly available records on the USEPA website and databases maintained by the OU-1 and OU-2 consultants that included historical groundwater data, reports, and correspondence pertinent to OU-3 were searched and reviewed during the RI/FS planning phase as outlined in Section 2.0. Existing spatial and temporal hydrogeologic, geochemical, and analytical data were digitized as needed and data were compiled to refine the current understanding of the hydrogeologic system, prepare the preliminary CSM which was presented in Section 3.0, and scope the OU-3 RI/FS. Digitized data included alluvial and bedrock borehole logs for monitoring wells; bedrock discontinuity data; monitoring well construction diagrams; aquifer testing results; stabilized groundwater monitoring field parameters; groundwater elevations; and surface water elevations. This information was incorporated into a 3-D data visualization tool and a USEPA-accessible database. Data will be managed in accordance with the SAP.

Additional records will be reviewed to refine the CSM as needed during site characterization and as the RI/FS progresses. Additional records include historical local and regional studies on OU-1, OU-2, and groundwater by local, state, federal, and private parties within the preliminary groundwater modeling domain shown on Figure 3-16. The USEPA-accessible database will be updated as new data become available and are incorporated. Data management and evaluation are discussed in more detail in Section 6.0 of this Work Plan. Findings of the evaluation and the refined CSM will be presented in the Annual Hydrogeologic Investigation and Groundwater Characterization Report.

5.3 EVALUATE EXISTING MONITORING WELL NETWORK

Existing and new on-site groundwater data will be used to support this OU-3 RI/FS. A preliminary well inventory was conducted to confirm the status of existing monitoring wells. This information was incorporated into the 3-D site visualization to evaluate which alluvial zones on-site monitoring wells are screened in, where groundwater impacts exist, and understand where additional monitoring wells are needed. The regional and local wells listed in the preliminary CSM were utilized to propose on-site, near-site, off-site, and background monitoring well locations.

5.3.1 PRELIMINARY MONITORING WELL INVENTORY

A preliminary monitoring well inventory was conducted on inactive monitoring wells not included in the active Bridgeton Landfill groundwater monitoring well network during a site walkover on April 17, 2018. The purpose of the preliminary monitoring well inventory was to update the monitoring well status and understand the available, existing monitoring well network. Inactive monitoring wells visited were photographed, and depth to water, well construction, and total depth were recorded as shown on Table 5-1. Photo-documentation is included in Appendix W. During the preliminary well inventory, a discrepancy was discovered between total depths for I-9 and D-93 and it was noted that these wells had been mislabeled. Labels on these wells appeared to pre-date field sampling forms from 2004, which indicate the correct depth, so it is unclear at what time samples may have been swapped at these wells. This will be evaluated as part of Section 6.0 in the Work Plan. Monitoring well I-4 has a pinched casing at 35.90 ft below measuring point. Current monitoring well status is shown on Figure 5-1. The complete monitoring well inventory (preliminary and proposed inventories) will be documented in the Well Inventory Summary Report as described in Section 9.1.

5.3.2 PROPOSED MONITORING WELL DESIGNATIONS

Monitoring wells are proposed to be installed to address the data gaps identified in the SOW. In general, the proposed well network embodies a more regional evaluation of groundwater in the vicinity of the site. Historical investigations focused almost entirely on areas situated within the site property boundary, but have not defined the potential horizontal, and vertical extent of impacts on groundwater quality. Additionally, the existing network did not provide adequate data to make a clear determination of background groundwater conditions upgradient or laterally away from the site. The overall objective of these wells is either to fill a critical on-site data gap, or to identify a nearby location not exhibiting impacts related to historical operations at the site.

Monitoring well nomenclature is generally consistent with that used in the past and consists of reference to a well series and a monitoring zone. New monitoring wells will be identified using the “MW” prefix. Series will be designated based on proximity to site features as described below:

- 300 Series – adjacent to the Inactive Sanitary Landfill
- 400 Series – within 500 feet of Area 2
- 500 Series – offsite
- 600 Series – background

The groundwater monitoring zone is dependent on hydrogeologic characteristics of the alluvium or bedrock and the vertical location the screened interval intersects. Alluvial monitoring zones are:

- AS – Shallow Alluvium; screened across or near the water table above 415 ft msl in the finer grained shallow alluvium.
- AI – Intermediate Alluvium; generally screened within elevations of approximately 385 to 415 ft msl across intermediate alluvial fine to coarse sand between the shallow alluvium and deep alluvium.
- AD – Deep Alluvium; generally screened within elevations of approximately 330 to 385 ft msl across alluvial coarse sand to coarse gravel near the alluvium bedrock interface.

Bedrock monitoring zones are:

- SS – Upper Salem Formation/St. Louis Formation
- SD – The base of the Salem Formation
- KS – Keokuk Formation

No additional Keokuk Formation monitoring wells are proposed during the initial site characterization activities. Four Keokuk Formation monitoring wells surrounding the South Quarry portion of the Bridgeton Landfill are part of the current MDNR groundwater monitoring program. Historical groundwater quality data from these wells show impacts do not appear to have migrated through the Warsaw Formation aquitard. Groundwater monitoring of the Warsaw Formation aquitard is not proposed. Monitoring well locations, screened intervals, and rationale are discussed below.

5.3.3 PROPOSED ON-SITE / NEAR-SITE MONITORING WELL LOCATIONS AND RATIONALE

New additional wells are proposed to evaluate: (a) aquifer properties; (b) localized hydraulic gradients and flow directions within and between the alluvial aquifer and bedrock aquifer system; (c) the occurrence and extent of groundwater impacts; (d) groundwater geochemistry; (e) effects of the Bridgeton Landfill-related infrastructure; (f) temporal variability in groundwater levels and flow direction; (g) and effects of nearby surface water features and storm events.

A review of existing groundwater data supports the need for additional groundwater characterization. Combined total Radium-226 and Radium-228 are considered COPCs for the OU-3 site investigation and were detected above the USEPA MCL in groundwater for all sampling dates between August 2012 and February 2014 in deep alluvial wells D-83, D-6, PZ-113-AD, and D-3, and Upper Salem/St. Louis Formation wells PZ-107-SS, PZ-115-SS, PZ-101-SS, PZ-102-SS and MW-1204. Additional detections of combined total Radium-226 and Radium-228 and the Radium-228/Radium-226 ratios are variable in these wells across the site. Chloride is considered a landfill leachate indicator and has also been detected in most of the on-site monitoring wells at concentrations above its MCL of 250 mg/L, with elevated concentrations near the Inactive Sanitary Landfill. Impacts to groundwater at the site are variable with a variety of potential sources. The proposed wells were therefore placed in strategic locations to fill data gaps.

Nine new on-site/near-site well locations are proposed to be installed as part of the OU-3 RI activities as shown on Figure 5-2. The rationale behind the location and depth of screened intervals is presented in Table 5-2. A brief discussion of each proposed on-site and near-site monitoring well series is provided below.

<u>MW-213-AS and MW-213-AD</u> – This series includes two wells, one shallow alluvial well (MW-213-AS) and one deep alluvial well (MW-213-AD). The MW-213 series wells are proposed to be installed adjacent to existing intermediate alluvial well I-67, which has had historical landfill leachate effects. No shallow alluvial or deep alluvial wells currently exist at this location and these wells will complete the alluvial series. No bedrock wells are proposed at this location, since the proposed and existing network is currently considered sufficient for the first phase of characterization. Wells installed at this location will provide additional information on the occurrence and extent of groundwater impacts and address the data gaps outlined above.

<u>MW-302-AD</u> – One deep alluvial well (MW-302-AD) is proposed adjacent to intermediate alluvial well PZ-302-AI to assess contaminant migration in the deeper more permeable alluvium. These wells will complete an alluvial cluster with monitoring well S-53. No bedrock wells are proposed at this location, since the proposed and existing network is currently considered sufficient for the first phase of characterization. Wells installed at this location will provide additional information on the effects of the Bridgeton Landfill, the occurrence and extent of groundwater impacts, and address the data gaps outlined above.

<u>MW-303-AI and MW-303-AD</u> – This series includes two wells, one intermediate alluvial well (MW-303-AI) and one deep alluvial well (MW-303-AD). The MW-303 series wells are proposed to be installed adjacent to existing shallow alluvial well PZ-303-AS, where landfill leachate effects have been documented historically. No intermediate alluvial or deep alluvial wells currently exist at this location. These wells will complete an alluvial cluster with well PZ-303-AS. No bedrock wells are proposed at this location, since the proposed and existing network is currently considered sufficient for the first phase of characterization. Wells installed at this location will provide additional information on the effects of the Bridgeton Landfill, the occurrence and extent of groundwater impacts, and address the data gaps outlined above.

MW-304-AD, MW-304-SS, MW-304-SD – This series includes three wells, one deep alluvial well (MW-304-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-304-SS), and one Salem Formation well (MW-304-SD). The MW-304 well series is proposed to be installed adjacent to existing wells PZ-304-AS and PZ-304-AI. No deep alluvial or bedrock wells currently exist at this location. Combined total Radium-226 and Radium-228 impacts were documented above the MCL in all samples collected from deep alluvial wells D-83 and D-6 and some samples collected from deep alluvial well D-93 located near the northern/western property boundaries during the 2012 to 2014 comprehensive groundwater monitoring event, but currently no deep alluvial wells are installed to the south. Elevated chloride concentrations are also present in deep alluvial well D-93. An evaluation of existing potentiometric data suggests this MW-304 series is occasionally downgradient of Area 1 in the deep alluvium. Wells installed at this location will provide additional information to evaluate impacts related to the Inactive Sanitary Landfill, evaluate the effects of the Bridgeton Landfill, and address the data gaps outlined above.

MW-306-AI and MW-306-AD – This series includes two wells: one intermediate alluvial well (MW-306-AI) and one deep alluvial well (MW-306-AD). The MW-306 series wells are proposed to be installed adjacent to existing shallow alluvial well MW-103. No intermediate alluvial or deep alluvial wells currently exist at this location. These wells will complete an alluvial cluster with well MW-103. No bedrock wells are proposed at this location, since the proposed and existing network is currently considered sufficient for the first phase of characterization. Wells installed at this location will provide additional information on the occurrence and extent of groundwater impacts and address the data gaps outlined above.

MW-400-AS, MW-400-AI, MW-400-AD, MW-400-SS, MW-400-SD – This series includes five wells: one shallow alluvial (MW-400-AS), one intermediate alluvial well (MW-400-AI), one deep alluvial well (MW-400-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-400-SS), and one Salem Formation well (MW-400-SD). The MW-400 series is proposed in close proximity to deep alluvial well D-6, which may be abandoned during OU-1 remedy implementation. Combined total Radium-226 and Radium-228 impacts were documented above the USEPA MCL in all samples collected from well D-6 during the 1995 to 1997 OU-1 RI, the 2004 FS groundwater sampling, and 2012 to 2014 comprehensive groundwater monitoring event. Shallow alluvial wells S-61 and MW-102 were abandoned after they were sampled in 2014. Shallow alluvial well S-1 and intermediate alluvial well I-2 were destroyed by grading work performed by AAA Trailer. An evaluation of existing potentiometric data suggests the proposed MW-400 series location is downgradient of well D-6 and Area 2. Potentiometric and water quality data for bedrock are not currently available at this location. Alluvial and bedrock wells at this location will help evaluate the near-site response to influences of the Missouri River and Bridgeton Landfill. Installation of the MW-400 series remains subject to access agreements with AAA Trailer.

MW-401-AS, MW-401-AI, MW-401-AD, MW-401-SS, MW-401-SD Series – This series includes five wells: one shallow alluvial (MW-401-AS), one intermediate alluvial well (MW-401-AI), one deep alluvial well (MW-401-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-401-SS), and one Salem Formation well (MW-401-SD). The MW-401 series is proposed to be installed in close proximity to alluvial wells S-8, I-62, and D-83, which will likely be abandoned during OU-1 remedy implementation. Combined total Radium-226 and Radium-228 impacts were documented above the USEPA MCL in all samples collected from well D-83 during the 2012 to 2014 comprehensive groundwater monitoring event. No bedrock wells have been installed at this location. An evaluation of existing potentiometric data suggests the proposed location of the MW-401 series is downgradient of Area 2 in the alluvium. Potentiometric and water quality data for bedrock are not currently available at this location. Alluvial and bedrock wells at this location will help evaluate the near-site response to influences of the Missouri River and Bridgeton Landfill. Installation of the MW-401 series remains subject to access agreements with AAA Trailer.

MW-402-AS, MW-402-AI, MW-402-AD, MW-402-SS, MW-402-SD – This series includes five wells: one shallow alluvial well (MW-402-AS), one intermediate alluvial well (MW-402-AI), one deep alluvial well (MW-402-AD), one Upper Salem/St. Louis Formation (if encountered) well (MW-402-SS), and one Salem Formation well (MW-402-SD). The MW-402 series is proposed to be installed in close proximity to alluvial wells D-13 and I-66, which will likely be abandoned during OU-1 remedy implementation. Combined total Radium-226 and Radium-228 impacts were documented above the USEPA MCL in some samples collected from well D-13 during the 2012 to 2014 comprehensive groundwater monitoring event. No bedrock wells have been installed at this location. An evaluation of existing potentiometric data suggests that the proposed MW-402 series location is downgradient of Area 2 in the alluvium. Potentiometric data for bedrock is not available at this location. Alluvial and bedrock wells at this location will help evaluate the near-site response to influences of the Missouri River and Bridgeton Landfill.

MW-403-AS, MW-403-AI, MW-403-AD – This series includes three wells: one shallow alluvial well (MW-403-AS), one intermediate alluvial well (MW-403-AI), and one deep alluvial well (MW-403-AD). The MW-403 series is proposed to be installed in close proximity to intermediate alluvial well I-65, which may be abandoned during OU-1 remedy implementation. This well series is proposed to assess possible landfill leachate effects and COPC migration in groundwater.

5.3.4 PROPOSED OFF-SITE MONITORING WELL LOCATIONS AND RATIONALE

There are currently no off-site monitoring wells beyond 350 feet of the property boundary. In order to characterize off-site groundwater quality, new off-site well locations are proposed towards the west and north, within the range of potential down-gradient flow based on localized and regional flow regimes. Five off-site monitoring locations are proposed approximately 1,300 to 1,800 feet from the site boundary and approximately 1,900 to 2,300 feet apart as part of the OU-3 RI activities as shown on Figure 5-3, including 21 total wells: MW-500 (5 wells), MW-501 (5 wells), MW-502 (5 wells), MW-503 (3 wells), and MW-504 (3 wells). Proposed off-site well locations were also selected based on the ability to physically access the areas with drilling equipment, and the likely success in securing access agreements with the current property owner(s). Off-site monitoring well locations remain subject to securing access agreements with individual property owners. In the event access issues prevent installation in a proposed location, Respondents will either propose an alternate location or seek assistance from USEPA in securing access at the subject property. In addition to defining downgradient extent of impacts, off-site monitoring wells are proposed to evaluate off-site: (a) aquifer properties; (b) localized hydraulic gradients and flow directions within and between the alluvial aquifer and bedrock aquifer system; (c) the occurrence and extent of groundwater impacts; (d) groundwater geochemistry; (e) effects of the Bridgeton Landfill-related infrastructure on groundwater; (f) temporal variability in groundwater levels and flow direction; (g) and effects of nearby surface water features and storm events. Specific rationale behind the location and selected screen intervals is presented in Table 5-2.

Proposed monitoring well series MW-500, MW-501, and MW-502 will be comprised of five wells at each location, including shallow alluvial, intermediate alluvial, deep alluvial, Upper Salem/St. Louis Formation (if encountered), and Salem Formation wells. Proposed monitoring well series MW-503 and MW-504 will be comprised of three alluvial wells, including shallow alluvial, intermediate alluvial, and deep alluvial. An evaluation of existing potentiometric data and groundwater velocities suggests the proposed locations are appropriate to evaluate the nature and extent of COPC impacts. Alluvial and bedrock wells at these locations will help to evaluate the extent of off-site impacts and response to influence of the Missouri River in addition to the data gaps outlined above.

5.3.5 PROPOSED BACKGROUND MONITORING WELL LOCATIONS AND RATIONALE

An understanding of background groundwater conditions is a critical and necessary component of the OU-3 groundwater study. The USGS attempted to establish background groundwater quality using available site data, but concluded that the data set of 17 alluvial radionuclide samples from 14 wells and 11 bedrock radionuclide samples from 6 wells was not sufficient (USGS 2015). As previously discussed, radionuclide contribution from alluvium and bedrock underlying the site may be indiscernible from potential impacts originating from the historical landfill operations. Regional potentiometric data for both the alluvium and the bedrock at the site suggest a down-valley groundwater flow direction, supporting the determination that newly-installed background wells should be situated southwest of the site.

Establishing background groundwater quality requires the collection of "near-site" data that are representative of aquifer background conditions. Locations of wells used by the USGS along with regional groundwater flow in the alluvial and bedrock aquifers were evaluated to determine additional background monitoring well locations, which will supplement the existing dataset. Five locations are proposed for new background monitoring wells as shown on Figure 5-4. The rationale behind the proposed background well locations and depth of screened intervals is shown on Table 5-2. Information collected from the proposed background monitoring wells will be used to evaluate: (a) aquifer properties; (b) regional and localized hydraulic gradients and flow directions within and between the alluvial aquifer and bedrock aquifer system; (c) background groundwater quality of aquifers located at and near the site; (d) the occurrence and extent of groundwater impacts; (e) groundwater geochemistry; (f) temporal variability in groundwater levels and flow direction; and (g) effects of nearby surface water features and storm events. A statistical evaluation will be completed on the current and new datasets after the first year of monitoring to evaluate whether the number of background samples and/or background well locations is sufficient to adequately characterize background water quality.

The proposed background monitoring well series MW-600 and MW-601, will be located southwest of the site and will each include three alluvial wells: shallow alluvial, intermediate alluvial, and deep alluvial. An evaluation of existing potentiometric data suggests these locations are upgradient of the site. Alluvial wells at these locations will help to establish background conditions and evaluate regional groundwater flow directions.

The proposed background monitoring well series MW-602 will be located southwest of the site and includes five wells: shallow alluvial, intermediate alluvial, deep alluvial (if encountered), Upper Salem/St. Louis Formation (if encountered), and Salem Formation. An evaluation of existing potentiometric data suggests this location is free of landfill-related impacts. Alluvial and bedrock wells at these locations will help to establish background conditions and evaluate regional groundwater flow directions.

The proposed background monitoring well series MW-603 and MW-604 will be located east and southeast of the site and will include two bedrock wells at each location: Upper Salem/St. Louis Formation and Salem Formation. An evaluation of existing potentiometric data suggests these locations are upgradient of the site. Bedrock wells at these locations will help establish background conditions and evaluate regional groundwater flow directions.

5.3.6 PROPOSED MONITORING WELL NETWORK

The existing on-site monitoring wells were evaluated and a subset of 86 wells were identified for inclusion in the proposed OU-3 monitoring well network, in addition to the 64 proposed new wells noted above in Section 5.3.3, Section 5.3.4, and Section 5.3.5, as shown on Figure 5-5. A description of the proposed monitoring well network is included as Table 5-3. The network will monitor site conditions (including, but not limited to, groundwater COPC analytical results, geochemical parameters, natural attenuation processes, and leachate/RIM impacts) under a routine frequency discussed in Section 5.4.15 until the investigation is complete and, as warranted, until a remedial action is selected and implemented at the site.

The proposed network is preliminary and subject to access agreements. It is understood that additional monitoring wells may be warranted at a future date if the proposed monitoring network does not adequately address the data gaps listed in the SOW. It is also possible that several existing monitoring wells can be removed from the monitoring network in the future. Thus, the monitoring network will be modified as site characterization activities commence and continue over time. The proposed groundwater monitoring network was created in coordination with USEPA and is comprised of 150 total wells, including 86 existing wells and 64 proposed new wells. Additional wells may be added if OU-1 activities result in the need for well replacement. However, the proposed well list was created in coordination with OU-1 and reflects wells that are currently expected to remain in place following OU-1 remedial activities.

5.3.7 PROPOSED STAFF GAUGES

A total of nine staff gauges will be installed to evaluate the temporal and spatial variability in groundwater levels and flow direction in response to potential influences of the Missouri River, impounded water, and other nearby surface water bodies. Proposed staff gauges are shown on Figure 5-6. Staff gauges will be installed and monitored continuously. Missouri River stage data will be downloaded from the USGS. The proposed network is preliminary and subject to securing access agreements with off-site property owners.

5.4 FIELD INVESTIGATION

Field investigation activities have been designed to determine, in part, if site COPCs have migrated in groundwater beyond the site boundaries at concentrations exceeding risk-based screening levels and/or USEPA MCLs or, if naturally-occurring background concentrations exceed MCLs, Alternate Concentration Levels (ACLs) (if approved at the discretion of USEPA). Appropriate field data will also be collected and analyzed to assist in the evaluation of viable groundwater remedies. An MDNR certified well installation contractor will oversee work in accordance with Missouri Code of State Regulations as outlined in the FSP (MDNR 2013).

Field investigation activities will generally include monitoring well installation, downhole geophysics, staff gauge installation, groundwater sampling, aquifer matrix sampling, leachate sampling, and on-site indoor air sampling. The following subsections include a detailed discussion on:

- Preparatory activities
- Site reconnaissance
- Monitoring well inventory, repair, replacement, and abandonment
- Borehole advancement
- Continuous coring and field logging
- Alluvium and bedrock aquifer matrix sampling
- Borehole geophysical logging
- Packer testing
- Monitoring well installation
- Monitoring well (re)development (new and existing)
- Slug testing
- Direct push – hydraulic profiling tool pilot test
- Aquifer Pumping Test
- Water-level measurements
- Groundwater monitoring
- Staff gauge installation
- Leachate collection system sampling
- On-site vapor intrusion assessment
- Ecological survey
- Surveying
- IDW
- Additional site characterization

Additional information related to well construction diagrams, boring logs, field sampling sheets, field books, scanning, etc., will be retained and, as appropriate, included with other data to provide a holistic summary of pertinent field activities. Details on the field investigation activities are included in the FSP (Volume 2). They are summarized below.

5.4.1 PREPARATORY ACTIVITIES

A field schedule detailing proposed investigative work such as new monitoring well installations or routine groundwater monitoring will be provided to USEPA and MDNR not less than 7 days in advance of those activities occurring. Soil boring permits, right-of-way permits, and access agreements will be obtained from property owners. Well inspections will be requested by MDNR as-needed during monitoring well construction. The drilling subcontractor will create a Missouri One Call System ticket at least 72 working hours before the start of field activities. This will notify public utilities of the excavation activities in the area. Additionally, a private utility locator will be used to check for other subsurface anomalies at the drilling locations.

5.4.2 SITE RECONNAISSANCE

Reconnaissance activities will be conducted to document the current conditions of the site and proposed drilling locations. Field personnel and subcontractors will inspect and photo-document the site and proposed monitoring well locations to identify any potential issues with access or utilities. A handheld global positioning system (GPS) will be used to survey proposed locations. Additional detail on site reconnaissance is provided Section 3.1 of the FSP.

5.4.3 WELL INVENTORY, REPAIR, REPLACEMENT, AND ABANDONMENT

A full monitoring well inventory will be conducted during site characterization to review the existing monitoring well network and re-survey existing well locations. The inventory will document each well's current condition and will include surveying and recording construction details on the existing and new wells. This will be compared to the existing well construction summary table (Table 3-2) to evaluate monitoring well integrity. Nearby residential wells, industrial wells, municipal wells, and water intake structures within 2 miles of the site will also be located as necessary during the well inventory to identify any potential receptors. Locations of wells not included in the OU-3 monitoring network will be surveyed using a handheld GPS, recorded on field forms, and photo-documented.

Wells with turbidity over 5 NTU or well screen occlusion greater than 10 percent of the screened interval will be considered for redevelopment as described in the QAPP. Wells that are damaged or missing parts will be repaired. Wells with significant damage which precludes gauging or sampling will either be replaced (with the original well abandoned), or the location abandoned entirely, as appropriate. The Missouri Well Code will be used to assist with well integrity evaluations, well installation requirements, and well abandonment requirements. Recommendations for well redevelopment, repair, replacement, or abandonment will be provided in the Well Inventory Summary Report. Following the USEPA review and approval of this report, wells deemed non-beneficial, damaged or inoperative will be repaired, replaced, and/or abandoned per applicable MDNR requirements. The well inventory will also identify wells at the site that may potentially be removed due to remedy implementation for OU-1, as well as other potential future site-related work that could impact the overall existing groundwater monitoring well network. Additional detail on the monitoring well inventory, repair, replacement, and abandonment is provided in Section 3.2 of the FSP.

5.4.4 BOREHOLE ADVANCEMENT

Boreholes will be drilled using a sonic drilling rig(s). Three other drilling techniques were considered, including direct-push technology (DPT), hollow stem auger drilling, and mud rotary drilling. Interviews with local contractors suggests DPT drilling may not be technically feasible for the OU-3 RI drilling program due to limitations on the depth of the rig, the diameter of the borehole, and inability to drill within gravel and bedrock. The hollow stem auger drilling method is potentially feasible but would require a large 14-inch diameter auger to accommodate the proposed well design, and flowing sands may be encountered. Lastly, mud rotary drilling was evaluated as technically feasible for achieving the desired depths and borehole diameter, but was eliminated from consideration due to the large quantity of IDW generated in comparison to the other methods and the potential interference with the proposed downhole geophysical methods. Additionally, there are concerns of introducing radionuclides into boreholes via naturally-occurring levels present in some drilling muds. Sonic drilling can achieve the desired well construction dimensions, reach total depths within bedrock, provide undisturbed core samples for lithologic logging, and does not generate excessive IDW. Sonic drilling can limit the downhole geophysics which can be run within the alluvium due to the presence of the casing. However, other testing methods can be used to obtain similar aquifer property information without an impact to the OU-3 RI goals. Additional detail on borehole advancement is provided in Section 3.5.2 of the FSP.

The deepest borehole for each proposed well series will be advanced to total depth first at each proposed well series location. The deepest borehole at each location will be continuous cored, logged by a field geologist, field screened, sampled, and logged using geophysical techniques. Borehole advancement will be performed by an MDNR certified well installation contractor and drilling company. Geophysical techniques are discussed in Section 5.4.7.

5.4.5 CONTINUOUS CORING AND FIELD LOGGING

The soil and bedrock horizons in each logged boring will be continuous cored during advancement. Recovered cores will be inspected by a field geologist. Alluvial descriptions will include the Unified Soil Classification System (USCS), color, grain size, stiffness or density, moisture content, sorting, angularity, mineralogy, and plasticity as applicable. Alluvial cores will be labeled and archived onsite for future reference as needed.

Bedrock descriptions will include weathering, bedding, color, grain/crystal size, strength, lithologic description, geologic formation, and geologic formation. Bedrock borehole logs will also include core recovery, RQD, fractures per foot, weathering index, strength index, and discontinuity data. Cores will be field screened using two scintillators, the microR gamma survey meter and dual phosphor alpha/beta detector, and a 10.6 eV photoionization detector (PID). Additional detail on continuous coring and field logging is provided in Sections 3.5.2 of the FSP.

5.4.6 ALLUVIUM AND BEDROCK AQUIFER MATRIX SAMPLING

Alluvium (unconsolidated) and bedrock samples will be collected from the water-bearing zones in the deepest borehole at each drilling location. A total of ten aquifer matrix samples will be collected per borehole at approximately 10-foot intervals in the saturated zone. Samples will be collected in accordance with procedures in the FSP, labeled, properly preserved, and submitted for laboratory analysis to MCLInc The purpose of collecting these solid samples is to analyze the matrix for the parameters necessary to evaluate fate and transport modeling. The sample results will be compared to similar work conducted previously in OU-1 for RIM and non-RIM sample matrices from the solid waste mass. They will be evaluated specifically to:

- Obtain site-specific data for use in the fate and transport evaluations requested by USEPA.
- Identify and distinguish the chemical composition of materials containing radionuclides and the speciation of the radionuclides in these materials.
- Provide data to parameterize the geochemical fate and transport model.

Additional information regarding the field sampling procedures for alluvial and bedrock aquifer matrix is described in Section 3.6 of the FSP. The following is a list of the analyses provided for the alluvium/bedrock matrix samples along with a brief description of the analytical objectives:

- Uranium, thorium, and radium isotopes. The results of these analyses can be used to determine the magnitude of the radiological isotopes present in the background and downgradient location samples.
- Major cations and anions (including calcium, magnesium, manganese, sodium, potassium, barium, carbonate, sulfate, fluoride and phosphate). The results of these analyses (conducted on background and downgradient samples) can be used to quantify the presence of cations and anions, assist in determining solid phase mineralogy, and allow for the comparison with radiological isotopes.
- pH: Used as baseline condition data for comparison with subsequent leaching tests.
- Fe(II) and Fe(III): Examination of contents of ferrous (Fe(II)) and ferric (Fe(III)) iron to total iron in a sample can be used as an indicator of the oxidizing-reducing conditions to which the solid phase materials have been exposed or under which were formed. The presence of Fe(III), as measured by amorphous-iron results, is an indicator presence of ferric iron oxides, which are strong sorbents/coprecipitates for radiological constituents. Also, microbial degradation of organic matter in a landfill can result in reduction of ferric iron to ferrous iron and

dissolution of ferric iron minerals and their sorbed radionuclides. Ferric iron reduces before sulfate; therefore, if abundant ferric iron phases are present, it would indicate that sulfate minerals and phases may be more stable.

- Sulfides: The presence of sulfides also can be used as indicator of the oxidizing-reducing conditions to which the solid phase materials have been exposed or under which they were formed. The presence of sulfide is a possible indicator of the stability of sulfate compounds (e.g., if not present, this indicates limited sulfate reduction and that sulfate minerals phases may be more stable; conversely, if present, sulfate reduction and therefore dissolution of solid sulfate salts, such as radium-bearing barium sulfate (barite), is possible).
- Total organic carbon (TOC): TOC results can be used to assess the levels of humic and fulvic acids that affect partitioning and mobility of radionuclides (as well as the longevity of potentially-reducing conditions within the landfill).
- X-Ray Diffraction (XRD): XRD results are used to quantify the abundance of the major minerals in a sample (e.g., barite and/or calcite in RIM) that potentially affect leachate composition and radionuclide speciation by their dissolution. The XRD results also provide a semi-quantitative description of the primary crystalline minerals present in a sample and corroborate the mineralogy based on comparisons with the cation and anion analyses. The limitation is the technique cannot detect minerals present in trace amounts (meaning about 3-5% or less) and has limited capability in detecting amorphous substances. Mineralogical analysis by XRD of aquifer materials will be completed to provide information on naturally occurring radionuclide concentrations and isotopic ratios and their phase associations in aquifer materials and support evaluation of its potential migration from the site.
- Scanning Electron Microscope with Energy Dispersive X-ray Spectrometry (SEM/EDS): The SEM/EDS analyses provide a semi-quantitative method for elemental mapping and determining the composition of selected grains in a sample (e.g., barite, gypsum, calcite, oxides, or even amorphous non-crystalline materials). The SEM/EDS results can be used to correlate and corroborate the mineralogy based on comparisons with XRD and cation and anion analyses or provide information on the possible nature of amorphous material, and potentially pinpoint the sources of the more abundant trace elements. Mineralogical analysis by SEM/EDS of aquifer materials will be completed to provide information on naturally occurring radionuclide concentrations and isotopic ratios and their phase associations in aquifer materials and support evaluation of its potential migration from the site.
- Sequential Extraction Analysis: The sequential extraction analysis consists of sample digestion in a series of sequential extraction steps, each using a different solvent, designed to dissolve specific solid or mineral phases (as described in the QAPP). Following each extraction process, anion/cation indicator analyses (e.g., barium, calcium, manganese, and sulfur) and radionuclide analyses (uranium, thorium, and radium) are conducted so that results obtained can be used to access the presence of radionuclides in the various phases targeted by the specific extraction procedure, and the results are compared to mineralogical (XRD) and SEM/EDS analysis to determine

solid-phase association of radionuclides. The sequential extraction analysis of aquifer matrix samples will be collected to understand the relation between water quality and geochemistry to aquifer matrix (mineralogy, chemical composition, organic carbon, and phase association of radionuclides and their ratios).

- Cation-Exchange-Capacity (CEC): CEC results can be used to provide estimates of the potential capacity of the alluvium/bedrock to adsorb/exchange charged cations and charged radionuclides from solution to the solid-phase surfaces.

Concentrations and the presence or absence of the various analytes will be compared to adequately evaluate potential site conditions (e.g., $Fe2+ > 1$ mg/L as an indicator of anaerobic degradation). Data evaluation is discussed in Section 6.2.

5.4.7 BOREHOLE GEOPHYSICAL LOGGING

Downhole geophysical logging will be conducted after the borehole is advanced to total depth in the cased portion of the alluvium and the open borehole in bedrock to evaluate well placement and hydrogeologic properties. Geophysical tools include some or all of the following 1) an acoustic televiewer, 2) spontaneous potential (SP)/resistivity, 3) induction/conductivity, 4) heat pulse flow meter, 5) fluid temperature and resistivity, 6) gamma-gamma-density, 7) natural gamma, 8) spectral gamma and 9) caliper as applicable for open and cased holes. Additional detail on each of these methods is provided in Section 3.7.2 of the FSP.

5.4.8 PACKER TESTING

Packer testing will be conducted on all deep bedrock boreholes to evaluate aquifer properties of the bedrock and identify higher transmissivity zones for screen placement. Constant head injection packer tests will be conducted in all open bedrock holes on select intervals identified during continuous coring based on based on fracture frequency and porosity, and intervals identified during borehole geophysical logging. Double (straddle) and/or single downhole packer assemblies will be lowered to the desired depth using the sonic drilling rig based on the presence or absence of fractures and the porosity. Straddle packer tests will generally isolate 5 to 10 feet of borehole length using pneumatic straddle packers. Downhole packer testing equipment will be connected via the drilling rods to a surface assembly consisting of a variable rate water pump, a flow meter manifold, a pressure gauge, valving, and hoses. Step tests will be conducted where possible. Additional detail on packer testing methods is provided in Section 3.8.2 of the FSP.

5.4.9 MONITORING WELL INSTALLATION

Results of continuous coring, soil and aquifer matrix sampling, geophysical testing, and packer testing will be used to select screened intervals of the 19 new monitoring well series as appropriate (64 new wells in total), which will generally target more transmissive and/or impacted zones. Screened intervals will be selected based on the most transmissive zones identified during logging or geophysical analysis, or at the preliminary target depth by zone. Preliminary target depths identified in Table 5-2 are based on geologic cross sections prepared during preparation of the RI/FS Work Plan. Collection of select field parameters in conjunction with well installation will be used to refine those proposed construction details and provide the best chance to achieve specific assessment objectives for each well location. Example monitoring well construction is shown on Figures 5-7a and 5-7b.

Alluvial monitoring wells will be constructed as nested wells within a single borehole approximately 12 inches in diameter. Bedrock monitoring wells will be double-cased to prevent downward migration of alluvial impacts. Deep alluvial wells and bedrock wells will be constructed using a 20-foot Schedule (Sch.) 80 polyvinyl chloride (PVC) 0.008-inch factory-slotted screen and Sch. 80 PVC blank riser. Shallow and intermediate alluvial wells (<100 ft deep) will be constructed using a 10 or 15-foot Sch. 40 PVC 0.008-inch factory-slotted screen and Sch. 40 PVC blank riser. A 40/60 silica sand pack or similar will be placed around the well screen. A 0.008-inch screen and 40/60 silica sand pack are proposed to reduce the chance for elevated quantities of suspended solids entering the well, which could affect sample integrity. A 10 to 20-foot screened interval will allow for sampling at discrete intervals to be selected based on results of continuous coring and aquifer matrix sampling. This is appropriate given the 25-foot thickness of the shallow alluvium, 30-foot thickness of the intermediate alluvium, and 55-foot thickness of the deep alluvium and lack of confining or isolating units within the alluvium. Surface completions for the wells will be selected based on individual proposed well location requirements. Given the nature of impacts being evaluated, downhole materials such as sand, grout, and bentonite will be sampled and submitted to the laboratory for analysis prior to placement into the borehole as discussed in the FSP. This will minimize the possibility of naturally occurring radioactive material being introduced into a monitoring point and creating a false-positive during monitoring activities. Additional information on monitoring well installation is provided in Section 3.9 of the FSP.

5.4.10 MONITORING WELL DEVELOPMENT

The objectives of the well development are to:

- Allow groundwater to enter the well screen freely, thus yielding a representative groundwater sample and water level measurements.
- Remove any water that may have been introduced or disturbed during drilling and well installation.

- Remove very fine-grained sediment in the filter pack to minimize groundwater sample turbidity and silting of the well.
- Maximize the efficiency of the filter pack.

The monitoring wells will be developed, no sooner than 48 hours after grouting is completed, by mechanically surging the well, followed by pumping. Surging will consist of forcing water into and out of the formation using a surge block. The surging action will be relatively gentle to avoid slumping formation material into the screen. Surging will be concentrated over 5-foot intervals, starting at the top of the screen, to avoid sand locking the surge block. In addition to the newly installed monitoring wells, existing wells included as part of the groundwater quality monitoring network will also be redeveloped in a similar manner.

Immediately following surging activities, groundwater and any sediment in the bottom of the well will be evacuated using a bailer or pump. The volume evacuated from each well, and physical characteristics of the purge water (color, relative turbidity, sediments, etc.) will be recorded during regular intervals during development activities. If natural recharge rates are adequate, development activities will continue until the extracted water is visibly free of sediment and/or until parameters (pH, temperature, and turbidity) are stable as noted in the field procedures included in Section 3.10 of the FSP. Water levels and total depths will be measured before and after well development and documented on the monitoring well development form. IDW is discussed in Section 5.4.20.

5.4.11 SLUG TESTING

Slug testing will be conducted on new and existing monitoring wells not previously tested. Slug testing will be performed after the monitoring wells are developed to determine the hydraulic conductivity of the formation materials near each well. Wells proposed for slug testing are shown on Table 5-4. Testing will be conducted using pneumatic slug techniques where possible and traditional slug testing if the screened interval intersects the water table. Two rising head tests will be performed on all monitoring wells not previously tested. Slug tests will be evaluated to calculate hydraulic conductivity using AQTESOLV software. Additional information on slug testing methods is provided in Section 3.12 of the FSP.

5.4.12 DIRECT PUSH - HYDRAULIC PROFILING PILOT TEST

DPT rigs can often be used in conjunction with advanced characterization tools such as a membrane interface probe (MIP) to provide a continuous vertical concentration profile. However, drilling through the gravels present within the alluvium to a total depth can seriously damage the MIP detector and is not recommended for this site. DPT drilling may be a viable method in conjunction with HPT, which could be deployed to provide another source of information regarding formation permeability. The HPT measures the injection pressure and flow rate of water into soil during advancement on a DPT rig and provides a continuous vertical estimate of hydraulic conductivity. Due to uncertainty in the capability of advancing DPT to the base of the alluvial gravels, a pilot test will be conducted near well D-6 to evaluate its efficacy. The pilot test will consist of a transect of borings near well D-6 within the buffer zone as shown on Figure 5-8. If the DPT equipped with HPT is successful, it will be considered for future site characterization as needed.

5.4.13 AQUIFER PUMPING TEST

In order to estimate storativity of the water-bearing zones, multi-well aquifer pumping tests will be conducted during the latter stages of the OU-3 RI activities. The aquifer pumping test will be conducted at one of the proposed OU-3 RI well locations which has all five vertical intervals represented. The well location will be selected based on the representativeness of the geology and hydrogeology relative to the groundwater model, and at a location that is unimpacted to avoid generation of impacted purge water. Therefore, the proposed aquifer pumping test will occur after the initial data quality and water level information are collected at the new monitoring wells. The proposed aquifer pumping test procedures will include a constant head test and step drawdown test for each water-bearing zone. Additional details will be submitted as part of the Groundwater Modeling Work Plan.

5.4.14 GROUNDWATER MONITORING

Quarterly groundwater monitoring is proposed for a minimum of eight quarters, and as warranted, will likely continue at a reduced frequency (e.g., annual) from selected wells. Thus, on-site monitoring will continue until the investigation is complete, or until a remedial action is selected and implemented at the site. The purpose of monitoring is to determine radionuclide and other constituent concentrations in aquifers located at and near the site. The groundwater monitoring program will be sufficiently robust to measure for radiological and non-radiological constituents that have historically been detected at the site, geochemical indicators, major ion suite, landfill leachate indicators, and stable isotopes as specified in the SOW. Additional information on the individual COPCs is included in the QAPP; they are summarized below in Section 5.4.14.3.

5.4.14.1 WATER-LEVEL MEASUREMENTS

A depth to static groundwater measurement will be collected at each groundwater monitoring well on a monthly basis, as well as prior to purging groundwater during sampling events. The monthly well gauging will be completed for a period of 24 consecutive months. An electronic water level probe, accurate to the nearest +/- 0.01 ft, will be used to measure depth to water in each well. Depth to dedicated pump and total well depth will be measured (if the pump can be removed) biannually due to the potential to increase turbidity in the monitoring well prior to sampling.

After completing the initial round of water level measurements and groundwater sampling, absolute pressure transducers/data loggers (DLs) will be placed in 70 select wells that provide sufficient horizontal and vertical spatial coverage. Two barometric barologgers will be placed onsite. Table 5-5 identifies the proposed wells where DLs are proposed to be used. The DLs measure groundwater levels and temperature. These DLs and barometric barologgers will remain within the wells, while the quarterly groundwater monitoring and monthly water level gauging occur. The DLs will be programmed to collect synchronized readings every hour. During each quarterly groundwater monitoring event, the data will be downloaded from the transducers and saved within the project files. The need for additional or relocation of DLs will be considered after one year of monitoring and temporal analysis has been completed. Additional information on water level measurements is provided in Section 3.16 of the FSP.

5.4.14.2 PURGING

Purging of monitoring wells prior to sampling is necessary to remove stagnant or thermally stratified groundwater from the well casing and sand pack that may not be representative of groundwater within the aquifer. If possible, purging will be performed at a flow rate at or below the well's recovery rate to minimize inflow of groundwater from above the well screen. Purged water will be considered IDW, containerized, and stored on-site within a temporary tank pending waste characterization analytical results as described in Section 6.0 of the FSP. All wells will be purged prior to sampling utilizing a dedicated bladder pump. Bladder pumps are currently installed in all of the active OU-2 monitoring wells. New bladder pumps will be installed in all monitoring wells identified for the OU-3 network. Additional information on bladder pump installation is provided in Section 3.14.1 of the FSP.

Bladder pump intakes will be placed at the most transmissive zone or impacted zone identified during well installation. If there are concerns with the well pumping dry, pumps will be placed 2 to 3 ft from the bottom of the well to permit reasonable draw down while preventing cascading conditions. For most of the monitored groundwater zones, the pump will be set within the well's screened interval. The exception is within wells with very deep screened intervals (e.g., the Keokuk Zone wells) where drop tubes are set within the screened interval. Pumping rates will be regulated or controlled to minimize turbulent flow, prevent damage to the monitoring well components, and minimize the introduction of sediment into the well.

Throughout the purging process, groundwater will be monitored for the following field parameters: pH, specific conductance, temperature, turbidity, DO and ORP. A flow-through cell will be used for field parameter measurements to ensure that the water quality meter's sensors are in contact with flowing water. Purging will continue until field parameter equilibrium is achieved. Equilibrium is achieved when parameters exhibit variation equal to or less than the

USEPA-prescribed tolerances for low-flow sampling, with special attention paid to turbidity (USEPA 1996). Additional information on well purging is provided in Section 3.14.2 of the FSP.

5.4.14.3 MONITORING WELL SAMPLING

A groundwater monitoring well may be sampled as soon as the field parameters have stabilized, or if purged to dry, as soon as it has recovered sufficiently, but typically no more than 24 hours after purging. The same methods used for well purging will be utilized for sample collection. Sample bottles will be filled directly from the pump's discharge tube to minimize agitation and aeration. The final set of parameter values will be used for the sampling. If the well is sampled later, a new set of parameter values will be measured and recorded concurrently with sampling.

Individual sample containers will be filled in order of decreasing sensitivity to potential volatilization of the analytical constituents. Groundwater samples will be transferred directly into the appropriate sample containers with preservative, if required, chilled if appropriate, and processed for shipment to the laboratory.

Both filtered and unfiltered samples will be collected for metals and isotope analyses due to the potential for these analytes to sorb or exchange with suspended colloids. An in-line disposable 0.45 micron filter will be used to remove particles that have been entrained in the water sample. A clean, unused filter will be used for each filtered sample collected. Groundwater samples will be transferred from the filter directly into the appropriate sample containers with a preservative and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the filter to the sample container. Depending on the viability of the proposed filtration process, this methodology may be altered as necessary in the field. Proposed alterations will be discussed with the OU-3 Respondents and USEPA prior to implementation. Additional information on monitoring well sampling is provided in Section 3.14.3 of the FSP.

Groundwater samples will be submitted to laboratories for analysis as outlined in the QAPP and Section 2.0 of the FSP. Previous monitoring events have generally sampled the following COPCs: metals, general parameters, radionuclides, VOCs, SVOCs, PCBs, pesticides, and TPH. Although only detected in select locations if at all, these will all be collected and analyzed during the first site-wide OU-3 monitoring event to evaluate the nature and extent of impacts. Groundwater samples will also be field screened for radon. This list will be reevaluated and shortened as appropriate (based on detected parameters) after the first monitoring event. If following collection of groundwater data, stable isotopes are required to answer a specific question to characterize the aquifer, groundwater samples will be collected from select locations to support that study. This information will be included in a work plan specific to that study.

5.4.15 STAFF GAUGE INSTALLATION

Staff gauges will be located in onsite and offsite surface water bodies near existing and newly installed shallow alluvial monitoring wells. The staff gauges will be installed in the locations shown on Figure 5-6. Transducers will be installed in all staff gauges and synced to record with transducers deployed in monitoring wells so that interconnection of the surface water and groundwater can be evaluated. Rain events (duration, rate, and totals) will also be noted in the logbook for the project. Transducers installed in staff gauges will be programmed to record elevations at hourly intervals and downloaded monthly during manual calibration. Additional information on staff gauge construction is provided in Section 3.17 of the FSP.

5.4.16 LEACHATE COLLECTION SYSTEM SAMPLING

The current leachate collection system is comprised of leachate collection sumps (LCS) within the North Quarry (LCS-5A, LCS-5B, and LCS-6A) and South Quarry (LCS-1D, LCS-2D, LCS-3D, LCS-4B, LCS-4C) as documented in the March 2019 Operation, Maintenance and Monitoring Plan (CECI 2019). Each sump has been installed towards the base of the quarry floor, approximately 270 feet below ground surface, with screens that range in length from 60 to 150 ft. Dedicated pumps were installed in each LCS point. Due to the SSR, some of the South Quarry sump pumps are no longer operational.

As part of the first phase of site characterization, leachate samples will be collected from LCS points which are safe to access, and which produce fluid. If a pump is not operational, the LCS point will not be sampled unless it is still identified as a data gap after the first phase of site characterization and is not a health and safety concern. Based on the most recent leachate report from Bridgeton Landfill, LCS-3D, LCS-4B, LCS-4C, LCS-5B, and LCS-6A were viable for sampling. Leachate sampling will be conducted to identify geochemical, inorganic, and organic characteristics which may be compared to off-site groundwater data for evaluation of the effects of the Bridgeton Landfill on nearby groundwater. Leachate sampling will include the same analytical suite as noted above for groundwater.

At the time of the OU-3 RI field activities, information will be obtained on operational status of the leachate collection and treatment system, including LCS points with fluid available for sampling without access issues, construction, operational history, frequency of use, pumping rates from each LCS point, pump configuration, and influent and effluent concentrations. Pumping information will be used to populate the groundwater flow model and complete a water balance for the site.

5.4.17 ON-SITE VAPOR INTRUSION ASSESSMENT

COPCs historically detected in on-site groundwater include VOCs such as benzene and chlorobenzene. Radon gas may also be present due to the presence of radium isotopes in soil/groundwater and anthropogenic sources of radon gas deposited within OU-1. Methane has also been detected in landfill gas monitoring probes. Therefore, data will be collected to evaluate the risk resulting from potential vapor intrusion of subsurface volatile organic compounds, methane, and radon gas into occupied buildings. Indoor air sampling will be conducted during site characterization within the five enclosed, occupied on-site structures with part- to full-time worker occupancy (i.e., commercial / industrial worker scenario): 1) the Engineering Office, 2) Leachate Treatment Building, 3) Scale House, 4) Pump House, and 5) a structure associated with the asphalt plant as shown on Figure 5-9.

One indoor air sample will be collected per 2,000 square feet of applicable building space for methane and VOCs. Based on initial measurements, a total of seven indoor air samples are anticipated to be collected. However, the quantity of samples may be adjusted following completion of an initial inspection of each structure. Both short-term and long-term radon testing will be completed within each building. The short-term radon testing will be conducted with real-time measurements to provide timely information for on-site worker safety. Due to the ongoing facility operations within on-site buildings, worst-case radon sampling is not achievable using real-time measurements. Therefore, long-term radon testing will be performed to obtain realistic radon exposure concentrations. Procedures for indoor air testing are included in Section 3.18 of the FSP and will follow the latest USEPA vapor sampling guidance (USEPA 1992b; USEPA 1993; USEPA 2015b; USEPA 2015c). Commercial/industrial land use will be assumed for the onsite indoor air evaluation due to existing deed restrictions on the site.

In addition to the proposed on-site indoor air testing noted above, an assessment will be performed to determine the current and future potential for completion of vapor intrusion pathways in off-site occupied residential and commercial/industrial structures. A vapor intrusion pathway is considered complete when the following conditions are met:

- A subsurface source of vapor-forming chemicals is present underneath or near the buildings.
- Vapors form and have a route along which to migrate toward the building.
- The buildings are susceptible to soil gas entry, which means openings exist for the vapors to enter the building and driving forces exist to draw the vapors from the subsurface through the openings of the buildings.
- One or more vapor-forming chemicals, comprising the subsurface vapor sources, is present in the indoor environment.
- The buildings are occupied by one or more individuals when the vapor forming chemicals are present indoors.

Results from the initial groundwater sampling dataset proposed above will be used to evaluate the need for off-site vapor testing, which may include passive soil gas vapor sampling, installation of soil gas vapor wells, soil gas vapor sampling, sub-slab vapor sampling, indoor air quality sampling, and/or installation of mitigation systems. This vapor intrusion evaluation will include comparison of groundwater data to target groundwater concentrations estimated by the latest version of the USEPA vapor intrusion screening level (VISL) calculator (USEPA 2019b) or using Henry's Law to estimate vapor phase concentrations (if no VISL target level is available). Results will be evaluated based on the potential future use of each property, which may include residential land use. The results of the vapor intrusion evaluation and recommendations will be submitted in the Annual Hydrogeologic Investigation and Groundwater Characterization Report in accordance with the schedule included in Section 10.0. Also as part of this task, information on potentially affected properties identified will be compiled, including land ownership, site use, zoning, and deed restrictions (if present).

5.4.18 ECOLOGICAL SURVEY

An ecological survey will occur in two steps and will include the baseline characterization of existing ecological and biological conditions within and adjacent to the site. A desktop assessment will be conducted first to characterize current habitat types, overall quality, and regional/landscape position by evaluating the existing OU-1 and OU-2 data, and best publicly available information at the regional, local, and site-specific scale. The desktop assessment will identify the anticipated ecological communities and habitat types, and biota likely to occur within those habitats. Potential exposure of ecological receptors to groundwater that is potentially discharging to surface water bodies within and/or adjacent to the site will be the primary emphasis. As such, surface water bodies (e.g., streams, rivers, and ponds) and wetlands will be the primary focus of the desktop assessment. Biota identified in these areas that may come in contact with surface expressed groundwater (e.g., potentially complete exposure pathway) will be considered potential ecological receptors that may be considered in subsequent phases.

Following the desktop assessment, an ecological survey of the flora and fauna onsite and near site will be conducted by a biologist. The survey will evaluate the findings of the desktop assessment, by reviewing the existing vegetation communities, the nature, location, and extent of aquatic resources described above, and the identification of potential ecological receptors relative to potential exposure to groundwater and/or groundwater/surface water interface. Data collection will include photographs, field notes, and GPS coordinates delineating notable points or boundaries. If subsequent ecological risk assessment (ERA) phases are necessary, and data gaps continue to exist to prevent adequate analysis and risk characterization, additional site-specific information may be obtained through the design and implementation of potential targeted sampling events. (e.g. vegetation surveys, wildlife inventories, characterization of benthic macroinvertebrate assemblages, plant or animal tissue sampling, etc.). The pending BRA Work Plan discussed in Section 7.1 will provide additional information and specific details regarding the planned ecological surveys and sampling. Additional information on the ecological survey is provided Section 3.19 of the FSP.

5.4.19 SURVEYING AND MAPPING OF THE INVESTIGATION AREAS

A site-wide monitoring well survey will be performed after new wells are installed and repairs are completed on existing wells. The OU-3 Respondents will develop relevant maps of the area that include topographic information and physical features on and near the site. Aerial photographs will be used along with information gathered during previous investigations to identify physical features of the investigation area. Sample locations (wells, piezometers, sample points, etc.) will be surveyed by a State of Missouri licensed land surveyor and the geospatial information will be summarized and provided to the USEPA in specified/acceptable formats. The collection and management of geospatial data will be defined in a geospatial data QAPP in accordance with USEPA guidance (USEPA 2003).

5.4.20 INVESTIGATION DERIVED WASTE

In the process of collecting environmental samples, the sampling team will generate different types of potentially contaminated IDW that include the following:

- Used personal protective equipment (PPE)
- Disposable sampling equipment
- Decontamination fluids
- Soil cuttings from soil
- Purged groundwater and excess groundwater collected for sample container filling

The USEPA's National Contingency Plan (NCP) requires that management of IDW generated during sampling comply with all applicable or relevant and appropriate requirements (ARARs) to the extent practicable. The sampling plan will follow the *Office of Emergency and Remedial Response (OERR) Directive 9345.3-02* (USEPA 1991), which provides the guidance for the management of IDW. In addition, other legal and practical considerations that may affect the handling of IDW will be considered.

- Used PPE and disposable equipment will be double bagged and placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of which can still be reused will be rendered inoperable before disposal in the refuse dumpster. Any PPE generated within OU-1 Areas 1 and 2 will be managed per site protocols.

- Decontamination fluids that will be generated in the sampling event will consist of distilled water, residual contaminants, and water with non-phosphate detergent. The volume and concentration of the decontamination fluid will be containerized and either stored on-site within a temporary tank pending analytical data, or transferred to the on-site leachate water treatment system.
- Soil cuttings generated during the subsurface sampling will be characterized and disposed of in an appropriate manner.
- Purged groundwater will be containerized and either stored onsite within a temporary tank pending analytical data or transferred to the on-site leachate water treatment systems leachate

5.4.21 ADDITIONAL SITE CHARACTERIZATION

Additional site characterization will be performed, as necessary, as part of the OU-3 RI field activities once initial data collection is completed. In addition to the aquifer pump testing noted above, examples of potential additional activities include installation of additional monitoring wells to help delineate the current nature and extent or predict the future nature and extent of groundwater impacts, monitoring soil gas, subslab and/or indoor air concentrations, and collection of sediment pore water, sediment and/or surface water samples to evaluate potential exposure pathways. Recommendations for additional site characterization will be included with the Annual Hydrogeologic Investigation and Groundwater Characterization Report. Additional characterization will be outlined as addendums to this Work Plan to allow for a more integrated and iterative approach. A schedule is included in Section 10.0.

5.5 GROUNDWATER MODELING AND FATE AND TRANSPORT

Groundwater flow and fate and transport modeling will be conducted during the investigation after the collection of sufficient groundwater hydrologic and chemical data, which will allow the modeling objectives and requirements to be determined. To date there is not a complete understanding of site conditions beyond the site boundaries, making the specifics of a larger modeling program difficult to ascertain. Results of the field activities described above in Section 5.4 will be used to populate input parameters for a 3-D groundwater flow and fate and transport model, which will be constructed to assist with refinement and understanding of the CSM, used as a predictive tool to evaluate long-term human health and ecological risks, and to assist with remedy evaluation and selection (if necessary). The scope, type (numerical, analytic) and modeling code of fate and transport modeling will be defined following initial data collection activities. A preliminary discussion of currently anticipated modeling objectives, conceptual framework, potentially applicable software, and calibration goals is provided in Section 6.2.1, and will be amended within the forthcoming Groundwater Modeling Work Plan. A preliminary process flow diagram of the modeling approach is included as Figure 5-10.

Before a detailed modeling approach can be scoped, additional spatial and temporal geologic, hydrogeologic, geochemical, and analytical data will be collected during site characterization to support a representative groundwater flow model and fate and transport evaluation. Geologic data required to sufficiently parameterize a flow model and support fate and transport evaluations include the 3-D distribution of hydrostratigraphic units, as well as material properties such as grain size, total organic carbon, cation exchange capacity, bulk density, and mineralogy. Hydrogeologic data include aquifer properties, groundwater elevation data sets, surface water elevation data sets, and hydraulic gradient data sets. Geochemical data important for fate and transport evaluations include pH, DO, ORP, and temperature. Analytical data include COPC distribution and phase associations. Existing and new data will be used to update and refine the CSM as the investigation progresses. Data from site characterization will be incorporated into maps and cross sections, potentiometric surface contours, geochemical diagrams, and COPC distribution figures.

Geochemical and contaminant analytical data will be analyzed to assess contaminant mobility. The common geochemical redox conditions and species and reactive minerals associated with landfills can affect radionuclide transport via exchange-adsorption/desorption and precipitation/co-precipitation or dissolution over time scales on the order of seconds to months. Radioactive decay occurs over much longer time scales. Therefore, it is important that both of these mechanisms are characterized and understood.

The Groundwater Modeling Work Plan will be developed following the first two groundwater monitoring events. The Groundwater Modeling Work Plan will integrate the understanding of groundwater flow and contaminant transport following the evaluation of the data sets collected during site characterization. The updated CSM will address groundwater flow in and around the site and in off-site areas that are impacted by COPCs. The updated CSM will also address how the alluvial aquifer, the Missouri River, and the hydraulic relationship between the alluvial and bedrock aquifers affect groundwater flow directions and gradients. Evaluation of the analytical data sets will also be important to the development of a fate and transport modeling strategy. Where appropriate, preliminary fate and transport modeling, possibly including calculations or preliminary models, will be developed to support the CSM and to develop fate and transport modeling requirements within the Groundwater Modeling Work Plan. A more specific strategy will be developed following collection of the appropriate data sets and included in the Groundwater Modeling Work Plan.

5.6 ENGINEERING AND INSTITUTIONAL CONTROLS

As characterization proceeds, existing mechanisms, engineering controls, and other existing legal instruments will be reviewed to ensure appropriate actions are implemented in accordance with federal, state, and local regulatory requirements that mitigate human health exposures. The engineering/institutional controls will be determined based upon results of the initial investigation results where potential exposures exceed risk-based cleanup objectives.

5.7 HEALTH AND SAFETY PLAN

A HASP, which includes the OU-1 RSP for work conducted within the boundaries of OU-1 Areas 1 and 2 and other OU-3 investigative areas that are suspected to, or have been documented to, contain radiological impacts at levels of a potential health concern, is included as Volume 3. The HASP provides a summary of personnel responsibilities, protective equipment, health and safety procedures and protocols, decontamination procedures, personnel training, and type and extent of medical surveillance. The plan identifies problems or hazards that may be encountered during performance of the RI and how these are to be addressed. Additionally, procedures for protecting third parties, such as site visitors, vehicular or pedestrian near sampling crews, and for the surrounding community, in general, is also described in the HASP.

6.0 DATA MANAGEMENT AND EVALUATION

The RI/FS will generate and compile an extensive amount of information requiring proper documentation and management to support risk assessment and remedy selection decisions. Data management procedures will be followed to ensure the quality, validity, and security of the data as detailed in the following sections regarding recordkeeping and the project database. Additional details and SOPs are included in the SAP. Proper chain-of-custody procedures will be followed, and sample locations/depths will be geospatially rendered and properly identified on maps and supporting tables and figures. Data will also be evaluated and compiled into text, tables, figures, and 3-D visualizations to help assist with evaluations and to identify any remaining data gaps. Data management and evaluation are discussed further below.

6.1 DATA MANAGEMENT

An inclusive data management system, Project Direct (proprietary to Trihydro), is already being utilized to manage existing data. The data management system can track and organize the project data sets including: field log data, boring log data, field scans, GPS/survey data, sample management and tracking procedures, document control procedures, laboratory data, field measurements, and other relevant items to ensure that the data collected during the investigation are of adequate quality and quantity to support the investigation, the risk assessment, and remedial alternatives. Data can be exported directly from Project Direct as needed to accommodate various output formats.

6.1.1 DATA VALIDATION

Collected data will be reviewed and validated at the appropriate quality control (QC) level(s) to determine whether it is adequate for its intended use. Laboratories are described in detail in the QAPP. The MCLInc data are specialty laboratory services for non-regulated results that will be used in fate and transport groundwater modeling. MCLInc data will be validated using Tier I data validation. Groundwater analytical data provided by Pace Analytical will be validated with at least a Tier II data validation, and the specific level of data validation will be determined by the final use of the data as discussed in the QAPP. Task management objectives and QC procedures and related findings will be provided, consistent with the project planning documents (e.g., FSP and QAPP). Information from this task will be incorporated into the RI and FS reports, appendices, and other related project deliverables, as appropriate.

6.1.2 PROJECT DATABASE

The project database will be provided for USEPA review and routinely updated as new reviewed and validated data becomes available. The USEPA will be notified in writing whenever new data has been uploaded to the site-wide OU-3 database. In general, the OU-3 database will include groundwater data and supporting information related to the site including, but not be limited to: well construction details, well completion information, geospatial/survey information, geochemistry data, field data, laboratory results and field parameters, fluid levels, laboratory qualifiers, additional qualifiers, and summary information relevant to OU-3. Uploading sampling, monitoring, and spatial data to the USEPA-accessible site-wide OU-3 database in the appropriate formats will be considered a submittal once USEPA is notified of its availability.

6.1.3 SPATIAL DATA

Sampling and monitoring data will be submitted in an appropriate Electronic Data Deliverable (EDD) format. Spatial data including spatially-referenced data and geospatial data will be submitted: in the ESRI File Geodatabase format; and (b) as un-projected geographic coordinates in decimal degree format using North American Datum 1983 (NAD83). Spatial data will be accompanied by metadata, and such metadata will be compliant with the Federal Geographic Data Committee (FGDC), Content Standard for Digital Geospatial Metadata and its USEPA profile, the USEPA Geospatial Metadata Technical Specification. An add-on metadata editor for ESRI software, the USEPA Metadata Editor (EME), will be used as needed. Each file will include an attribute name for each site unit or sub-unit submitted. Spatial data that will be submitted related to this work does not and is not intended to define the boundaries of the site.

6.1.4 FIELD RECORD KEEPING

Field logbooks and field datasheets will provide the means of recording the data collection activities. All field logbooks and field datasheets will be scanned to create PDF files for electronic archiving with the central project file. A SOP for field recordkeeping is provided in the FSP.

6.1.4.1 FIELD LOGBOOKS

Field logbooks will be used to document field observations and activities. The field notes will be clear, with sufficient detail so that events can be reconstructed later if necessary. Field logbooks will document any deviations from the RI/FS WP and/or FSP, as well as the reason for the changes. Requirements for logbook entries are detailed in the FSP.

6.1.4.2 FIELD DATASHEETS

Field datasheets/forms will be utilized when appropriate to achieve efficient and standardized recording of field measurements and observations. The type of field data sheet and the information recorded on it may vary by activity. Information from the field datasheets will be entered into the database as needed. A reference date and activity will be entered in the field logbook to refer to the field datasheets being generated. The field datasheets will be scanned into a

PDF and become a permanent record within the project file. Details regarding field datasheets that may be used, and example field datasheets are included in the FSP.

6.2 DATA EVALUATION

Data evaluation will be conducted once it is verified that the data are of acceptable accuracy and precision. The investigation data will be reviewed and analyzed, and the results of the analyses will be presented to the USEPA. Summaries of the data shall include: (1) descriptions of the locations, quantities, and concentrations of specific chemicals at the study area; (2) a discussion of background conditions/levels for the study area; (3) descriptions of the number, locations and types of nearby populations and activities; (4) a discussion of the influence of the Bridgeton Landfill and related infrastructure on the hydrogeologic system; and (5) evaluations of the potential transport mechanism and the expected fate of the contaminant in the environment (fate and transport modeling). Laboratory and independent data evaluation and validation processes will be performed and properly documented in accordance with the approved QAPP.

6.2.1 GROUNDWATER FLOW MODELING AND CONTAMINANT TRANSPORT MODELING

A 3-D numerical groundwater flow and transport model will be prepared for the on-site and off-site areas to meet several overall objectives, including refinement of the CSM, prediction of future potential groundwater conditions, evaluation of human health and ecological risks, and evaluation of potential remedies (if needed). Objectives and scope of the groundwater modeling effort will be further defined in the modeling work plan which will be developed after review of data collected in the first phase of the RI/FS. The Groundwater Modeling Work Plan will include detailed descriptions of the following elements:

- Purpose and Objectives
- Modeling Code and Software
- Model Conceptualization, Boundary Conditions, Grid Extent
- Grid Dimensions and Layering
- Calibration
- Predictive Simulations
- Reporting

Preliminary details regarding the groundwater model are detailed below, including potential modeling software packages, a preliminary hydrologic conceptual model and proposed model domain, a proposed geochemical fate and transport approach, and calibration procedures.

6.2.1.1 MODELING OBJECTIVES

Tentatively, the following objectives are proposed for the modeling effort:

1. Aid in development of a CSM for groundwater conditions, by simulating flow conditions and transport between the on-site and potential off-site receptors.
2. Determine potential future COPC groundwater migration in off-site areas, under pumping and non-pumping scenarios.
3. Forecast the rate of ingrowth of Radium-226 and potentially other soluble and mobile radionuclides with long half-lives, into the future.
4. Assist with evaluation and comparison of remedial alternatives for the site.

6.2.1.2 PROPOSED MODELING SOFTWARE

The selection of appropriate groundwater flow and transport modeling codes cannot be conducted at this time, due to the existing data gaps for off-site groundwater conditions. However, it is anticipated that a flow model within the suite of USGS MODFLOW codes may likely be the most appropriate flow modeling code. An appropriate transport code to be used will be determined based on consideration of the results of groundwater chemical analyses, and will be capable of simulating relevant chemical reactions, sorption, and other relevant processes. A more definitive statement on the selection of flow and transport modeling software will be provided in the Groundwater Modeling Work Plan.

6.2.1.3 CONCEPTUAL MODEL AND INITIAL MODELING DOMAIN

The preliminary hydrologic conceptual model for the site includes two bedrock hydrologic units (St. Louis Formation and Salem Formation) and three alluvial hydrologic units (shallow, intermediate, and deep alluvium) as discussed in Section 3.1.5. This will be updated in a revised CSM based on the additional data collected during the first phase of OU-3 RI/FS site investigation and characterization. The computer model will be constructed with sufficient 3-D discretization and vertical layering to accurately simulate groundwater flow and transport within this complex setting. Interactions between the alluvial aquifers and the Missouri River are dynamic and the effect of these interactions on groundwater flow directions and gradients will also be incorporated into the modeling to account for base flow and underflow. There is a hydrogeologic transition which occurs in the approximate middle of the site along a southwest-northeast trending line at the edge of the alluvial valley. South and east of this transition, Mississippian bedrock aquifers are the primary water bearing units while the Missouri River alluvium is the primary water bearing unit of interest to the north and west. This hydrogeologic feature will be represented in the model. Groundwater withdrawals by the leachate collection system (described in Section 3.1.5.7.2), which currently pumps approximately 60,000 to 110,000 gpd, and historically pumped higher rates, will be simulated. The effect of pumping on head and gradient in the alluvial aquifers will be matched to observational records. The flow model will be gridded and parameterized to represent the complex hydrogeologic framework.

The preliminary domain of the anticipated groundwater flow model is shown on Figure 3-16. Details related to boundary conditions, layering strategies, grid discretization, and flow budgets will be determined and discussed in the Groundwater Modeling Work Plan.

6.2.1.4 GEOCHEMICAL AND ENVIRONMENTAL FATE AND TRANSPORT

As part of the modeling effort, an evaluation of geochemical processes that affect fate and transport of solutes such as adsorption/desorption, mineral precipitation and dissolution, and ingrowth and decay of radionuclides, will be performed. Additional data are being collected during site characterization that are relevant to fate and transport considerations, and which may affect the CSM and may cause some of these processes to need to be included in modeling simulations. However, data collection and evaluation may also determine that certain processes are not relevant to COPC transport. Therefore, the Groundwater Modeling Work Plan will provide a determination on which processes are appropriate be included in transport simulation.

6.2.1.5 ANTICIPATED CALIBRATION GOALS

It is anticipated that the model will be calibrated to “current” conditions, as measured during the RI field investigation. If appropriate, this may include calibration to transient hydrologic events that are measured during the OU-3 RI/FS investigation, such as transient surface water-groundwater interactions, or transient changes in pumping conditions. In model calibration, simulated heads, fluxes, concentrations, and other model-computed variables (if relevant) are compared to field measured values and estimates (Woessner and Andersen 1992). Aquifer parameters and stresses are adjusted repeatedly to reduce the residual error between simulated and measured values. This process generally continues until the remaining residual errors and subjectively judged “acceptable.” The amount of effort that is required in calibrating a ground-water flow model is dependent upon the intended use of the model (that is, the modeling objectives). The adequacy of the model calibration will be based on the modeling objectives stated in the modeling work plan, and upon the following criteria (Reilly and Harbaugh 2004):

- Is the conceptual model of the system under investigation reasonable?
- Are the mathematical representations of the boundary conditions reasonable for the objectives of the study?
- Does the simulated head and flow distribution mimic the important aspects of the flow system, such as magnitude and direction of the head contours?
- Does some quantitative measure of head and flow differences between the simulated and observed values seem reasonable for the objectives of the investigation?
- Does the distribution of areas where simulated heads are too high and areas where simulated heads are too low seem randomly distributed? If they are not randomly distributed, then is there a hydrogeologic justification to change the model and make the residuals more random?

6.2.2 GEOLOGIC DATABASE

A geologic database incorporating available and relevant data is currently under development and near completion. The geologic database includes the historical dataset presented on Table 2-2. The database will be used to support the groundwater modeling efforts, including the modeling work plan and report. As discussed in Section 5.2 and Section 5.4.3, additional local and regional historical hydrogeologic and hydrologic records within the preliminary groundwater modeling domain will be reviewed. The USEPA-accessible database will be updated as new data become available and are incorporated. Results will be included in the Well Inventory Summary Report and the Groundwater Modeling Work Plan.

6.2.3 DATA EVALUATION METHODS IDENTIFIED DURING SCOPING

Applicable data will be reviewed and compared to: USEPA MCLs, ARARs, GWPS, USEPA regional screening levels (RSLs), ecological screening levels, and other risk-based standards as needed; values indicative of assessment monitoring performance standards for natural attenuation/geochemical parameters; and/or the background levels and concentrations of COPCs. Additionally, laboratory testing, geochemical evaluation or modeling, and other relevant sources of site-specific or site-related data will be evaluated to develop a more in-depth understanding of the landfill's geochemical conditions. Furthermore, the evaluation of the site conditions will specify how these conditions may affect RIM located in Area 1 and Area 2, landfill waste in general, and naturally occurring materials located in the bedrock and alluvial deposits beneath the site.

6.2.4 PRELIMINARY DETERMINATION OF TASKS TO BE CONDUCTED AFTER SITE CHARACTERIZATION

Tasks will be conducted during and after site characterization to refine the CSM. Data will be evaluated and compiled into text, tables, figures, and 3-D visualizations to help identify and address data gaps, refine the current understanding of the hydrogeologic system, calculate a water balance for the hydrogeologic system, evaluate background groundwater quality, determine the extent of groundwater impacts, provide predictive tools/models to evaluate potential future impacts, and identify potential remedies as needed. Fate and transport processes will be evaluated to develop a robust and current CSM. Examples of potential figures and diagrams used to convey information include but are not limited to: potentiometric surface figures, hydrogeologic cross-sections, isopach diagrams, Stiff diagrams, Piper diagrams, modified Stiff diagrams, and 3-D site visualizations. Data will be updated and evaluated iteratively to refine the CSM and database as new information becomes available. Additional data collection may be completed to support the Baseline Risk Assessment (described below in Section 7.0) and groundwater model, which will be outlined as necessary within an addendum to this Work Plan.

7.0 BASELINE RISK ASSESSMENT AND RI REPORT

Results of site characterization and CSM development will be used to determine if site-related constituents have migrated in groundwater or may migrate in the future beyond site boundaries. Concentrations will be compared to risk-based screening levels/USEPA MCLs or ACLs to conservatively evaluate the potential for human health and environmental risks posed by groundwater at and near the site. For the purpose of the screening step for human receptors, the BRA will use the latest USEPA RSLs for tapwater (USEPA 2019c) set to a cancer risk of 1E-06 and a non-cancer hazard quotient of 0.1 or 1 depending on the number of detected and co-occurring constituents. Central tendency and reasonable maximum exposure scenarios will be included in the analysis.

Potential exposure of receptors in comparison to background groundwater conditions will be incorporated into the BRA. Background concentrations of constituents will be established through statistically robust methods. If COPC concentrations exceed ecological or human health screening levels, a comparison to background conditions will be completed during the screening level risk assessments so that background can appropriately be taken into consideration when evaluating potential risk to receptors. The BRA will be comprised of the Human Health Risk Assessment (HHRA) and the ERA. A BRA Work Plan will be developed and submitted for review prior to beginning the human health and/or ecological risk assessments. Ecological risk assessment will be completed in accordance with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997c). Information from this task will be incorporated into the RI/FS Report(s) and applicable appendices.

7.1 BASELINE RISK ASSESSMENT

A BRA will be conducted to assess the potential human health and environmental risks posed by groundwater at and near the site in the absence of any remedial action. A separate BRA Work Plan will be generated and submitted to USEPA for the human health and ecological risk assessments. The risk assessments will be conducted according to the USEPA guidance, including the *Risk Assessment Guidance for Superfund (RAGS)* (USEPA 1989b). Part D tables will be included as part of the HHRA, per the USEPA RAGS Part D guidance (USEPA 2001b). This effort will involve four components: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization. The BRA will include a Screening Level Ecological Risk Assessment followed by a Baseline Ecological Risk Assessment, as necessary. These components of the baseline Risk Assessment are described below.

7.1.1 DATA COLLECTION AND EVALUATION

Site data will be evaluated relative to human health and ecological screening criteria. COPCs will be selected based on exceedances of screening levels, along with consideration of background concentrations as described in RAGS Part A

(USEPA 1989b), where maximum concentrations of chemicals detected at the site are compared to their respective RSLs. Previous studies and investigations conducted for the site will be used in conjunction with data from the OU-3 investigation to determine the specific COPCs in groundwater. Ecological screening criteria will be submitted for review and approval in advance of completing screening level comparisons.

7.1.2 EXPOSURE ASSESSMENT

The magnitude of actual and/or potential human and ecological exposures, the frequency and duration of these exposures, and the pathways by which humans and/or ecological receptors are potentially exposed will be estimated. The existing and predicted nature and extent of impacts will be evaluated. This will be compared to potential exposure pathways identified during the OU-3 well inventory and RI/FS process.

Potential ecological risk is predicated on the confirmation of a connection between groundwater and surface water bodies within or in close proximity to the site and the conveyance of site-related constituents to those water bodies. Hydrogeological data collection and modeling will be used to identify potential surface water bodies where site-related constituents could migrate. For surface water bodies in which there is no potential connection to groundwater, no further consideration of potential ecological exposure will be completed. For surface water bodies in which there is potential (historical, present, or future) connection to groundwater, constituent concentrations in groundwater from the closest groundwater well locations will be compared to freshwater ecological screening levels, recognizing that this is a conservative estimate of potential risk. COPCs will be identified for further evaluation and additional sampling of surface water and sediment, based on this conservative comparison. If necessary, the procedures for data collection to support an ecological assessment will be proposed as part of the OU-3 Phase II RI Work Plan, including procedures for data collection and performing a screening level evaluation. The resulting data would then be used to further define the list of COPCs for ecological receptors. The OU-3 Phase II Work Plan would identify potentially complete exposure pathways (i.e. surface water bodies), potential receptors (both aquatic and terrestrial), and potential media (water and sediment) that would need to be compared to freshwater and sediment screening criteria to determine whether a screening level risk assessment is necessary.

7.1.3 TOXICITY ASSESSMENT

A toxicity assessment of those chemicals identified to be of potential concern for the site will be conducted. The toxicity assessment component of the BRA will consider: (1) the types of adverse health effects associated with chemical exposures as reported in literature reviews/compendia/databases and linked to the published toxicity reference values and/or screening levels; (2) the relationship between magnitude of exposure and adverse effects, i.e., available dose-response information, threshold limits; and (3) related uncertainties such as the weight of evidence, systematic review, evidence-based toxicology of a particular chemical's effects on the receptors of interest.

The ecological toxicity assessment of the BRA will focus on potential constituents, ecological receptors, and habitats that may present, and the pathways by which exposure could potentially occur. Identifying complete exposure pathways prior to a quantitative evaluation of toxicity will allow for the assessment to focus on only those contaminants that can reach ecological receptors. The assessment will account for exposure routes as they differ for ecological receptors and the specific chemical and physical properties of constituents that influence their relative toxicity for (1) different groups of organisms, and (2) exposure pathways and routes are unique to constituents. Other considerations will include federally and state-listed threatened and endangered species, in addition to the presence of sensitive environmental areas (including wetlands and other aquatic resources) both within and in close proximity to the site. Both direct and indirect exposure pathways will also be examined in conjunction with potential toxicity, with a focus on the assessment endpoint of populations of receptors.

For each complete exposure pathway, route, and contaminant, screening ecotoxicity values based on no observed adverse effect levels will be developed and proposed to USEPA in advance of performing a screen. After the screening level evaluation has been completed, exposure duration, bioaccumulation, bioavailability, and dose will be included into the quantification of risk, and the uncertainty associated with these elements as they impact toxicity will be considered.

7.1.4 RISK CHARACTERIZATION

Outputs of the exposure and toxicity assessments will be summarized and combined to characterize baseline risk, both in quantitative expressions and qualitative statements. During risk characterization, chemical-specific toxicity information will be compared against both measured contaminant exposure levels and those levels predicted through appropriate modeling to determine whether current or future levels at and/or near the site are of potential concern. Further, the BRA shall be separated into two components: (1) HHRA; and (2) ERA. Any modeling used to calculate contaminant exposure levels will be described in the BRA Work Plan and approved by the USEPA prior to use.

7.1.5 HUMAN HEALTH RISK ASSESSMENT

The HHRA shall address the following:

- Hazard identification
- Dose-response assessment

- Exposure assessment
- Risk characterization
- Limitations/uncertainties

7.1.6 ECOLOGICAL RISK ASSESSMENT

The ERA shall be conducted according to the 8-step ecological risk assessment process (USEPA 1997c):

- Screening-Level Problem Formulation
- Screening-Level Exposure Estimate and Risk Calculation
- Baseline Problem Formulation
- Baseline Study Design and DQO Process
- Baseline FSP Verification
- Baseline Site Investigation and Data Analysis
- Baseline Risk Characterization
- Risk Management

The BRA will be submitted to the USEPA as part of the RI Report. Additionally, the methods used to evaluate risks in this assessment will be consistent with current USEPA guidelines for HHRA and ERA at Superfund sites (USEPA 1997c; USEPA 2001b).

7.2 RI REPORT

The RI Report will summarize the findings of the RI process and provide information to assess risks to human health and the environment and, as warranted, support the development, evaluation, and selection of appropriate response alternatives. This task will be completed once sufficient data has been collected and fully evaluated and the CSM has been updated. The task includes all draft and final reports. The RI Report at a minimum will include the following sections.

7.2.1 INTRODUCTION AND SITE BACKGROUND

The RI Report will include an introduction and site background section that presents a brief description of the site, including the location, an overview of past and current operations, a summary of previous investigations, and a discussion of activities occurring adjacent to the site. A summary of pertinent information, that will expand upon Section 2 of this Work Plan, as needed, will be provided.

7.2.2 STUDY AREA INVESTIGATION

Site characterization activities will be summarized in this section. The field investigation and technical approach/rationale will be presented. Surface features, contaminant sources, surface water, geological, soil and vadose zone, groundwater, and ecological investigations will be compiled, and the results of chemical and analytical analyses will be provided.

7.2.3 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

An updated CSM will be presented in this section of the RI Report. Site characteristics will include geology, hydrogeology, geochemistry, meteorology, ecology, demographics, land use, and a reuse assessment.

7.2.4 NATURE AND EXTENT OF CONTAMINATION

The results of the site characterization will be presented in this section of the RI Report. COPCs in media sampled as part of the RI Report will be discussed. Contaminant distribution and trends, and background groundwater quality will be included.

7.2.5 CONTAMINANT FATE AND TRANSPORT

Potential routes of migration, contaminant persistence, and contaminant migration will be reported in this section of the RI Report. If applicable, the estimated persistence of the COPCs in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest will be reviewed; factors affecting contaminant migration for the affected media of importance will be reviewed; and fate and transport modeling methods and results will be discussed.

7.2.6 BASELINE RISK ASSESSMENT

Results of the BRA, including the HHRA and ERA, will be included in this section of the RI Report.

7.2.7 SUMMARY AND CONCLUSIONS

A summary of the nature and extent of contamination, fate and transport and risk assessment will be presented in this section of the RI Report. Conclusions will include data limitations and recommendations for future investigations as well as recommended remedial action objectives or the need for a FS.

8.0 FEASIBILITY STUDY

An FS may be conducted based upon the findings of the RI, once the results of the investigation are analyzed and complete. This work element includes the preparation and presentation of findings for potential remedial alternatives that have been screened and evaluated. If required, the FS will be completed using SMART remedial objectives. The FS Report for OU-3, if prepared, shall include, but is not limited to a discussion of the following:

8.1 INTRODUCTION AND BACKGROUND INFORMATION

This section will present the purpose and organization of the report and summarize the background information presented in the RI Report. Feasibility Study Objectives will also be presented.

8.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section will present the remedial action objectives for each medium of interest (e.g., groundwater, surface water, etc.). For each medium, the contaminants of interest, the allowable exposure based on risk assessment (including ARARs), and the development of remediation goals will be discussed. General response actions will be presented and for each medium of interest, and an estimation of areas or volumes will be described to which treatment, containment, or exposure technologies may be applied. For each medium of interest, an identification and screening of technologies will be discussed, and an evaluation will be performed for a selection of technologies.

8.3 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section will describe the rationale for the combination of technologies/media into alternatives. The screening of alternatives will present each option, provide a description, and discuss the evaluation.

8.4 DETAILED ANALYSIS OF ALTERNATIVES

Individual analysis of alternatives will be presented in this section, including, but not limited to, the presentation of the alternative, a description, and an assessment of the alternative. A comparative analysis will be presented for all of the alternatives, including institutional controls and screenings. This will include a summary and conclusions.

9.0 RI/FS REPORTING

The following sections summarize the deliverables that will document the results of the OU-3 RI/FS at the site. Additional submittals may be added to those detailed below based upon the scoping process that will continue throughout the project. Deliverables listed below, as well as any additional deliverables required during the course of the project, will be initially submitted to the USEPA as draft documents. Following receipt of USEPA comments, the documents will be revised as needed and submitted in final form for approval by USEPA. A summary of the submittals, including a schedule for each submittal, is provided in Section 10.3.

9.1 WELL INVENTORY SUMMARY REPORT

The Well Inventory Summary Report will provide a narrative summary of each well's current condition. The summary will include survey and GPS coordinates, construction details on the existing site wells, and recommendations/reports of performed or proposed redevelopment, repair, replacement, or abandonment of existing wells to support the OU-3 RI. The report will also include a review of previous/historical data sets associated with the existing wells in accordance with the QAPP to determine if data quality issues may be present for any of the existing monitoring wells and evaluate the adequacy and usability of data from site-associated former/abandoned wells. Following the USEPA review and approval of this report, the unsuitable, damaged or inoperative wells will be repaired, replaced, and/or abandoned per applicable state requirements. Recommendations will be provided to address identified data gaps at the former/abandoned well locations, if they exist.

9.2 ANNUAL HYDROGEOLOGIC INVESTIGATION AND GROUNDWATER CHARACTERIZATION REPORT

An Annual Hydrogeologic Investigation and Groundwater Characterization Report will be submitted on March 1 of each calendar year to summarize the prior year's results of the hydrogeologic investigation and groundwater characterization activities necessary to support the CSM, groundwater model, and other remedial investigation tasks at and near the site. Development of groundwater recharge/flow and evaluation of natural attenuation processes will be performed in accordance with approved planning documents. Results from the sampling program will provide a detailed estimate of the horizontal and vertical distribution of contaminants, the mobility of contaminants, estimates of attenuation rates from well transects, and prediction of long-term disposition of contaminants. This will include the collection of sufficient data in and near the site to produce a statistically valid background range and a statistically valid baseline range of contaminant concentrations and geochemistry parameters. This effort may provide a means to potentially differentiate leachate-induced and/or landfill gas effects from background concentrations onsite and/or near the site.

9.3 GROUNDWATER MODELING WORK PLAN

As noted above in Section 6.2, the Groundwater Modeling Work Plan will establish the approach and methods for groundwater modeling, and will incorporate relevant site data available at the time of preparation. The Groundwater Modeling Work Plan will be based on a revised CSM that incorporates existing data and site information, and follows USEPA guidance (USEPA 2002). The Groundwater Modeling Work Plan will address the simulation of both groundwater flow and fate and transport of COPCs.

The Groundwater Modeling Work Plan will describe the modeling software to be used, the conceptual model of the flow system and how it will be represented in the modeling software to include: the extent of the model area, model discretization (number of model layers, cell size, stress period lengths), model boundaries and boundary conditions (recharge, faults, streams, springs, lakes, no flow, head dependent, etc.), model calibration (manual and/or parameter estimation, closure criteria, rules for comparison of simulated and measured head and flow targets), model stresses (historical and future pumping, recharge, river stage changes, lake stage changes, impervious surface changes, etc.), model aquifer and confining unit hydraulic properties, and predictive scenarios to be evaluated. The Groundwater Modeling Work Plan will also address methods to be used for corroborating data that supports model construction or calibration, and for sensitivity analysis and uncertainty analysis. The Groundwater Modeling Work Plan will also detail how the model will be used to simulate contaminant transport, describe the methods of determining calibration and predictive uncertainty in the model, and model archival processes. The groundwater model will also be used to further update the CSM and to evaluate current site conditions, provide future prediction simulations on potential long-term groundwater impacts, and assist with the placement of additional monitoring wells for long-term understanding of groundwater.

9.4 GROUNDWATER MODELING REPORT

The Groundwater Modeling Report will document the groundwater modeling approach and outputs. It will include the modeling software(s) used, the conceptual model of the flow system and how it was represented in the modeling software based on model extent, model discretization, model boundaries and boundary conditions, model calibration, model stresses, model aquifer and confining unit hydraulic properties, and predictive scenarios which were evaluated. The report will also detail how the model(s) was used to simulate contaminant transport, describe the methods of determining calibration and predictive uncertainty in the model, and model archival processes. The report will provide an updated CSM; evaluate current site conditions; provide future prediction simulations on potential long-term groundwater impacts; discuss the findings of data corroboration, sensitivity analysis, and uncertainty analysis; and assist with the placement of additional monitoring wells for long-term understanding of groundwater.

9.5 BASELINE RISK ASSESSMENT WORK PLAN

A Baseline Risk Assessment Work Plan (BRAWP) will be prepared following the completion of the Annual Hydrogeologic Investigation and Groundwater Characterization Reports, the Groundwater Modeling Report, and additional field investigation to sufficiently characterize the site. Data gaps relevant to the risk assessment that are identified following the review of the groundwater characterization, modeling and vapor intrusion investigation, if any, will be identified and discussed in the BRAWP. The nature of the data gap analysis will consist of assessing the results and conclusions of the four abovementioned characterization reports in the context of the needs of human health and ecological risk assessments. Specifically, each report will be reviewed by the human health and ecological risk assessors to gauge the quality and quantity of exposure data and information on the potentially complete exposure pathways. For example, if groundwater modeling shows that there is a complete exposure pathway to surface water, the ecological risk assessment will need to address potential aquatic receptors. A draft CSM including potential exposure pathways is included in the QAPP.

Potential ecological risk associated with the site is limited to exposure that might result if impacted groundwater is hydrologically connected to one or more surface water bodies. At the completion of the Groundwater Characterization Report, the Groundwater Modeling Report, and additional field investigation to sufficiently characterize the site, surface water bodies that could potentially serve as exposure points for ecological receptors (due to their connection with impacted groundwater) will be identified. As a preliminary screening step, constituent concentrations in the groundwater well in closest proximity to potential surface water exposure points will be compared to freshwater ecological screening criteria to develop a preliminary COPC list. The BRAWP will detail the plan for collecting surface water and sediment samples from surface water bodies that are potentially hydrologically connected to groundwater as necessary. The sampling plan will be developed to characterize constituent concentrations at exposure points identified within a CSM that includes both terrestrial and aquatic receptors.

The BRAWP will discuss in detail the key components of data, exposure assessment, hazard evaluation, and risk assessment for USEPA review and approval. Briefly, the BRAWP will include a section on data availability and usability for risk assessment, latest CSM identifying potentially complete exposure pathways, media, and routes, toxicity reference values, risk and hazard thresholds, screening-level assessment/selection of COPC methodology, exposure equations and inputs, and exposure units and exposure point concentration statistical methods as recommended by RAGS and other EPA risk assessment guidance.

9.6 RI REPORT

After completion of all phases of the RI, a comprehensive RI report will be prepared to present and evaluate the data for meeting the stated RI objectives. The RI report will include the site background, investigation, site characteristics, nature and extent of contamination, fate and transport evaluation, and the results of the BRA. The RI Report will be prepared in accordance with the Work Plan and SOW.

9.7 FEASIBILITY STUDY REPORT

A FS Report will be prepared to document the process if a FS is deemed appropriate. The FS Report will be consistent with the most recent USEPA guidelines. The FS Report will include detailed evaluation of alternatives as discussed in Section 8.0.

10.0 PROJECT MANAGEMENT PLAN

A project management plan (PMP) was developed for use by the OU-3 RI/FS project team. The PMP includes the work breakdown structure, personnel resources loading, project team roles and responsibilities, project communication, document distribution, subcontracted services, materials, and equipment; which will be implemented to assist the OU-3 Respondents and USEPA with the RI/FS process. A proposed project schedule is also included in this section.

10.1 PROJECT PERSONNEL

OU-3 respondents designated Trihydro Corporation as the contractor for overall support of the RI/FS process. A team of individuals and subcontractors will provide additional support and be involved in the collection, management, and evaluation of data. Project team members will have designated responsibilities throughout the RI/FS process. Personnel with designated responsibilities are shown on Figure 10-1 and listed below:

- Project Principal
- Project Manager
- Technical Director
- Assistant Project Manager
- Trihydro Health and Safety Systems
- Project Site Health and Safety Officer
- Radiation Safety Officer
- Certified Health Physicist
- Radiological Control Supervisor
- Field Team Leader
- Field Team Members
- Site Quality Control Officer
- Laboratory Specific Project Management and Quality Assurance Officers
- Quality Assurance Director

10.2 COORDINATION WITH USEPA

Community involvement activities in support of the USEPA will be provided by the OU-3 Respondents, as requested by USEPA. The USEPA will provide information and direction regarding this item as the OU-3 investigation progresses and will largely focus on communications with community members and other stakeholders as OU-3 related milestones and associated submittals/information become available.

10.3 PROJECT SCHEDULE

A proposed schedule in Microsoft Project format that details proposed investigative work such as new well installations, direct push sampling locations, and/or piezometer installations upon approval of the RI/FS Work Plan is included as Figure 10-2. The schedule will be updated upon final Work Plan approval, and then monthly thereafter during project execution. Details regarding planned sampling events and/or supplemental sampling events will be included with the FSP or included with other appropriate project documentation.

Milestones for the major project tasks are currently estimated as follows:

- Finalized OU-3 RI/FS Work Plan - January 2020
- RI Field Work - Spring 2020 - Fall 2022*
- Well Inventory Summary Report - Fall 2020
- Addendum to RI Work Plan - Winter 2020
- Additional RI Field Work - Spring 2021*
- Groundwater Modeling Work Plan - Summer 2021
- Groundwater Modeling Report - Fall 2022
- RI Report - Spring 2023
- Baseline Risk Assessment Report - Spring 2023

**Major field events denoted with an asterisk.*

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TABLES

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Year(s)	Investigation Conducted for:	Description
1973	West Lake Landfill	Four wells at unknown locations were sampled for five sampling rounds; samples were analyzed for general inorganic parameters, metals, and phenol.
1976	West Lake Quarry	Three wells along the western property boundary were sampled in one sampling round; samples were analyzed for general inorganic parameters, metals, and phenol.
1976-1984	West Lake Quarry	Wells around the perimeter of the inactive landfill on the western portion of the site, and after 1981 near the leachate retention pond, were sampled intermittently. Samples were analyzed for a varying list of parameters which included general inorganic parameters, ions, metals, and radionuclides.
1979-1982	Missouri Department of Natural Resources	Wells around the perimeter of the inactive landfill and the perimeter of the site, as well as site surface water bodies and off-site private wells, were sample intermittently. The samples were analyzed for a varying list of general inorganic parameters, ions, metals, and radionuclides.
1982	Nuclear Regulatory Commission	The Radiological Survey of the West Lake Landfill, St, Louis County, Missouri identified two areas of radiological contamination on-site, and concluded that there is no indication of off-site migration of the contaminants.
1983	College of Engineering, University of Missouri-Columbia	The Engineering Evaluation of Options for Disposition of Radioactively Contaminated Residues Presently in the West Lake Landfill, St. Louis County, Missouri, Draft identified radiological contamination and concluded that radon gas release from the site would increase.
1984	Nuclear Regulatory Commission	The perimeter berm around the northern extent of the site was surveyed for radiological contamination and inspected for erosion. Migration of contamination and slope failure were observed on selected portions of the berm west of OU-2 Area 2.
1986	West Lake Landfill	Existing and new wells around the inactive landfill on the western portion of the site, and the leachate retention pond, were included in a thorough hydrogeologic investigation. The hydrogeologic characterization concluded that three levels of the alluvial aquifer (shallow, intermediate, and deep) were in complete communication, and that groundwater flow was generally towards the northwest. Groundwater samples were collected and analyzed for volatile organic compounds, acid-base neutral extractables, pesticides and polychlorinated biphenyls, phenol, cyanide, and metals. Concentrations of certain parameters exceeded applicable standards, but the distribution was erratic and generally could not be attributed specifically to site activities. Concentrations of parameters which exceeded standards were likely to be diluted below standards prior to exposure to any downgradient uses.
1986	Nuclear Regulatory Commission	Eighteen groundwater monitoring wells were sampled and analyzed for radionuclides.
1989 and 1991	USEPA	A review of historical aerial photographs, from 1941 through 1991, was conducted to identify areas of potential environmental concern. Solid waste and mine spoils areas were identified.
1989 to Present	Laidlaw Waste Systems	Groundwater samples were collected from wells throughout the site on an intermittent basis, focusing specifically on wells around the active landfill area in recent years. Samples were analyzed for a variable list of parameters, including general inorganics, metals, radionuclides, volatile organic compounds, pesticides, herbicides, polychlorinated biphenyls, cyanide, and phenol.
1990-1991	Earth City Industrial Park	An investigation of potential radiological impacts to neighboring properties was conducted in three phases. Radiological contamination reportedly originating from OU-1 Area 2 was identified in soils at two hot spots near the property boundary.
1991	Agency for Toxic Substances and Disease Registry	A review of available information concluded that the site presented no apparent health hazard, although exposure could occur if groundwater contamination increased and migrated off-site.
1991	Laidlaw Waste Systems	A subsurface soil gas survey conducted in the vicinity of MW-F2 identified BTEX and TPH impacts to subsurface soils in an area extending 150 feet north and 300 feet south of MW-F2.
1992	Laidlaw Waste Systems	An environmental investigation for the development of a site Health and Safety Plan identified radon in the landfill gas collection system.
1992	Laidlaw Waste Systems	The slope of the berm along the western portion of the inactive landfill was reworked to 3H:1V slope, recovered, and revegetated.
1993	Laidlaw Waste Systems	A health impact assessment concluded that radiological contaminants from site sources were not a threat to site workers, the general public, or the environment.
1994	Laidlaw Waste Systems	A health assessment analyzed chemical constituents of the landfill gas collection system and concluded that landfill gas composition was similar to EPA-reported averages, and that exposures to site workers were below analytical detection limits.
1994	OU-1 Respondent Group	An overland gamma survey conducted in and in the immediate vicinity of OU-1 identified radiologically-contaminated hot spots both inside and outside of OU-1 boundaries, and recommended alteration of those boundaries.
1996	Laidlaw Waste Systems	A hydrogeology study of the West Lake Landfill site and proposed sampling locations for groundwater, leachate, surface water and sediments.
1996	West Lake Respondent Group	A study of the installation of groundwater monitoring wells, collection of groundwater samples, groundwater elevation monitoring, and aquifer testing in and adjacent to Radiological Areas 1 and 2 at the West Lake Landfill.

TABLE 2-1. SITE HISTORY SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Year(s)	Investigation Conducted for:	Description
1997	West Lake OU-1 Respondents Group	A summary to present the various site characterization activities for use in completing the RI, BRA and FS for OU-1. Summarized investigative activities that have taken place, description and display of the data documenting the location and characteristics of subsurface and surface features, description and display of the data documenting contamination at the Site including the affected media, location, types, physical state, contaminant concentrations and quantities, and documentation of the location, dimensions, physical condition, and varying concentration of each contaminant throughout each source and the extent of contaminant migration through each of the affected media.
1997	Allied Waste Industries, Inc.	Results of site characterization activities conducted as par of the West Lake Landfill OU-2 RI/FS. A review of investigative activities that have taken place, a description of data collected to document the location and characteristics of surface and subsurface features and contamination including affected media, location, types, physical state, concentration of the contamination, and quantity, and the location, dimensions, physical condition and varying concentrations of each contaminant throughout each source and the extent of contaminant migration through each of the affected media.
2000	West Lake OU-1 Respondents Group	Presents the results of the various site cauterization activities for OU-1 at the West Lake Landfill. The report summarizes the results of field activities conducted to characterize the conditions at the Site, the sources of contaminants, the nature and extent of contaminants and associated impacts, and the fate and transport of the contaminants.
2005	Allied Waste Industries, Inc.	Present the results of the various site characterization activities for OU-2 at the West Lake Landfill and summarize the results of the activities being conducted to characterize site physical and biological characteristics, sources of contamination, site hydrogeologic conditions, quality of groundwater, surface water and sediments, and prepare a conceptual site model that identifies contaminant migration pathways and potential receptors.
2006	West Lake OU-1 Respondents Group	Feasibility study for OU-1 at West Lake Landfill to develop an appropriate range of waste management options that ensure the protection of human health and the environment and to assess each alternative.
2008	West Lake OU-1 Respondents Group	ROD for OU-1 at West Lake Landfill. Presents the selected remedy from the EPA, and accepted by the MDNR. The major components are installation of a landfill cover, consolidation of radiologically contaminated surface soil from the Buffer Zone/Crossroad Property to the containment area, apply groundwater monitoring and protection standards, surface water runoff control, gas monitoring and control, institutional controls to prevent land and resource uses that are inconsistent with a closed sanitary landfill containing long-lived radionuclides, and long term surveillance and maintenance of the remedy.
2008	Allied Waste Industries, Inc.	ROD for OU-2 at West Lake Landfill. Presents the selected remedy from the EPA, and accepted by the MDNR. Major components for the Inactive Sanitary Landfill are install landfill cover, apply groundwater monitoring and protection standards, surface water runoff control, gas monitoring and control, institutional controls to prevent land uses, and long term surveillance and maintenance of the remedy.
2011	West Lake Landfill OU-1 Respondents	The SFS was performed to provide additional evaluation of a select group of potential remedial alternatives for OU-1 at the West Lake Landfill. The EPA requested the SFS consisting of an engineering cost and analysis of the ROD selected remedy, and two remedial alternatives that would remove all material containing radionuclides at levels greater than those that would allow for unrestricted use of the radiologically contaminated areas in OU-1.
2015	USEPA, Region 7	Administrative report prepared by the USGS for the groundwater quality and potential origin of radium at the West Lake Landfill.
2015	Missouri Geological Survey	Groundwater investigation report summarizing existing groundwater data (as of 2015) and conducting additional investigation to determine if groundwater near landfill has been impacted by landfill operations. Focus on south quarry area. In addition to review of previously collected groundwater level and water quality data, five monitoring wells were installed on private property adjacent to BSLF site. Water quality sampling was conducted at the five newly installed wells as well as in 18 existing BSLF monitoring wells.
2016	Bridgeton Landfill, LLC	Technical report regarding the West Lake Landfill's groundwater monitoring network that evaluates groundwater quality at monitoring wells that are located near the North and South Quarry, but are not currently sampled as part of the facility's detection or assessment monitoring programs and an evaluation of the facility's current groundwater monitoring well network.
2017	Bridgeton Landfill, LLC	Evaluation report prepared as a follow-up to 2016 technical report and the additional groundwater monitoring performed at the facility in 2017.
2018	West Lake OU-1 Respondents Group	OU-1 ROD Amendment that provided an Amended Remedy based on a better understanding of the volume, concentration and location of RIM that may present an unacceptable risk, new information regarding the potential for RIM to leach under certain circumstances, concern that should a subsurface heating event occur, the heat could dry and desiccate a cap providing a conduit for increased release of radon from the subsurface and potentially for the leaching of RIM, and a determination that implementation of the 2008 ROD could not be accomplished without disturbance of both putrescible waste and RIM.
2018	West Lake OU-1 Respondents Group	RI Addendum to update discussion of the Site conditions, nature and extent of radionuclide and chemical occurrences, and other evaluations presented in the original RI for OU-1.
2018	West Lake Landfill OU-1 Respondents	Final FS for OU-1 which incorporates four additional measures or performance standards from the EPA, which are: the proposed landfill cover should meet UMTRCA guidance for a 1,000-year design period including additional thickness as necessary to prevent radiation emissions, air monitoring station for radioactive materials should be installed on-site and off-site, groundwater monitoring should be implemented at the waste management unit boundary and also at off-site locations, and 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.

Notes:
BRA - Baseline Risk Assessment
BTEX - Benzene, Toluene, Ethylbenzene, and Xylene
USEPA - United States Environmental Protection Agency
FS - Feasibility Study
MDNR - Missouri Department of Natural Resources
MW - Monitoring Well
OU - Inoperable Unit
RI - Remedial Investigation
ROD - Record of Decision
SFS - Supplemental Feasibility Study
TPH - Total Petroleum Hydrocarbons
UMTRCA - Uranium Mill Tailings Radiation Control Act
USGS - United States Geological Survey

TABLE 2-2. DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Date Ranges	Groundwater Elevations	Analytical Data	Surface Water Elevations	St. Charles USGS River Gauge Elevations	Field Parameters	Slug Tests	Packer Tests	Borehole Logs and Well Construction Diagrams	Report ID Pertinent to Date Ranges
1976-1986	1,053	8,113	-	728	496	-	-	21	1979, Reitz & Jens Inc., Historic Fluid Levels 1986, Burns & McDonnell, Hydrogeologic Investigation Report
1987-1996	2,053	13,847	28	3,410	94	77	49	86	1989, NRC, Site Characterization and Remedial Action Concepts 1996, Golder, Physical Characterization Technical Memorandum 1996, McLaren Hart, Groundwater Conditions Report WLL Areas 1 and 2
1997	277	17,536	109	360	353	-	-	-	1997, EMSI, Site Characterization Summary Report OU-1 1997, Water Management Consultants, WLL OU-2 RI/FS Site Characterization Summary Report
1998-2011	1,502	46,257	-	5,005	2,188	-	-	-	2000, EMSI, OU-1 RI 2005, Herst & Associates, OU-2 RI 2006, EMSI, OU-1 FS 2008, OU-1 & OU-2 ROD 2011, EMSI, Supplemental FS
2012-2018	1,927	137,011	-	2,459	4,325	-	-	14	2015, USGS, Background Study 2015, MGS, Groundwater Investigation Report 2013, Herst & Associates, Groundwater Statistical Analysis Semi-Annual Report 2015, Herst & Associates, Quarterly Assessment Monitoring Event Reports (3) 2016, Feezor Engineering, Groundwater Technical Report 2016, Feezor Engineering, Quarterly Assessment Monitoring Event Reports (4) 2016, Jett Environmental Consulting, Quarterly Groundwater Statistical Analysis Reports (4) 2017, Feezor Engineering, Quarterly Assessment Monitoring Event Reports (4) 2017, Jett Environmental Consulting, Quarterly Groundwater Statistical Analysis Reports (4) 2017, Jett Environmental Consulting, Groundwater Annual Assessment Monitoring Report 2017, Feezor Engineering, Groundwater Evaluation Report 2018, EMSI, OU-1 RI Addendum 2018, EMSI, OU-1 Final FS 2018, USGS St. Charles Stream Gauge Historical Records
Totals:	**6,812**	**222,764**	**137**	**11,962**	**7,456**	**77**	**49**	**121**	

Notes:
EMSI - Engineering Management Support, Inc
FS - Feasibility Study
MGS - Missouri Geological Survey
NRC - Nuclear Regulatory Commission
OU - Inoperable Unit
RI - Remedial Investigation
USGS - United States Geological Survey
WLL - West Lake Landfill

TABLE 3-1a. GENERALIZED STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

System	Series	Group	Symbol	Formation	Thickness (ft)	Description	Dominant Lithology	Water-Bearing Character
Quaternary	Holocene		Qal	Alluvium	10-215	Sand, gravel, silt, and clay on floodplains of major rivers and smaller streams	Sand, gravel, silt, and clay	Some wells yield over 2,000 gpm.
	Pleistocene			Loess	1-110		Silt	Not water yielding.
				Glacial Till	0-55		Pebbly clay and silt	
			Qt	Terrace Deposits		Sand, gravel, and silt	Sand, gravel, and silt	
Tertiary	Pliocene or Miocene		Tg	Grover Gravel		High level deposits of gravel, sand, and clay	Rounded, polished, light-brown chert pebbles	
Pennsylvanian	Missourian	Pleasanton	Pp	Undivided	0-100	Shale and sandstone	Shales, siltstones, "dirty" sandstones, coal beds, and thin limestone beds.	Generally yields very small quantities of water to wells between 0 to 10 gpm.
	Desmoinesian	Marmaton	Pm	Undivided	80	Intercalated shale, limestone, clay, and coal		
		Cherokee	Pc	Undivided	0-100	Cycles of sandstone, siltstone, shale, clay, and coal		
		Atokan		Cheltenham Formation	Unknown			
Mississippian	Meramecian		Msg	Ste. Genevieve Limestone	0-150	White, massive, coarsely crystaline, sandy, clastic limestone with oolitic beds and gray, black, or red chert. Some fine grained calcaerous sandstones separated by argillaceous limestone present in the upper part of the formation.	Argillaceous to arenaceous limestone	Yields small to moderate quantities of water to wells ranging between 5 to 50 gpm. Higher yields are reported locally.
			Msl	St. Louis Limestone	100-250	Dark-gray, finely crystalline to lithographic, thin- to medium-bedded to massive limestone with thin beds of bluish gray shale. Also contains dolomite, cherty limestone, fossiliferous limestone, and evaporites. Some beds are sandy and cross laminated		
			Ms	Salem Formation	70-180	Fossiliferous calcarenite consisting of broken fossil fragments and small fossils set in a matrix that ranges from micrite to sparite with common banded overgrowths around fossils. Also contains minor lithologies including fine-grained limestone, sandstone, chert, and evaporites.		
			Mw	Warsaw Formation	60-100	Dark, fissile shale and intercalated argillaceous and silty dolomite or dolomitic limestone in upper half; shaly to argillaceous, cherty, very fossiliferous, finely crystalline, dolomitic limestone in the lower half. Contains abundance of corkscrew byrozoan *Archimedes*.	Shales and silty dolomite in upper half, dolomitic limestone in lower half	
	Osagean		Mkbf	Keokuk and Burlington Limestones	175-200	Keokuk Limestone - Medium crystalline limestone and lesser finely and coarsely crystalline limestone with common crinoidal fossil horizons and light-gray, nodular chert. Keokuk contains greater heterogeneity of fossils with more abundant bryozoans, corals, and brachiopods. Burlington Limestone - Light-colored, medium to coarsely crystalline limestone with abundant large crinoid stems. Medium to thick beds are commonly cross stratified and occasionally glauconitic. Erratic occurrence of 1-10 ft chert zones separated by 30-50 ft of chert free zones.	Cherty limestone	
			Mkbf	Fern Glen Formation	30-60	Red and green calcareous shale, shaly limestone, and a basal bed of massive, dolomitic limestone.	Red limestone and shale	
	Kinderhookian		Mc	Chouteau Limestone	3-70	Gray, argillaceous limestone in irregular beds less than 1 ft thick that have wavy bedding planes and shale partings. Beds are fossiliferous with crinoids dominant.	Argillaceous limestone	
Devonian	Upper	Sulphur Springs	Du	Bushberg Sandstone	0-60	Limestone, sandstone, calcareous siltstone, and hard fissile, carbonaceous shale. Uppermost beds are non-calcareous friable sandstone or very sandy limestone. Lower beds are massive well-indurated, very fossiliferous, crystalline limestone and fine-grained, poorly indurated, cherty, moderately fossiliferous sandy limestone.	Limestone and sandstone	
			Du	Glen Park Limestone				
			Du	Grassy Creek Shale	0-50		Fissile, carbonaceous shale	
Silurian			Sou	Undivided	0-200	Dolomite containing sparse fossils and oolitic limestone.	Cherty limestone	
Ordovician	Cincinnation		Om	Maquoketa Shale	0-150	Massive platy mudstone to fissile claystone or shale with basal argillaceous dolomite and calcareous mudstone. Thin layers in lowermost beds contain small phosphatic grains and microscopic fossils.	Silty, calcareous or dolomititc shale	Probably constitutes an confining influence of water movement
			-	Cape Limestone	0-5		Argillaceous limestone	Yields small to moderate quantities of water to wells ranging between 3 to 50 gpm.
	Champlainian		Ok	Kimmswick Formation	60-120	Coarsely crystalline, light-colored, medium-bedded to massive fossiliferous limestone. *Receptaculites* is an index fossil	Massive limestone	
			Od	Decorah Formation	30-60	Guttenberg Limestone - light-gray, thick-bedded, sublithographic limestone and intercalated red to reddish-brown shale. Kings Lake Limestone - thinly bedded, silty and dolomitic, fossiliferous, finely crystalline to coquinoidal limestone with shale partings. Spechts Ferry Formation - green to brown shale and minor calcarenite, argillaceous limestone, and limestone over massive bed of fine-grained, slightly argillaceous limestone with basal shale.	Shale with interbedded limestone	Probably acts as a confining bed locally.
			Op	Plattin Formation	80-300	Gray mudstone interbedded with thin, laminated to cross-laminated grainstone	Finely crystalline limestone	
			-	Rock Levee Formation	0-93		Dolomite and limestone, some shale	
			Oj	Joachim Dolomite	60-160	Consists of five members: Metz, Matson, Defiance, Boles, and Augusta. Metz Member - Yellow-brown, laminated, shaly dolomite with algal stromatolies, mud cracks, scour surfaces, and birdseye structures. Matson Member - Dense, dark-brown, fetid, algal dolomite. Defiance Member - Silty, shaly dolomite Boles Member - Silty, shaly dolomite containing seven discontinuous layers of white to black chert Augusta Member - Alternating layers of shale, siltstone, and dolomitic sandstone.	Primarily argillaceous dolomite	
			Osp	St. Peter Sandstone	60-165	Well-sorted, medium- to fine-grained quartzose sandstone and orthoquartzite with rounded spherical grains	Silty sandstone, cherty limestone grading upward into quartzose	Yields moderate quantities of water to wells ranging between 10 to 140 gpm.
			-	Everton Formation	0-130			
	Canadian		Opow	Powell Dolomite	30-150	Medium to finely crystalline dolomite containing thin beds of green shale and fine-grained sandstone.	Sandy and cherty dolomites and sandstone	Yields small to large quantities of water to wells ranging between 10 to 300 gpm. Upper part of aquifer group yields only small amounts of water to wells.
			Oc	Cotter Dolomite	180-330	Brown to gray, medium to finely crystalline dolomite containing localized thin beds of green shale and sandstone and highly variable chert content.		
			Ojc	Jefferson City Dolomite	140-275	Brown, medium to finely crystalline dolomite and agrillaceous dolomite and localized lenses of orthoquartzite, conglomerate, and shale.		
			Or	Roubidoux Formation	110-170	Interbedded sandstone, sandy dolomite, chert, sandy chert, and cherty dolomite		
			Og	Gasconade Dolomite Gunter Sandstone Member	230-290	Thin- to medium-beded, medium to finely crystalline dolomite with varying amounts of chert and minor sandstone lenses. Gunter Sandstone Member - 25 to 30 feet of medium-grained quartzose sandstone and sandy dolomite.		
Cambrian	Upper		O€e	Eminence Dolomite	110-285	Sandy, fine- to medium-grained dolomitized oolitic to coquinoidal calcarenite.	Cherty dolomites, siltstones, sandstone, and shale	Yields moderate to large quantities to wells ranging between 10 to 400 gpm.
			€p	Potosi Dolomite	100-550	Slightly argillaceous, medium to finely crystalline dolomite.		
		Elvins	€dd	Derby-Doerun Dolomite	120-155	Dense, medium to finely crystalline dolomite over irregularly bedded, shaly to silty, glauconitic dolomititzed cacarenite.		
			€d	Davis Formation	30-240	Repeating sequences of shale, siltstone, and silty dolomite or limestone.		
Precambrian			Yi	Igneous Crystalline Basement		Gabbro, norite, and diorite intruded by granitic dikes and leucogranite.	Igneous and metamorphic rocks	Does not yield water to wells in this area

Notes:
Highlighted formations are regional aquifers
Descriptions and Thickness adapted from Harrison 1997
Dominant Lithology and Water-Bearing Character from Miller et al. 1974
ft - feet
gpm - gallons per minute

TABLE 3-1b. SITE-SPECIFIC STATIGRAPHIC COLUMN
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Era	System	Series	Formation	Thickness (ft.)	Dominant Lithology	Regional Aquifer Unit
Cenozoic	Quaternary	Holocene	Alluvium	10-120	Missouri River deposits consisting primarily of sand and gravel with minor silt interbeds.	Missouri River Alluvial Aquifer
			Terrace Deposit		Sand, gravel and silt deposited during fluvial events; minor lacustrine clay.	
		Pleistocene	Loess		Windblown silt, clayey silt and silty loam.	Not Classified
Unconformity						
Paleozoic	Mississippian	Meramecian	St. Louis Limestone	100-250	Thin to medium-bedded limestone, containing minor dolomite, cherty limestone, fossiliferous limestone, and evaporite lithologies. Thin beds of shale are present throughout the formation.	Post-Maquoketa Aquifer
			Salem	70-180	Fossiliferous calcarenite, characterized by a distinct chert zone near the top of the formation in the St. Louis area. Numerous minor lithologies are present, including fine-grained limestone, sandstone, chert, and evaporites.	
			Warsaw	60-100	Upper half of the formation is comprised of fissile shale and intercalated argillaceous and silty dolomite or dolomitic limestone. Lower half is composed of fossiliferous, dolomitic limestone that is shaly and argillaceous.	
		Osagean	Keokuk-Burlington Limestones (undivided)	175-200	Keokuk limestone is characterized by medium crystalline limestone with an abundance of fossils. Nodular chert is common in the lowermost and uppermost thirds of the formation. The Burlington limestone is similar limestone in composition to the Keokuk into which it grades. Beds are medium to thick and commonly cross-stratified with some glauconite. Chert occurs erratically, in high concentrated zones 1-10 feet thick, separated by chert-free zones 30-50 feet thick.	

Note:
ft. - feet

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
D-3	D	3	AD	I	WL-105A	8/1/1995	1069178	836047	468.34	465.12	EMSI 2012 Survey	3.22	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	109.62	106.5	357.798	3.12	96.5	10	96.5	106.5	370.298	360.298	109.62	As-built
D-6	D	6	AD	I	WL-206	8/1/1995	1070235.1	834723.49	447.62	444.33	EMSI 2012 Survey	3.291	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	109.7	106.5	334.998	3.2	96.5	10	96.5	106.5	347.498	337.498	109.7	As-built
D-12	D	12	AD	I	WL-216A	10/1/1995	1069877.2	835110.76	479.74	477.16	EMSI 2012 Survey	2.579	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	146.21	143.7	330.798	2.51	133.7	10	133.7	143.7	343.298	333.298	146.21	As-built
D-13	D	13	AD	I	WL-224	10/1/1995	1070527	835776.56	470.25	467.73	EMSI 2012 Survey	2.5123	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	135.7	133	334.998	2.7	123	10	123	133	344.998	334.998	135.7	As-built
D-14	D	14	LR	X	WL-109B	10/1/1995	1068988.9	836700.02	482.97	480.71	EMSI 2012 Survey	2.2604	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	61.77	58.5	425.098	3.27	53.5	5	53.5	58.5	430.598	425.598	61.77	As-built
D-81	D	81	AD	I	NA	8/13/1984	1067378.7	834638.55	450.65	448.07	EMSI 2012 Survey	2.58	5" (0 - 15 ft), 4 1/2" (15 - 61.5 ft)	2	PVC	0.01 inch machine slot	NA	NA	61.5	385.898	3	48	15	45	60	402.398	387.398	60	RIA
D-83	D	83	AD	I	NA	8/16/1984	1070970.9	834807.79	448.21	444.84	EMSI 2012 Survey	3.369	5" (0-15 ft) 4 1/2" (15-115.3 ft)	2	PVC	0.01 inch machine slot	NA	NA	115.3	328.698	3.2	80.2	20	77	97	366.998	346.998	97	RIA
D-85	D	85	AD	A	NA	8/1/1984	1069667.3	836605.17	457.26	454.26	EMSI 2012 Survey	3.007	5" (0-10 ft) 4 1/2" (10-84.1 ft)	2	PVC	0.01 inch machine slot	NA	NA	84.1	372.648	3	65	20	62	82	390.698	370.698	82	RIA
D-87	D	87	AD	I	NA	8/1/1984	1069252.4	835579.37	464.47	461.22	EMSI 2012 Survey	3.251	5" (0 - 30 ft) 4 1/2" (30-111.7 ft)	2	PVC	0.01 inch machine slot	NA	NA	111.7	347.898	3	94	20	91	111	368.598	348.598	111	RIA
D-89	D	89	AI	I	NA	8/27/1984	1067011	835274.7	456.7	453.7	EMSI 2018 - Calculated	NA	5" (0-25 ft) 4 1/2" (25-49 ft)	2	PVC	0.01 inch machine slot	NA	NA	49	404.698	3	36	15	33	48	420.698	405.698	48	RIA
D-90	D	90	AI	X	NA	8/7/1985	1066201	834474.7	450.2	445.6	EMSI 2018 - Calculated	NA	4", 3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	47	398.598	NA	NA	NA	37	47	408.598	398.598	47	RIA
D-91	D	91	AI	X	NA	8/1/1985	1065261	833944.7	452.97	447.6	EMSI 2018 - Calculated	NA	4", 3 7/8"	2	Sch 50 PVC Riser, Sch 20 PVC Screen	200 slots	NA	NA	45	402.598	5	40	10	35	45	412.598	402.598	45	RIA
D-92	D	92	AD	X	NA	4/9/1985	1069801	835264.7	474.97	475.1	EMSI 2018 - Calculated	NA	4" (0 - 40 ft), 3 7/8" (40 -143.6 ft)	2	PVC	0.01 inch machine slot	NA	NA	143.6	331.498	-0.2	122.8	20	123	143	352.098	332.098	143	RIA
D-93	D	93	AD	I	NA	4/18/1985	1069369.8	834443.56	450.84	448.28	EMSI 2012 Survey	2.556	6" (0-8 ft) 4 7/8" (8-119.2ft)	2	PVC	0.01 inch machine slot	NA	NA	119.2	337.798	3.3	95.3	20	92	112	358.298	338.298	112	RIA
D-94	D	94	AD	X	NA	4/1/1985	1070686	835994.7	442.28	438.1	EMSI 2018 - Calculated	NA	3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	109	329.098	2.6	91.6	20	86	106	352.098	332.098	106	RIA
D-95	D	95	AD	X	NA	4/1/1985	1070861.5	836524.52	452.69	449.6	Georeferenced/ Calculated	NA	3 7/8"	2	PVC	0.01 inch machine slot	NA	NA	101	348.598	3.3	84.3	20	81	101	368.598	348.598	101	RIA
F-1-D	F	1	AD	X	NA	8/1/1990	1068649.7	836034.74	461.23	458.38	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	NA	79.5	NA	2.85	76.95	5	NA	NA	NA	NA	79.1	RIA
F-1-S	F	1	AS	X	NA	8/1/1990	1068644	836040.05	460.95	458.7	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	34.9	32.9	NA	2.4	22.5	10	22.5	32.5	436.198	426.198	34.9	As-built
F-2	F	2	AS	X	NA	8/10/1990	1067726	834591.7	449.7	447.5	EMSI 2018	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	27.55	25.7	NA	2.25	10.3	15	10.3	25.3	437.198	422.198	27.55	As-built
F-3	F	3	AS	X	NA	8/1/1990	1070530.8	835994.53	468.83	466.53	McLaren Hart 1996	NA	8"	2	Sch 40 PVC	10 slot	Locking steel protective cover	45.1	46	NA	2.3	32.8	10	32.8	42.8	433.728	423.728	45.1	As-built
I-2	I	2	AI	X	NA	Unknown	1069739.2	834386.88	446.01	442.8	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	52.71	52	393.298	3.21	39.5	10	39.5	49.5	403.298	393.298	52.71	As-built
I-4	I	4	AI	I	WL-105B	8/1/1995	1069190	836064.6	465.74	462.95	EMSI 2012 Survey	2.789	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	79.07	79	389.098	2.57	66.5	10	66.5	76.5	399.098	389.098	79.07	As-built
I-7	I	7	AI	U	WL-207	Unknown	1070784	834474.57	446.57	444.1	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	49.97	50	396.598	2.47	37.5	10	37.5	47.5	406.598	396.598	49.97	As-built
I-9	I	9	AI	I	WL-229	9/1/1995	1069358.4	834444.23	449.88	447.92	EMSI 2012 Survey	1.964	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	55.59	55.6	394.998	2.49	43.1	10	43.1	53.1	404.998	394.998	55.59	As-built
I-11	I	11	AI	I	WL-216C	8/1/1995	1069860.2	835099.74	480.11	477.58	EMSI 2012 Survey	2.526	8.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	93.17	93	386.698	2.67	80.5	10	80.5	90.5	396.698	386.698	93.17	As-built
I-50	I	50	AI	X	N-1	10/1/1983	1065231.3	834006.66	453.26	448.6	McLaren Hart 1996	NA	NA	0	0	0	NA	NA	40.6	407.998	4.48	35.08	10	30.6	40.6	417.998	407.998	40.6	RIA
I-55	I	55	AI	X	35	6/26/1978	1067828	834649.7	NA	471.5	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60	RIA
I-56	I	56	AI	X	34	6/27/1978	1068098	834661.7	NA	474.7	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60 (61.1 well schedule)	RIA
I-58	I	58	AI	X	40	6/28/1978	1068915	834632.7	NA	477.1	EMSI 2018	NA	6"	2	PVC	NA	NA	NA	60	NA	NA	NA	NA	NA	NA	NA	NA	60	RIA
I-59	I	59	AI	X	N-2	10/1/1983	1069373	834463.7	NA	444.5	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	43.5	NA	NA	NA	NA	NA	NA	NA	NA	43.5	RIA
I-62	I	62	AI	I	N-3	10/1/1983	1070979.1	834821.33	446.14	444.34	EMSI 2012 Survey	1.7984	NA	NA	NA	NA	NA	NA	44	399.698	1.98	35.98	10	34	44	409.698	399.698	44	RIA
I-65	I	65	AI	I	N-4	10/1/1983	1070994.1	835507.99	441.26	438.93	EMSI 2012 Survey	2.3269	NA	NA	NA	NA	NA	NA	36	402.098	3.3	29.3	10	26	36	412.098	402.098	36	RIA
I-66	I	66	AI	I	N-5	10/1/1983	1070645.4	836025.96	441.7	438.96	EMSI 2012 Survey	2.7373	NA	NA	NA	NA	NA	NA	36.9	400.398	4.1	31	10	26.9	36.9	410.398	400.398	36.9	RIA

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
I-67	I	67	AI	I	N-6	10/1/1983	1070142.4	836418.55	441.68	439.34	EMSI 2012 Survey	2.342	NA	NA	NA	NA	NA	NA	35.4	400.698	2.58	27.98	10	25.4	35.4	410.698	400.698	35.4	RIA
I-68	I	68	AI	A	N-7	10/1/1983	1069613	836861.2	450.2	447.41	EMSI 2012 Survey	2.794	NA	NA	NA	NA	NA	NA	31.2	409.298	7.42	28.62	10	21.2	31.2	419.298	409.298	31.2	RIA
I-72	I	72	AI	X	39	6/1/1978	1067931	835519.7	465	462.3	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	50	412.298	2.7	49.7	3	47	50	415.298	412.298	50	RIA
I-73	I	73	AI	A	38	6/1/1978	1067735.8	835745.29	461.08	457.98	EMSI 2012 Survey	3.1019	NA	NA	NA	NA	NA	NA	50	412.298	3.7	50.7	3	43.2	46.2	415.298	412.298	50	RIA
LR-100	LR	100	LR	I	NA	10/4/1995	1067334.4	835068.65	468.11	465.34	EMSI 2012 Survey	2.77	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	26.72	26	442.298	1.92	19.7	4.8	19.7	24.5	447.098	442.298	26.72	As-built
LR-101	LR	101	LR	X	NA	10/10/1995	1068443.2	834893.11	NA	NA	Golder 1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	RIA
LR-102	LR	102	LR	X	NA	10/8/1995	1068978.2	834962.83	513.12	511.6	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	61.52	76	451.898	1.52	54.9	4.8	54.9	59.7	456.698	451.898	61.52	As-built
LR-103	LR	103	LR	I	NA	10/20/1995	1068567.5	835392.18	470.24	466.87	EMSI 2012 Survey	3.371	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	39.8	40	420.998	1.1	28.6	9.8	28.6	38.4	431.098	421.298	39.8	As-built
LR-104	LR	104	LR	I	NA	10/18/1995	1068105.8	835808.49	459.65	457.79	EMSI 2012 Survey	1.8591	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	40.23	40	419.098	1.73	28.4	9.8	28.4	38.2	429.198	419.398	40.23	As-built
LR-105	LR	105	LR	I	NA	10/3/1995	1067750.4	834699.95	485.21	482.36	EMSI 2012 Survey	2.843	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	38.89	38	447.498	2.59	26.2	9.8	26.2	36	457.598	447.798	38.89	As-built
MW-41	MW	41		X	NA	6/1/1978	1069328	834551.7	NA	NA	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	RIA
MW-101	MW	101	AS	X	NA	4/1/1990	1070871.5	834598.7	446.43	444.96	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	29.6	25	NA	2.3	17.3	10	17.3	27.3	427.658	417.658	29.6	As-built
MW-102	MW	102	AS	X	NA	4/1/1990	1070135.7	834707.41	447.83	445.66	EMSI 2012 Survey	2.173	8	2	PVC	0.010 slotted	Locking steel protective cover	29.1	25	NA	2.3	16.8	10	16.8	26.8	428.86	418.86	29.1	As-built
MW-103	MW	103	AS	I	NA	4/1/1990	1068668.9	834508.8	438.92	437.07	EMSI 2012 Survey	1.85	8	2	PVC	0.010 slotted	Locking steel protective cover	21.1	18	NA	2.7	8.4	10	8.4	18.4	428.665	418.665	21.1	As-built
MW-104	MW	104	AS	I	NA	4/1/1990	1067565.7	834513.71	440.81	437.81	EMSI 2012 Survey	3.003	8	2	PVC	0.010 slotted	Locking steel protective cover	22.8	17	NA	2.9	9.9	10	9.9	19.9	427.909	417.909	22.8	As-built
MW-105	MW	105	AS	X	NA	4/12/1990	1067565.7	833405.95	439.77	442.07	McLaren Hart 1996*	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	17.3	15	15	2.3	7.3	10	5	15	437.068	427.068	NA	As-built
MW-106	MW	106	AS	X	NA	4/12/1990	1065996.7	833791.62	443.38	439.77	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	NA	15		NA	NA	10	5	15	434.768	424.768	NA	As-built
MW-107	MW	107	AS	X	NA	4/1/1990	1064711.7	833775.82	447.74	NA	McLaren Hart 1996	NA	8	2	PVC	0.010 slotted	Locking steel protective cover	NA	15	NA	NA	5	10	5	10	NA	NA	na	As-built
MW-1201	MW	1201	AS	I	PZ-1201-SS & 1201	3/1/1985	1067344	837077.7	482.44	480.2	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.198	2.24	53	197	53	250	427.198	230.198	250	RIA
MW-1202	MW	1202	AS	X	NA	3/1/1985	1067384	837049.7	482.18	480.1	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.098	2.08	NA	NA	NA	NA	NA	NA	250	RIA
MW-1203	MW	1203	AS	X	NA	7/1/1985	1067230	837129.7	483.61	480.7	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	250	230.698	2.91	NA	NA	NA	NA	NA	NA	250	RIA
MW-1204	MW	1204	SD	A	NA	4/1/1991	1066461.1	835998.97	485.36	483.09	EMSI 2012 Survey	2.267	8	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	225.8	227	NA	2.3	213.5	10	213.5	223.5	269.591	259.591	225.8	As-built
MW-1205	MW	1205	AS	X	NA	4/1/1991	1067428.4	835795.45	386.37	384.1	Foth & Van Dyke 1991	NA	11 and 6	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	125.3	132	NA	2.3	113	10	113	123	271.098	261.098	125.3	As-built
MW-1206	MW	1206	AS	X	NA	3/1/1991	1067437.2	835799.07	388.08	385.8	Foth & Van Dyke 1991	NA	8	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	75.3	73	NA	2.3	63	10	63	73	322.798	312.798	75.3	As-built
PZ-100-KS	PZ	100	KS	A	1209	2/17/1995	1068883.1	837386.27	485.95	484.82	EMSI 2012 Survey	1.134	10 1/4" (0-34 ft) 5 7/8" (34-391 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	386.01	391.2	99.228	1.88	374	9.8	374	383.8	109.358	99.558	386.01	As-built
PZ-100-SD	PZ	100	SD	A	1208	2/23/1995	1068892.8	837369.99	486.08	484.49	EMSI 2012 Survey	1.592	10 1/4 "(0-51 ft) 5 7/8" (51-246 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	246.4	246	239.018	1.47	234.8	9.8	234.8	244.6	249.148	239.348	246.4	As-built
PZ-100-SS	PZ	100	SS	A	1207	2/25/1995	1068908.8	837349.65	486.15	484.84	EMSI 2012 Survey	1.312	10 1/4 "(0-51 ft) 5 7/8" (51-94.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	95.42	94.5	390.018	1.49	73.96	19.64	73.96	93.6	409.988	390.348	95.42	As-built
PZ-101-SS	PZ	101	SS	A	1210	3/6/1995	1068513.9	836797.32	491.16	488.95	EMSI 2012 Survey	2.214	10 1/4 "(0-14 ft) 5 7/8" (14-140 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	141.4	140	334.878	1.79	129.48	9.8	129.48	139.28	345.008	335.208	141.4	As-built
PZ-102R-SS	PZ	102	SS	A	1211	6/18/1995	1068172.7	837033.55	486.05	484.18	EMSI 2012 Survey	1.874	10 1/4 "(0-35 ft) 5 7/8" (35-90.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	91.08	90.3	394.138	1.12	79.83	9.8	79.83	89.63	404.268	394.468	91.08	As-built
PZ-102-SS	PZ	102	SS	A	NA	3/12/1995	1068128.7	837062.59	484.25	482.06	EMSI 2012 Survey	2.185	10 1/4 "(0-37 ft) 5 7/8" (37-90.4 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	92.63	90.4	390.818	1.8	79.7	9.8	79.7	89.5	401.948	392.148	92.63	As-built
PZ-103-SS	PZ	103	SS	A	1212	2/26/1995	1067701.3	836897.82	483.8	479.9	EMSI 2012 Survey	3.899	10 1/4 "(0-51 ft) 5 7/8" (51-145.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	147.22	145.5	332.548	2.39	134.7	9.8	134.7	144.5	342.678	332.878	147.22	As-built
PZ-104-KS	PZ	104	KS	A	1215	6/19/1995	1067034	836995.22	484.2	481.84	EMSI 2012 Survey	2.359	10 1/4 "(0-249 ft) 5 7/8" (249-408 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 483.3 - 233.32	409.22	408	74.418	1.72	397.37	9.8	397.37	407.17	84.548	74.748	409.22	As-built
PZ-104-SD	PZ	104	SD	A	1214	6/17/1995	1067054.1	837009.27	483.75	481.47	EMSI 2012 Survey	2.277	10 1/4 "(0-38 ft) 5 7/8" (38-252.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	246.92	252.5	236.368	1.59	235.2	9.8	235.2	245	246.498	236.698	246.92	As-built

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
PZ-104-SS	PZ	104	SS	A	1213	6/4/1995	1067068.8	837021.99	483.6	481.65	EMSI 2012 Survey	1.948	10 1/4 "(0-37 ft) 5 7/8" (37-145 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	146.7	145	336.528	2.07	134.5	9.8	134.5	144.3	346.658	336.858	146.7	As-built
PZ-105-SS	PZ	105	SS	A	1216	5/24/1995	1066462.1	836405.05	483.64	480.81	EMSI 2012 Survey	2.83	10 1/4 "(0-45 ft) 5 7/8" (45-149 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 482.7 - 436.22	151.02	149	332.188	2.39	138.5	9.8	138.5	148.3	342.318	332.518	151.02	As-built
PZ-106-KS	PZ	106	KS	A	1219	3/23/1995	1066744.7	835606.9	464.32	462.14	EMSI 2012 Survey	2.181	10 1/4 "(0-204 ft) 5 7/8" (204-375 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 463.3 - 257.77	376.39	375	87.468	2.49	363.75	9.8	363.75	373.57	97.618	87.798	376.39	As-built
PZ-106-SD	PZ	106	SD	A	1218	3/24/1995	1066755.7	835590.7	463.44	461.42	EMSI 2012 Survey	2.017	10 1/4 "(0-26 ft) 5 7/8" (26-201.1 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	202.9	201.1	260.118	1.97	190.79	9.8	190.79	200.59	270.258	260.458	202.9	As-built
PZ-106-SS	PZ	106	SS	A	1217	4/5/1995	1066767.1	835574.64	462.7	460.95	EMSI 2012 Survey	1.752	10 1/4 "(0-23 ft) 5 7/8" (23-165.4 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	297.2	165.4	295.118	1.75	155.3	9.8	155.3	165.1	305.248	295.448	297.2	As-built
PZ-107-SS	PZ	107	SS	A	1220	5/22/1995	1067204	835429.35	465	462.85	EMSI 2012 Survey	2.151	10 1/4 "(0-32ft) 5 7/8" (32-103 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 463.6 - 407.63	104.76	103	359.498	2.03	92.6	9.8	92.6	102.4	369.628	359.828	104.76	As-built
PZ-108-SS	PZ	108	SS	X	1221	3/29/1995	1067719.3	836147.31	455.8	453.7	Golder 1996	NA	10 1/4 "(0-20ft) 5 7/8" (20-143.9 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	145.76	143.9	310.038	2.08	133.54	9.8	133.54	143.35	320.178	310.368	145.76	As-built
PZ-109-SS	PZ	109	SS	A	1222	4/25/1995	1068052.3	836318.5	458.9	456.9	EMSI 2012 Survey	2.002	10 1/4 "(0-15ft) 5 7/8" (15-135.7 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	137.56	135.7	320.538	1.73	125.7	9.8	125.7	135.5	330.668	320.868	137.56	As-built
PZ-110-SS	PZ	110	SS	I	1223	5/20/1995	1068377	836094.3	461.06	458.03	EMSI 2012 Survey	3.0292	10 1/4 "(0-61ft) 5 7/8" (61-111.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 457.3 - 395.84	113.37	111.5	345.138	2.07	100.9	9.8	100.9	110.7	355.538	345.738	113.37	As-built
PZ-111-KS	PZ	111	KS	A	1225	5/6/1995	1068662	836025.21	465.4	461.34	EMSI 2012 Survey	4.0621	14 3/4 "(0-84ft) 10" (84.0-215.5) 5 7/8" (215.5-368.8 ft)	2	Sch 80 PVC	0.01 inch machine slot	10 7/8" Steel Casing elev 459.9 - 375.38; 6 5/8" Steel Casing elev 460.2 - 243.88	368.99	368.8	91.478	1.69	357.15	9.8	357.15	366.96	101.628	91.818	368.99	As-built
PZ-111-SD	PZ	111	SD	A	1224	4/21/1995	1068678.2	836009	466.17	461.95	EMSI 2012 Survey	4.2226	10" (0-98 ft) 5 7/8" (98-210 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 459.7 - 361.22	211.83	210	249.318	2.33	199.4	9.8	199.4	209.2	259.418	249.618	211.83	As-built
PZ-111-SS	PZ	111	SS	A	NA	8/29/2017	1068631.9	835989.4	464.23	461.71	Feezor 2017	NA	8"	2	Sch 80 PVC	0.01 inch machine slot	6" Steel Casing 0 - 93 ft bgs	NA	0	0	0	0	0	462.11	462.11	0	0	0	RIA
PZ-112-AS	PZ	112	AS	A	1226	4/10/1995	1069042.8	835849.45	462.13	458.41	EMSI 2012 Survey	3.722	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	36.63	36	422.798	1.9	29.6	4.8	29.6	34.4	427.928	423.128	36.63	As-built
PZ-113-AD	PZ	113	AD	A	1228	5/3/1995	1069274	835934.5	461.84	459.47	EMSI 2012 Survey	2.368	10 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	110.33	108.7	350.728	1.6	98.6	9.8	98.6	108.4	360.858	351.058	110.33	As-built
PZ-113-AS	PZ	113	AS	A	1227	4/11/1995	1069265	835922.4	461.78	459.58	EMSI 2012 Survey	2.203	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	40.53	40	420.488	1.5	28.9	9.8	28.9	38.7	430.618	420.818	40.53	As-built
PZ-113-SS	PZ	113	SS	A	1229	5/20/1995	1069283	835951.3	462.26	459.65	EMSI 2012 Survey	2.601	9 3/4" (0-115 ft) 5 7/8" (115-159 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460.4 - 344.96	160.51	159	300.858	1.81	148.57	9.8	148.57	158.37	310.988	301.188	160.51	As-built
PZ-114-AS	PZ	114	AS	A	1230	4/20/1995	1069460	836942.99	451.74	449.56	EMSI 2012 Survey	2.175	10 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	31.56	30.5	419.348	1.53	19.9	9.8	19.9	29.7	429.478	419.678	31.56	As-built
PZ-115-SS	PZ	115	SS	A	1231	5/21/1995	1069449.6	836929.87	452.5	450.21	EMSI 2012 Survey	2.284	9 7/8" (0-39ft) 5 7/8" (39-85ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	86.5	85	365.398	1.69	74.68	9.8	74.68	84.48	375.528	365.728	86.5	As-built
PZ-116-SS	PZ	116	SS	A	1232	6/20/1995	1066451.1	836018.58	486.04	483.55	EMSI 2012 Survey	2.49	10 1/4 "(0-33ft) 5 7/8" (33-162 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 451.6 - 411.61	163.13	162	321.338	1.8	151.4	9.8	151.4	161	331.268	331.668	163.13	As-built
PZ-200-SS	PZ	200	SS	A	NA	2/28/1995	1068537.1	837146.56	485.83	483.55	EMSI 2012 Survey	2.28	10 1/4 "(0-27.5ft) 5 7/8" (27.5-98.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	99.99	98.7	385.238	2.02	9.62	88.02	9.62	97.64	473.588	385.568	99.99	As-built
PZ-201A-SS	PZ	201	SS	A	1223	4/23/1995	1067872.8	837021.16	481.93	479.87	EMSI 2012 Survey	2.058	10 1/4 "(0-33ft) 5 7/8" (33-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	91.94	90	387.818	1.81	80	9.8	80	89.8	397.948	388.148	91.94	As-built
PZ-201-SS	PZ	201	SS	X	NA	3/6/1995	1067860.5	837036.76	479.93	477.6	Golder 1996	NA	10 1/4 "(0-33ft) 5 7/8" (33-39 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	90.96	89	388.968	2.32	9.75	78.56	9.75	88.31	467.858	389.298	90.96	As-built
PZ-202-SS	PZ	202	SS	A	1234	3/12/1995	1067361.2	837276.12	481.42	479.47	EMSI 2012 Survey	1.942	10 1/4" (0-33.5 ft) 5 7/8" (33.5-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 480 - 445.01	91.59	90	389.178	2.16	40.2	48.9	40.2	89.1	438.408	389.508	91.59	As-built
PZ-203-SS	PZ	203	SS	A	1235	6/3/1995	1066702.4	836782.55	486.78	484.12	EMSI 2012 Survey	2.66	10 1/4" (0-56 ft) 5 7/8" (56-110 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 484.7 - 428.08	112.11	110	374.078	2.41	99.6	9.8	99.6	109.4	384.178	374.378	112.11	As-built
PZ-204A-SS	PZ	204A	SS	A	1236	8/21/1995	1066470.4	835731.27	464.88	464.88	EMSI 2012 Survey	0	10 1/4" (0.0-14 ft) 5 7/8" (14-90 ft)	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	90.93	90	376.828	1.5	79.5	9.6	79.5	89.1	386.758	377.158	90.93	As-built
PZ-204-SS	PZ	204	SS	A	NA	3/10/1995	1066470.4	835731.27	464.88	464.88	EMSI 2012 Survey	0	10 1/4" (0-14 ft) 5 7/8" (14-90.3 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	92.28	90.3	376.948	2.6	10.95	78.4	10.95	89.35	455.678	377.278	92.28	As-built
PZ-205-AS	PZ	205	AS	A	1237	5/5/1995	1067504.5	835637.88	460.48	458.54	EMSI 2012 Survey	1.944	14 3/4 "(0-29ft) 8 1/4" (29-49ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460 - 430.33	50.34	49	410.248	1.66	38.55	9.8	38.55	48.35	420.378	410.578	50.34	As-built
PZ-205-SS	PZ	205	SS	A	1238	5/21/1995	1067524.5	835652.19	461.87	459.62	EMSI 2012 Survey	2.256	9 3/4" (0-54 ft) 5 7/8" (54-90 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 460.5 - 405.53	100.36	99	360.428	1.66	88.57	9.8	88.57	98.37	370.558	360.758	100.36	As-built
PZ-206-SS	PZ	206	SS	A	1239	4/24/1995	1068071.8	835984.01	460.39	458.19	EMSI 2012 Survey	2.1958	10" (0-52 ft) 5 7/8" (52-125.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 459.1 - 406.38	126.82	125.5	332.978	1.82	115	9.8	115	124.8	342.978	333.178	126.82	As-built
PZ-207-AS	PZ	207	AS	A	1240	4/10/1995	1069685.5	836212.47	462.24	460.16	EMSI 2012 Survey	2.088	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	41.72	40	421.448	1.69	34.9	4.8	34.9	39.7	426.578	421.778	41.72	As-built
PZ-208-SS	PZ	208	SS	A	1241	6/18/1995	1069260.1	837344.08	474.79	472.48	EMSI 2012 Survey	2.311	10 1/4" (0-17 ft) 5 7/8" (17-99.2 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	100.55	99.2	373.298	1.72	88.7	9.8	88.7	98.5	383.428	373.628	100.55	As-built
PZ-209-SS	PZ	209	SS	A	NA	10/15/2013	1067112.5	837283.27	489.28	486.99	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	152.29	150	336.988	2.29	140	10	140	150	346.988	336.988	152.29	As-built
PZ-209-SD	PZ	209	SD	A	NA	10/4/2013	1067116.7	837279.12	489.18	486.84	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	252.34	250	236.838	2.34	240	10	240	250	246.838	236.838	252.34	As-built
PZ-210-SS	PZ	210	SS	A	NA	10/16/2013	1066869.4	836952.11	486.5	484.13	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	150.37	148	336.128	2.37	138	10	138	148	346.128	336.128	150.37	As-built

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
PZ-210-SD	PZ	210	SD	A	NA	10/16/2013	1066865	836947.82	486.6	484.08	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	250.52	248	236.078	2.52	238	10	238	248	246.078	236.078	250.52	As-built
PZ-211-SS	PZ	211	SS	A	NA	10/8/2013	1067101.8	837195.85	487.01	484.66	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	149.35	147	337.658	2.35	137	10	137	147	347.658	337.658	149.35	As-built
PZ-211-SD	PZ	211	SD	A	NA	10/7/2013	1067097.7	837191.31	487.06	484.43	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	240.46	247	237.428	2.63	237	10	237	247	347.428	237.428	240.46	As-built
PZ-212-SS	PZ	212	SS	A	NA	10/18/2013	1067532	838151.16	482.39	479.76	H&A As-Built		9" for soil, 6" for rock	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	146.63	150	329.758	2.63	134	10	134	144	345.758	335.758	146.63	As-built
PZ-212-SD	PZ	212	SD	A	NA	10/21/2013	1067536.7	838155.08	482.32	480.08	H&A As-Built		7.25	2	Sch. 80 PVC	0.010 slotted	Locking steel protective cover	246.24	245	235.078	2.24	234	10	234	244	246.078	236.078	246.24	As-built
PZ-300-AD	PZ	300	AI	X	NA	9/24/1995	1065254.8	834002.76	449.22	447.7	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	43.72	42.2	405.498	1.52	37.1	4.8	37.1	41.9	410.598	405.798	43.72	As-built
PZ-300-AS	PZ	300	AS	X	NA	9/26/1995	1065539.4	834042.53	450.26	448.1	Golder 1996	NA	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	22.16	20	428.098	2.16	9.9	9.8	9.9	19.7	438.198	428.398	22.16	As-built
PZ-300-SS	PZ	300	SS	X	NA	9/26/1995	1065245.7	834024.51	449.2	448	Golder 1996	NA	9 7/8" (0-46ft) 5 7/8" (46-93ft)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 447.6 - 402.4	95.2	94.5	353.998	1.2	83.88	9.8	83.88	93.7	364.118	354.298	95.2	As-built
PZ-301-SS	PZ	301	SS	X	NA	9/23/1995	1064842.7	835691.69	514.31	512.7	Golder 1996	NA	8 1/4" (0-19 ft) 5 7/8" (19-161.5 ft)	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	162.61	161.5	351.698	1.61	150.9	9.8	150.9	160.7	361.798	351.998	162.61	As-built
PZ-302-AI	PZ	302	AI	I	NA	9/26/1995	1067250.9	834895.67	451.19	449.77	EMSI 2012 Survey	1.423	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	43.85	43	406.898	1.15	32.6	9.8	32.6	42.4	416.998	407.198	43.85	As-built
PZ-302-AS	PZ	302	AS	I	NA	9/25/1995	1067238.2	834912.69	451.57	449.36	EMSI 2012 Survey	2.217	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	24.22	22.3	426.798	1.92	12.2	9.8	12.2	22	436.898	427.098	24.22	As-built
PZ-303-AS	PZ	303	AS	I	NA	10/5/1995	1067703.9	834600.48	453.28	451.04	EMSI 2012 Survey	2.237	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	28.48	26.5	424.298	2.38	16	9.8	16	25.8	434.398	424.598	28.48	As-built
PZ-304-AI	PZ	304	AI	I	NA	10/2/1995	1068166.3	834609.4	454.15	451.76	EMSI 2012 Survey	2.395	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	51.52	50	402.098	2.42	39	9.8	39	48.8	412.198	402.398	51.52	As-built
PZ-304-AS	PZ	304	AS	I	NA	9/27/1995	1068187	834609.3	453.89	451.73	EMSI 2012 Survey	2.159	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	29.51	28	423.798	2.31	17.1	9.8	17.1	26.9	433.898	424.098	29.51	As-built
PZ-305-AI	PZ	305	AI	I	NA	10/19/1995	1068119.7	835797.89	459.98	458.09	EMSI 2012 Survey	1.8917	8 1/4"	2	Sch 80 PVC	0.01 inch machine slot	Locking steel protective cover	64.98	64	393.898	1.68	53.2	9.8	53.2	63	403.998	394.198	64.98	As-built
PZ-1201-SS	PZ	1201	SS	X	NA	7/7/1995	1067343.4	837078.26	482.02	480	Golder 1996	NA	Unknown (0-53 ft) 5 7/8" (53-250)	2	Sch 80 PVC	0.01 inch machine slot	6 5/8" Steel Casing elev 483-427.41	NA	250	229.998	2.01	139.71, 0.3	9.6	137.69	147.29	342.308	332.708	147.63	RIA
S-1	S	1	AS	X	NA	6/3/1905	1069726.8	834379.71	446.11	442.9	McLaren Hart 1996	NA	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	25.71	25	417.898	3.21	2.5	20	2.5	22.5	440.398	420.398	25.71	As-built
S-5	S	5	AS	I	WL-105C	8/1/1995	1069197	836075.6	466.23	463.02	EMSI 2012 Survey	3.203	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	42.95	49.3	415.998	2.95	30	10	30	40	435.298	425.298	42.95	As-built
S-8	S	8	AS	I	WI-228	9/1/1995	1071085	834898.67	443.93	441.55	EMSI 2012 Survey	2.3847	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	29.23	29.3	411.898	2.43	6.8	20	6.8	26.8	434.398	414.398	29.23	As-built
S-10	S	10	AS	I	WL-216C; WL-232	9/1/1995	1069868.8	835106.24	480.1	477.6	EMSI 2012 Survey	2.497	8.25	2	Sch. 40 PVC	0.010 slotted	Locking steel protective cover	49.22	54.5	422.598	2.78	32	20	32	52	445.098	425.098	49.22	As-built
S-51	S	51	AS	X	HL-3	6/3/1905	1066202.3	834495.42	449.17	445.9	McLaren Hart 1996	NA	NA	NA	NA	NA	NA	NA	25.8	420.098	1.42	24.22	3	22.8	25.8	423.098	420.098	25.8	RIA
S-52	S	52	AS	X	HL-2	6/3/1905	1066511	834374.7	446.68	444.3	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	25.2	419.098	2.38	24.58	3	22.2	25.2	422.098	419.098	25.2	RIA
S-53	S	53	AS	I	HL-1	6/3/1905	1066911.2	834671.97	444.1	441.04	EMSI 2012 Survey	3.058	NA	NA	NA	NA	NA	NA	23.7	420.698	4.2	24.9	3	20.7	23.7	423.698	420.698	23.7	RIA
S-54	S	54	AS	X	36	Unknown	1067647	834642.7	NA	469.6	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.4	RIA
S-60	S	60	AS	X	S-2	7/1/1981	1069791	834484.7	446.53	442.7	EMSI 2018 - Calculated	NA	NA	NA	NA	NA	NA	NA	21	421.698	3.83	NA	NA	NA	21	NA	421.698	21	RIA
S-61	S	61	AS	X	S-1	7/1/1981	1070200.9	834754.56	449.2	445.5	EMSI 2012 Survey	3.706	NA	NA	NA	NA	NA	NA	21.5	423.698	4.57	NA	NA	NA	21.5	NA	423.698	21.5	RIA
S-75	S	75	AS	X	37	Unknown	1067291.4	834893.45	461.68	458.4	McLaren Hart 1996	NA	NA	NA	NA	NA	NA	NA	26	432.398	1.1	24.1	3	23	26	435.398	432.398	26	RIA
S-76	S	76	AS	X	37A	6/1/1978	1067447	834743.7	NA	474	EMSI 2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50	RIA
S-80	S	80	AS	X	NA	8/28/1984	1065232.7	834033.05	452.71	448	McLaren Hart 1996	NA	5"	2	PVC	0.01 inch machine slot	NA	NA	22	425.998	5	15	10	10	20	437.998	427.998	20	RIA

TABLE 3-2. MONITORING WELL SURVEY AND CONSTRUCTION DATA SUMMARY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	Env. Control Prefix	Env. Control Point Number	Hydro Zone	Monitoring Status	Alias	Install Date	Northing (ft)	Easting (ft)	MPE (ft msl)	GSE (ft msl)	Survey Source	2012 Cap Ht. Above Grade	Borehole Diameter (in)	Pipe Size (in)	Pipe Type	Perforation Detail	Surface Casing	Total Pipe Length (ft)	Boring Depth (ft)	Bottom Elev (ft MSL)	Cap Ht. Above Grade (ft)	Solid Length[1] (ft)	Screen Length (ft)	Screen From	Screen To	Top Screen Elevation (msl)	Bottom Screen Elevation (msl)	Total Pipe Length (ft)	Construction Source
S-82	S	82	AS	I	NA	8/27/1984	1069352.6	834447.5	450.11	448.17	EMSI 2012 Survey	1.941	5"	2	PVC	0.01 inch machine slot	NA	NA	26.5	420.798	3	18.5	10	15.5	25.5	431.798	421.798	25.5	RIA
S-84	S	84	AS	A	NA	8/1/1984	1069674.2	836614.27	457.04	454.24	EMSI 2012 Survey	2.804	5"	2	PVC	0.01 inch machine slot	NA	NA	31.5	420.998	4	24.9	10	20.9	30.9	431.598	421.598	30.9	RIA
S-88	S	88	AS	X	NA	8/1/1984	1068439.4	835408.73	462.36	459.6	McLaren Hart 1996	NA	5" (0-30 ft), 4 1/2" (30-41.5)	2	PVC	0.01 inch machine slot	NA	NA	41.5	418.098	2.7	33	10	30	40	429.598	419.598	40	RIA

Notes:
ft - feet
in - inches
msl - mean sea level
NA - Not available
Coordinate system updated to NAD83 State Plane Missouri East using conversion in Work Plan

EMSI - Environmental Management Support, Inc
RIA - Remedial Investigation Addendum
MPE - Measuring Point Elevation
GSE - Ground Surface Elevation
PVC - Polyvinyl Chloride
Sch - Schedule

Monitoring Status
A - Active
I - Inactive
U - Unknown
X - Abandoned

Environmental Control Prefix
D - Deep
F - Foth
I - Intermediate
LR - Leachate Riser
MW - Monitoring Well
PZ - Piezometer
S - Shallow

Hydrological Zone
AD - Deep Alluvial
AS - Shallow Alluvial
AI - Intermediate Alluvial
LR - Leachate Riser
KS - Keokuk Formation
SD - Salem Formation
SS - Upper Salem/St. Louis Formation

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
Shallow Alluvium	PZ-112-AS	RH	AS	1069042.848	835849.449	PZ-112-AS-RH1	1.90E-03	3.70E-03	1.10E-03	2.20E-03	NA	NA	1.50E-03	3.00E-03	4.32	Golder 1996	0.35	97	8.9
	PZ-112-AS	FH	AS	1069042.848	835849.449	PZ-112-AS-FH1	3.00E-03	5.90E-03	1.70E-03	3.30E-03	NA	NA	2.40E-03	4.60E-03	6.62	Golder 1996			
	PZ-113-AS	RH	AS	1069264.97	835922.4	PZ-113-AS-RH1	1.40E-02	2.80E-02	5.30E-02	1.00E-01	NA	NA	3.40E-02	6.60E-02	95.04	Golder 1996			
	PZ-113-AS	FH	AS	1069264.97	835922.4	PZ-113-AS-FH1	8.00E-03	1.60E-02	5.10E-03	1.00E-02	NA	NA	6.60E-03	1.30E-02	18.72	Golder 1996			
	PZ-114-AS	FH	AS	1069459.999	836942.992	PZ-114-AS-FH1	3.10E-03	6.10E-03	1.70E-03	3.30E-03	NA	NA	2.40E-03	4.70E-03	6.77	Golder 1996			
	PZ-114-AS	FH	AS	1069459.999	836942.992	PZ-114-AS-FH2	4.50E-03	8.90E-03	2.70E-03	5.30E-03	NA	NA	3.60E-03	7.10E-03	10.22	Golder 1996			
	PZ-205-AS		AS	1067504.507	835637.878	PZ-205-AS	6.00E-04	1.20E-03	4.40E-04	8.70E-04	NA	NA	5.20E-04	1.00E-03	1.44	Golder 1996			
	PZ-207-AS		AS	1069685.45	836212.47	PZ-207-AS	7.60E-03	1.50E-02	4.80E-03	9.40E-03	NA	NA	6.20E-03	1.20E-02	17.28	Golder 1996			
	PZ-300-AS	FH[2]	AS	1065539.41	834042.53	PZ-300-AS-FH2	5.80E-04	1.10E-03	NA	NA	NA	NA	5.80E-04	1.10E-03	1.58	Golder 1996			
	PZ-300-AS	RH	AS	1065539.41	834042.53	PZ-300-AS-RH	7.10E-04	1.40E-03	2.10E-03	4.10E-03	NA	NA	1.40E-03	2.80E-03	4.03	Golder 1996			
	PZ-302-AS	FH[2]	AS	1067238.22	834912.693	PZ-302-AS-FH2	1.10E-04	2.20E-04	NA	NA	NA	NA	1.10E-04	2.20E-04	0.32	Golder 1996			
	PZ-302-AS	RH	AS	1067238.22	834912.693	PZ-302-AS-RH	1.20E-04	2.40E-04	NA	NA	NA	NA	1.20E-04	2.40E-04	0.35	Golder 1996			
	PZ-303-AS	FH[2]	AS	1067703.94	834600.481	PZ-303-AS-FH12	4.00E-04	7.90E-04	NA	NA	NA	NA	4.00E-04	7.90E-04	1.14	Golder 1996			
	PZ-303-AS	FH[2]	AS	1067703.94	834600.481	PZ-303-AS-FH22	6.00E-04	1.20E-03	NA	NA	NA	NA	6.00E-04	1.20E-03	1.73	Golder 1996			
	PZ-303-AS	RH	AS	1067703.94	834600.481	PZ-303-AS-RH	3.70E-03	7.30E-03	1.50E-02	3.00E-02	NA	NA	9.40E-03	1.80E-02	25.92	Golder 1996			
	PZ-304-AS	FH[2]	AS	1068187.019	834609.304	PZ-304-AS-FH2	8.70E-04	1.70E-03	NA	NA	NA	NA	8.70E-04	1.70E-03	2.45	Golder 1996			
	PZ-304-AS	RH	AS	1068187.019	834609.304	PZ-304-AS-RH	5.90E-03	1.20E-02	1.80E-02	3.50E-02	NA	NA	1.20E-02	2.40E-02	34.56	Golder 1996			
	S-1	RH	AS	1069726.8	834379.71	S-1	NA	NA	3.78E-03	7.44E-03	NA	NA	NA	NA	10.71	McLaren Hart 1996			
	S-5	RH	AS	1069196.97	836075.6	S-5	NA	NA	8.76E-04	1.72E-03	NA	NA	NA	NA	2.48	McLaren Hart 1996			
	S-8	RH	AS	1071085.014	834898.6739	S-8	NA	NA	3.43E-02	6.75E-02	NA	NA	NA	NA	97.23	McLaren Hart 1996			
	S-84	RH	AS	1069674.22	836614.269	S-84	NA	NA	2.32E-03	4.57E-03	NA	NA	NA	NA	6.58	McLaren Hart 1996			
	MW-101	RH	AS	1070871.45	834598.7	MW-101	NA	NA	4.17E-03	8.21E-03	NA	NA	NA	NA	11.82	McLaren Hart 1996			
	F-3	RH	AS	1070530.77	835994.53	MW-F3	NA	NA	3.83E-03	7.54E-03	NA	NA	NA	NA	10.86	McLaren Hart 1996			
Intermediate Alluvium	PZ-300-AD	FH	AI	1065254.81	834002.76	PZ-300-AD-FH	3.70E-04	7.30E-04	2.70E-04	5.30E-04	NA	NA	3.20E-04	6.30E-04	0.91	Golder 1996	0.39	189	49
	PZ-300-AD	RH	AI	1065254.81	834002.76	PZ-300-AD-RH	1.60E-04	3.10E-04	1.10E-04	2.20E-04	NA	NA	1.40E-04	2.70E-04	0.39	Golder 1996			
	PZ-302-AI	FH	AI	1067250.868	834895.669	PZ-302-AI-FH	1.50E-02	3.00E-02	9.80E-03	1.90E-02	NA	NA	1.20E-02	2.40E-02	34.56	Golder 1996			
	PZ-302-AI	RH	AI	1067250.868	834895.669	PZ-302-AI-RH	1.50E-02	3.00E-02	1.00E-02	2.00E-02	NA	NA	1.30E-02	2.50E-02	36.00	Golder 1996			
	PZ-304-AI	FH	AI	1068166.325	834609.398	PZ-304-AI-FH	2.40E-02	4.70E-02	1.70E-02	3.30E-02	NA	NA	2.10E-02	4.00E-02	57.60	Golder 1996			
	PZ-305-AI	FH[1]	AI	1068119.659	835797.8921	PZ-305-AI-FH1	1.80E-02	3.50E-02	1.40E-02	2.80E-02	NA	NA	1.60E-02	3.10E-02	44.64	Golder 1996			
	PZ-305-AI	FH[2]	AI	1068119.659	835797.8921	PZ-305-AI-FH2	1.90E-04	3.70E-04	1.70E-04	3.30E-04	NA	NA	1.80E-04	3.50E-04	0.50	Golder 1996			
	I-2	RH	AI	1069739.23	834386.88	I-2	NA	NA	3.27E-02	6.44E-02	NA	NA	NA	NA	92.69	McLaren Hart 1996			
	I-4	RH	AI	1069189.97	836064.6	I-4	NA	NA	5.41E-02	1.06E-01	NA	NA	NA	NA	153.35	McLaren Hart 1996			
	I-7	RH	AI	1070784.02	834474.57	I-7	NA	NA	6.68E-02	1.31E-01	NA	NA	NA	NA	189.35	McLaren Hart 1996			
	I-9	RH	AI	1069358.403	834444.232	I-9	NA	NA	5.47E-02	1.08E-01	NA	NA	NA	NA	155.06	McLaren Hart 1996			
	I-11	RH	AI	1069860.187	835099.736	I-11	NA	NA	4.63E-02	9.11E-02	NA	NA	NA	NA	131.24	McLaren Hart 1996			
	I-68	RH	AI	1069612.97	836861.2	I-68	NA	NA	1.22E-02	2.40E-02	NA	NA	NA	NA	34.58	McLaren Hart 1996			
Deep Alluvium	PZ-113-AD	FH	AD	1069273.97	835934.5	PZ-113-AD-FH1	1.80E-03	3.50E-03	1.50E-03	3.00E-03	NA	NA	1.70E-03	3.20E-03	4.61	Golder 1996	4.6	251	59
	PZ-113-AD	FH	AD	1069273.97	835934.5	PZ-113-AD-FH2	1.90E-03	3.70E-03	1.40E-03	2.80E-03	NA	NA	1.70E-03	3.20E-03	4.61	Golder 1996			
	D-3	RH	AD	1069177.97	836047	D-3	NA	NA	3.15E-02	6.20E-02	NA	NA	NA	NA	89.29	McLaren Hart 1996			
	D-6	RH	AD	1070235.1	834723.492	D-6	NA	NA	4.29E-02	8.44E-02	NA	NA	NA	NA	121.61	McLaren Hart 1996			
	D-12	RH	AD	1069877.227	835110.755	D-12	NA	NA	4.14E-02	8.15E-02	NA	NA	NA	NA	117.35	McLaren Hart 1996			
	D-13	RH	AD	1070527.015	835776.5617	D-13	NA	NA	8.85E-02	1.74E-01	NA	NA	NA	NA	250.87	McLaren Hart 1996			
	D-85	RH	AD	1069667.265	836605.173	D-85	NA	NA	4.50E-03	8.86E-03	NA	NA	NA	NA	12.76	McLaren Hart 1996			
	D-93	RH	AD	1069369.757	834443.556	D-93	NA	NA	4.78E-02	9.41E-02	NA	NA	NA	NA	135.50	McLaren Hart 1996			

TABLE 3-3. SLUG TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Zone	Well ID	Test	Zone	Northing (ft)	Easting (ft)	Test ID	Hvorslev (cm/sec)	Hvorslev (ft/min)	B-R (cm/sec)	B-R (ft/min)	C-P (cm/sec)	C-P (ft/min)	Mean Hvorslev B-R (cm/sec)	Mean Hvorslev B-R (ft/min)	Mean Hvorslev B-R (ft/day)	Source	Min (ft/day)	Max (ft/day)	Geometric Mean (ft/day)
St. Louis Form.	PZ-100-SS		SS	1068908.761	837349.65	PZ-100-SS	1.00E-07	2.00E-07	5.70E-08	1.10E-07	NA	NA	7.90E-08	1.50E-07	0.00	Golder 1996	0.000065	7.8	0.0037
	PZ-101-SS		SS	1068513.92	836797.322	PZ-101-SS	8.60E-07	1.70E-06	5.10E-07	1.00E-06	NA	NA	6.90E-07	1.30E-06	0.00	Golder 1996			
	PZ-102R-SS		SS	1068172.734	837033.545	PZ-102R-SS	4.70E-08	9.30E-08	3.00E-08	5.90E-08	NA	NA	3.90E-08	7.60E-08	0.00	Golder 1996			
	PZ-103-SS		SS	1067701.303	836897.822	PZ-103-SS	8.40E-07	1.70E-06	1.70E-06	3.30E-06	NA	NA	1.30E-06	2.50E-06	0.00	Golder 1996			
	PZ-104-SS		SS	1067068.815	837021.987	PZ-104-SS	6.00E-07	1.20E-06	1.30E-06	2.60E-06	NA	NA	9.50E-07	1.90E-06	0.00	Golder 1996			
	PZ-105-SS		SS	1066462.138	836405.054	PZ-105-SS	3.50E-06	6.90E-06	8.50E-06	1.70E-05	NA	NA	6.00E-06	1.20E-05	0.02	Golder 1996			
	PZ-106-SS		SS	1066767.07	835574.642	PZ-106-SS	3.90E-06	7.70E-06	2.50E-06	4.90E-06	NA	NA	3.20E-06	6.30E-06	0.01	Golder 1996			
	PZ-107-SS		SS	1067204.044	835429.345	PZ-107-SS	1.60E-06	3.10E-06	1.20E-06	2.40E-06	NA	NA	1.40E-06	2.80E-06	0.00	Golder 1996			
	PZ-108-SS		SS	1067719.34	836147.31	PZ-108-SS	6.30E-07	1.20E-06	4.30E-07	8.50E-07	NA	NA	5.30E-07	1.00E-06	0.00	Golder 1996			
	PZ-109-SS		SS	1068052.306	836318.4981	PZ-109-SS	1.80E-07	3.50E-07	8.70E-08	1.70E-07	NA	NA	1.30E-07	2.60E-07	0.00	Golder 1996			
	PZ-110-SS		SS	1068376.97	836094.3	PZ-110-SS1	1.60E-06	3.10E-06	8.90E-07	1.80E-06	NA	NA	1.20E-06	2.50E-06	0.00	Golder 1996			
	PZ-113-SS		SS	1069282.97	835951.3	PZ-113-SS	5.20E-06	1.00E-05	4.90E-06	9.60E-06	NA	NA	5.10E-06	9.90E-06	0.01	Golder 1996			
	PZ-115-SS		SS	1069449.628	836929.871	PZ-115-SS	2.90E-05	5.70E-05	2.40E-05	4.70E-05	NA	NA	2.70E-05	5.2E-05	0.07	Golder 1996			
	PZ-116-SS		SS	1066451.146	836018.584	PZ-116-SS	2.90E-08	5.70E-08	1.70E-08	3.30E-08	NA	NA	2.30E-08	4.50E-08	0.00	Golder 1996			
	PZ-200-SS		SS	1068537.089	837146.557	PZ-200-SS	1.50E-06	3.00E-06	2.80E-06	5.50E-06	NA	NA	2.20E-06	4.20E-06	0.01	Golder 1996			
	PZ-201-SS		SS	1067860.52	837036.76	PZ-201-SS	3.30E-05	6.50E-05	5.40E-05	1.10E-04	NA	NA	4.40E-05	8.60E-05	0.12	Golder 1996			
	PZ-201A-SS		SS	1067872.76	837021.163	PZ-201A-SS	1.30E-07	2.60E-07	8.30E-08	1.60E-07	NA	NA	1.10E-07	2.10E-07	0.00	Golder 1996			
	PZ-202-SS		SS	1067361.152	837276.124	PZ-202-SS	3.00E-03	5.90E-03	2.50E-03	4.90E-03	NA	NA	2.80E-03	5.40E-03	7.78	Golder 1996			
	PZ-204-SS		SS	1066470.424	835731.2717	PZ-204-SS	1.80E-06	3.50E-06	2.80E-06	5.50E-06	NA	NA	2.30E-06	4.50E-06	0.01	Golder 1996			
	PZ-204A-SS		SS	1066470.424	835731.2717	PZ-204A-SS	3.50E-07	6.90E-07	2.30E-07	4.50E-07	NA	NA	2.90E-07	5.70E-07	0.00	Golder 1996			
	PZ-205-SS		SS	1067524.521	835652.192	PZ-205-SS	4.40E-07	8.70E-07	3.90E-07	7.70E-07	NA	NA	4.20E-07	8.20E-07	0.00	Golder 1996			
	PZ-206-SS		SS	1068071.821	835984.0148	PZ-206-SS	1.80E-05	3.50E-05	1.10E-05	2.20E-05	NA	NA	1.50E-05	2.90E-05	0.04	Golder 1996			
	PZ-208-SS		SS	1069260.125	837344.084	PZ-208-SS	4.30E-07	8.50E-07	2.70E-07	5.30E-07	NA	NA	3.50E-07	6.90E-07	0.00	Golder 1996			
	PZ-300-SS		SS	1065245.72	834024.51	PZ-300-SS	9.00E-07	1.80E-06	7.70E-07	1.50E-06	NA	NA	8.40E-07	1.60E-06	0.00	Golder 1996			
	PZ-301-SS		SS	1064842.65	835691.69	PZ-301-SS1	7.50E-07	1.50E-06	NA	NA	NA	NA	7.50E-07	1.50E-06	0.00	Golder 1996			
Salem Form.	PZ-100-SD		SD	1068892.808	837369.99	PZ-100-SD	9.10E-07	1.80E-06	6.40E-07	1.30E-06	NA	NA	7.80E-07	1.50E-06	0.00	Golder 1996	0.00024	0.042	0.0019
	PZ-104-SD		SD	1067054.135	837009.268	PZ-104-SD	1.80E-05	3.50E-05	1.20E-05	2.30E-05	NA	NA	1.50E-05	2.90E-05	0.04	Golder 1996			
	PZ-106-SD		SD	1066755.685	835590.703	PZ-106-SD	3.00E-07	5.90E-07	1.60E-07	3.10E-07	NA	NA	2.30E-07	4.50E-07	0.00	Golder 1996			
	PZ-111-SD		SD	1068678.166	836009.0044	PZ-111-SD	1.00E-07	2.00E-07	6.80E-08	1.30E-07	NA	NA	8.40E-08	1.70E-07	0.00	Golder 1996			
Keokuk Form.	PZ-100-KS		KS	1068883.062	837386.265	PZ-100-KS	NA	NA	NA	NA	6.00E-07	1.20E-06	NA	NA	0.00	Golder 1996	0.0017	0.011	0.0058
	PZ-104-KS		KS	1067034.018	836995.216	PZ-104-KS	NA	NA	NA	NA	2.50E-06	4.90E-06	NA	NA	0.01	Golder 1996			
	PZ-106-KS		KS	1066744.652	835606.899	PZ-106-KS	NA	NA	NA	NA	3.10E-06	6.10E-06	NA	NA	0.01	Golder 1996			
	PZ-111-KS		KS	1068661.958	836025.2057	PZ-111-KS	NA	NA	NA	NA	3.80E-06	7.50E-06	NA	NA	0.01	Golder 1996			

Notes:
cm/sec - centimeters per second
ft/min - feet per minute
ft/day - feet per day
Form. - Formation
RH - Rising Head
FH - Falling Head
B-R - Bouwer & Rice
C-P - Cooper Papadopulos
Min - minimum
Max - maximum
[1] Slug tests conducted before piezometer reached equilibrium; data presented but not included in geometric means.
[2] Falling head slug tests conducted within sand pack zone of well; data presented but not included in geometric means.
Rising Head test used to calculate geometric mean; falling head test used if rising head test unavailable
Wells shown in gray not included in geometric mean
Burns & McDonnell slug testing results not included in summary

TABLE 3-4. PACKER TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Borehole ID	GSE (ft msl)	GSE (ft msl)	Test Interval (ft bgs)	Interval Top (ft bgs)	Interval Bottom (ft bgs)	Interval Top (ft msl)	Interval Bottom (ft msl)	Interval Mid Point (ft msl)	Interval Thickness (ft)	K (cm/s)	K (ft/min)	K (ft/day)	Formation	Comments	Minimum (ft/day)	Maximum (ft/day)	Geometric Mean (ft/day)
PZ-100-KS	438.3	484.82	37.3-42.3	37.3	42.3	447.5	442.5	445.0	5	7.50E-04	1.50E-03	2.16E+00	St. Louis	Unsaturated			
PZ-100-KS	438.3	484.82	50.0-55.0	50.0	55.0	434.8	429.8	432.3	5	3.30E-06	6.60E-06	9.50E-03	St. Louis	Unsaturated			
PZ-104-KS	482.3	481.838	50.0-55.0	50.0	55.0	431.8	426.8	429.3	5	2.90E-06	5.70E-06	8.21E-03	St. Louis	Unsaturated			
PZ-106-KS	460.8	462.143	42.0-47.0	42.0	47.0	420.1	415.1	417.6	5	6.00E-06	1.20E-05	1.73E-02	St. Louis	Unsaturated			
PZ-106-KS	460.8	462.143	61.0-66.0	61.0	66.0	401.1	396.1	398.6	5	2.10E-06	4.10E-06	5.90E-03	St. Louis	Unsaturated	1.0E-03	1.2E-02	2.7E-03
PZ-100-KS	438.3	484.82	110.0-115.0	110.0	115.0	374.8	369.8	372.3	5	3.70E-07	7.20E-07	1.04E-03	St. Louis	Saturated			
PZ-104-KS	482.3	481.838	113.0-118.0	113.0	118.0	368.8	363.8	366.3	5	1.50E-07	2.90E-07	4.18E-04	St. Louis	Unsaturated			
PZ-111-KS	459.2	461.3366	105.0-127.0	105.0	127.0	356.3	334.3	345.3	22	4.40E-06	8.60E-06	1.24E-02	St. Louis	Saturated			
PZ-111-KS	459.2	461.3366	125.0-130.0	125.0	130.0	336.3	331.3	333.8	5	5.40E-07	1.10E-06	1.58E-03	St. Louis	Saturated			
PZ-106-KS	460.8	462.143	148.0-153.0	148.0	153.0	314.1	309.1	311.6	5	4.50E-06	8.80E-06	1.27E-02	Salem				
PZ-111-KS	459.2	461.3366	162.0-167.0	162.0	167.0	299.3	294.3	296.8	5	7.90E-07	1.50E-06	2.16E-03	Salem				
PZ-111-KS	459.2	461.3366	127.0-210.0	127.0	210.0	334.3	251.3	292.8	83	1.30E-06	2.60E-06	3.74E-03	Salem				
PZ-106-KS	460.8	462.143	140.0-201.0	140.0	201.0	322.1	261.1	291.6	61	2.50E-05	5.00E-05	7.20E-02	Salem				
PZ-100-KS	438.3	484.82	195.0-200.0	195.0	200.0	289.8	284.8	287.3	5	3.90E-06	7.70E-06	1.11E-02	Salem				
PZ-111-KS	459.2	461.3366	140.0-210.0	140.0	210.0	321.3	251.3	286.3	70	3.30E-06	6.40E-06	9.22E-03	Salem				
PZ-104-KS	482.3	481.838	162.0-252.5	162.0	252.5	319.8	229.3	274.6	90.5	4.90E-06	9.70E-06	1.40E-02	Salem		1.6E-04	7.2E-02	4.6E-03
PZ-104-KS	482.3	481.838	208.0-213.0	208.0	213.0	273.8	268.8	271.3	5	8.40E-06	1.70E-05	2.45E-02	Salem				
PZ-111-KS	459.2	461.3366	175.0-210.0	175.0	210.0	286.3	251.3	268.8	35	1.20E-06	2.40E-06	3.46E-03	Salem				
PZ-106-KS	460.8	462.143	187.0-201.0	187.0	201.0	275.1	261.1	268.1	14	1.80E-07	3.50E-07	5.04E-04	Salem				
PZ-111-KS	459.2	461.3366	195.0-200.0	195.0	200.0	266.3	261.3	263.8	5	5.80E-08	1.10E-07	1.58E-04	Salem				
PZ-100-KS	438.3	484.82	220.0-225.0	220.0	225.0	264.8	259.8	262.3	5	2.10E-06	4.10E-06	5.90E-03	Salem				
PZ-104-KS	482.3	481.838	235.0-252.5	235.0	252.5	246.8	229.3	238.1	17.5	3.20E-07	6.40E-07	9.22E-04	Salem				
PZ-106-KS	460.8	462.143	215.0-220.0	215.0	220.0	247.1	242.1	244.6	5	2.60E-07	5.10E-07	7.34E-04	Warsaw				
PZ-111-KS	459.2	461.3366	221.0-226.0	221.0	226.0	240.3	235.3	237.8	5	9.50E-07	1.90E-06	2.74E-03	Warsaw				
PZ-111-KS	459.2	461.3366	226.0-231.0	226.0	231.0	235.3	230.3	232.8	5	1.70E-06	3.30E-06	4.75E-03	Warsaw				
PZ-106-KS	460.8	462.143	237.0-242.0	237.0	242.0	225.1	220.1	222.6	5	2.40E-06	4.80E-06	6.91E-03	Warsaw				
PZ-111-KS	459.2	461.3366	220.0-260.0	220.0	260.0	241.3	201.3	221.3	40	1.30E-06	2.50E-06	3.60E-03	Warsaw				
PZ-104-KS	482.3	481.838	270.0-290.0	270.0	290.0	211.8	191.8	201.8	20	4.40E-06	8.70E-07	1.25E-03	Warsaw				
PZ-111-KS	459.2	461.3366	260.0-265.0	260.0	265.0	201.3	196.3	198.8	5	2.00E-06	3.80E-06	5.47E-03	Warsaw				
PZ-100-KS	438.3	484.82	290.0-295.0	290.0	295.0	194.8	189.8	192.3	5	5.60E+05	1.10E-04	1.58E-01	Warsaw		7.3E-04	1.6E-01	5.5E-03
PZ-104-KS	482.3	481.838	287.0-292.5	287.0	292.5	194.8	189.3	192.1	5.5	2.70E-06	5.30E-06	7.63E-03	Warsaw				
PZ-111-KS	459.2	461.3366	260.0-290.0	260.0	290.0	201.3	171.3	186.3	30	1.10E-06	2.20E-06	3.17E-03	Warsaw				
PZ-104-KS	482.3	481.838	290.0-320.0	290.0	320.0	191.8	161.8	176.8	30	7.10E-07	1.40E-06	2.02E-03	Warsaw				
PZ-100-KS	438.3	484.82	265.0-357.6	265.0	357.6	219.8	127.2	173.5	92.6	5.30E-06	1.00E-05	1.44E-02	Warsaw				
PZ-111-KS	459.2	461.3366	290.0-343.7	290.0	343.7	171.3	117.6	144.5	53.7	3.10E-06	6.10E-06	8.78E-03	Warsaw				
PZ-104-KS	482.3	481.838	320.0-358.3	320.0	358.3	161.8	123.5	142.7	38.3	3.40E-06	6.60E-07	9.50E-04	Warsaw				
PZ-106-KS	460.8	462.143	301.0-346.4	301.0	346.4	161.1	115.7	138.4	45.4	3.30E-05	6.60E-05	9.50E-02	Warsaw				
PZ-104-KS	482.3	481.838	343.0-348.0	343.0	348.0	138.8	133.8	136.3	5	1.90E-06	3.70E-06	5.33E-03	Warsaw				
PZ-111-KS	459.2	461.3366	343.0-348.0	343.0	348.0	118.3	113.3	115.8	5	2.50E-05	4.90E-05	7.06E-02	Keokuk				
PZ-104-KS	482.3	481.838	366.0-371.0	366.0	371.0	115.8	110.8	113.3	5	4.00E-06	7.90E-06	1.14E-02	Keokuk				
PZ-100-KS	438.3	484.82	366.0-391.0	366.0	391.0	118.8	93.8	106.3	25	7.60E-07	1.50E-06	2.16E-03	Keokuk				
PZ-111-KS	459.2	461.3366	343.0-368.0	343.0	368.0	118.3	93.3	105.8	25	2.10E-05	4.10E-05	5.90E-02	Keokuk				
PZ-111-KS	459.2	461.3366	355.0-360.0	355.0	360.0	106.3	101.3	103.8	5	4.30E-05	8.50E-05	1.22E-01	Keokuk				
PZ-106-KS	460.8	462.143	357.0-362.2	357.0	362.2	105.1	99.9	102.5	5.2	2.80E-05	5.50E-05	7.92E-02	Keokuk		2.2E-03	1.2E-01	2.8E-02
PZ-106-KS	460.8	462.143	346.0-374.1	346.0	374.1	116.1	88.0	102.1	28.1	2.20E-05	4.30E-05	6.19E-02	Keokuk				
PZ-100-KS	438.3	484.82	377.0-391.0	377.0	391.0	107.8	93.8	100.8	14	1.40E-06	2.70E-06	3.89E-03	Keokuk				
PZ-104-KS	482.3	481.838	360.0-408.0	360.0	408.0	121.8	73.8	97.8	48	5.70E-06	1.10E-05	1.58E-02	Keokuk				
PZ-106-KS	460.8	462.143	364.0-374.0	364.0	374.0	98.1	88.1	93.1	10	1.70E-05	3.40E-05	4.90E-02	Keokuk				
PZ-104-KS	482.3	481.838	390.0-408.0	390.0	408.0	91.8	73.8	82.8	18	1.30E-05	2.60E-05	3.74E-02	Keokuk				

Notes:
ft - feet
min - minute
cm/sec - centimeters per second
bgs - below ground surface
msl - above mean sea level
GSE - Ground Surface Elevation
K - Hydraulic Conductivity
Minimum, maximum, and geometric means calculated using saturated intervals

TABLE 3-5. LABORATORY PERMEABILITY TESTING RESULTS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Sample Number	Sample Length (cm)	Sample Diameter (cm)	Sample Dry Density (pcf)	Maximum Dry Density (pcf)	Compaction (%)	Initial Moisture Content (%)	Optimum Moisture Content (%)	Effective Pressure (psi)	Back Pressure (psi)	Gradient	Average Permeability (cm/sec)	Average Permeability (ft/day)
PZ-101-SS 6-8	7.99	7.22	91.7	---	---	24.4	---	6	94	2	3×10^{-4}	8.5E-01
PZ-102-SS 4-6	8.82	7.07	92.2	---	---	28.2	---	5	95	9	8×10^{-7}	2.3E-03
PZ-103-SS 14-16	7.73	7.18	97.7	---	---	28.3	---	13	87	4	2×10^{-6}	5.7E-03
PZ-104-KS 6-8	9.11	7.14	95.7	---	---	23.6	---	6	94	24	2×10^{-7}	5.7E-04
PZ-106-KS 6-8	8.89	7.14	103.0	---	---	22.2	---	6	94	5	3×10^{-6}	8.5E-03
PZ-106-KS GTS-1 201.9-202.5	7.63	4.50	151.9	---	---	4.5	---	153	98	129	$<1.1 \times 10^{-10}$	3.1E-07
PZ-106-KS GTS-2 229.6-230.1	7.66	4.47	148.0	---	---	4.4	---	170	88	94	1.5×10^{-10}	4.3E-07
PZ-200-SS 6-8	9.59	7.17	95.3	---	---	27.5	---	6	94	4	2×10^{-6}	5.7E-03
PZ-201-SS 26-28	8.11	7.13	86.4	---	---	34.5	---	23	77	14	3×10^{-6}	8.5E-03
PZ-202-SS 6-8	8.08	7.10	96.4	---	---	26.7	---	6	94	10	3×10^{-7}	8.5E-04
PS-1 10	9.56	7.23	100.8	105.0	96	18.4	19.0	5	95	6	2×10^{-7}	5.7E-04
PS-2 7	9.55	7.24	101.7	106.0	96	17.5	17.5	5	95	10	3×10^{-7}	8.5E-04
LR-103	10.16	7.22	79.9	---	---	37.4	17.5	5	95	3	2×10^{-4}	5.7E-01

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
40 C.F.R. Part 192, Subpart A Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Standards for the Control of Residual Radioactive Material from Inactive Uranium Processing Sites; 40 C.F.R. Appendix Table 1 to Subpart A of Part 192, Maximum Concentration of Constituents for Groundwater Protection	Radium, uranium, and trace metals in groundwater, Radium-226 (Radium-228) in soil	Maximum constituent concentration:		Not applicable, but potentially relevant and appropriate for OU- 3.
		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	
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Groundwater	Water contaminants shall not cause or contribute to an exceedance of the following:		Not applicable, but potentially relevant and appropriate for OU-3.
		Inorganics (mg/L)		
		Fluoride	4	
		Nitrate	10	
		Trace metals (ug/L)		
		Antimony	6	
		Arsenic	50	
		Barium	2000	
		Beryllium	4	
		Boron	2000	
		Cadmium	5	
		Chromium III	100	
		Cobalt	1000	
		Copper	1300	
		Iron	300	
		Lead	15	
		Manganese	50	
		Mercury	2	
		Nickel	100	
		Selenium	50	
		Silver	50	
		Thallium	2	
		Zinc	5000	
		Organics (ug/L)		
		Acrolein	320	
		Bis-2-chloroisopropyl ether	1400	
		2, chlorophenol	0.1	
		2,4-dichlorophenol	93	
		2,4-dinitrophenol	70	
		2,4-dimethylphenol	540	
		2,4,5-trichlorophenol	2600	
		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	
		Atrazine	3	
		Carbofuran	40	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Groundwater (cont.)	Dalapon	200	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Dibromochloropropane	0.2	
		Dinoseb	7	
		Diquat	20	
		Endothall	100	
		Ethylene dibromide	0.05	
		Oxamyl (vydate)	200	
		Picloram	500	
		Simazine	4	
		Glyphosate	700	
		Bioaccumulative Anthropogenic Toxics (ug/L)		
		PCBs	0.000045	
		DDT	0.00059	
		DDE	0.00059	
		DDD	0.00083	
		Endrin	2	
		Endrin aldehyde	0.75	
		Aldrin	0.00013	
		Dieldrin	0.00014	
		Heptachlor	0.4	
		Heptachlor epoxide	0.2	
		Methoxychlor	40	
		Toxaphene	3	
		Lindane (gamma-BHC)	0.2	
		Alpha,beta,delta-BHC	0.0022	
		Chlordane	2	
		Benzidine	0.00012	
		2,3,7,8-TCDD (dioxin)	0.000000013	
		Pentachlorophenol	1	
		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	1000	
		Xylenes (total)	10000	
		Vinyl chloride	2	
		Styrene	100	
		1,2-dichloropropane	0.52	
		Polynuclear Aromatic Hydrocarbons (ug/L)		
		Anthracene	9600	
		Fluoranthene	300	
		Fluorene	1300	
		Pyrene	960	
		Benzo(a)pyrene	0.2	
		Other polynuclear aromatic hydrocarbons	0.0044	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Groundwater (cont.)	Acenaphthene	1200	Not applicable, but potentially relevant and appropriate for OU-3.
		Phthalate Esters (ug/L)		
		Bis(2-ethylhexyl) phthalate	6	
		Butylbenzyl phthalate	3000	
		Diethyl phthalate	23000	
		Dimethyl phthalate	313000	
		Di-n-butyl phthalate	2700	
		Health Advisory Levels (ug/L)		
		Ametryn	60	
		Baygon	3	
		Bentazon	20	
		Bis-2-chloroisopropyl ether	300	
		Bromacil	90	
		Bromochloromethane	90	
		Bromomethane	10	
		Butylate	350	
		Carbaryl	700	
		Carboxin	700	
		Chloramben	100	
		o-chlorotoluene	100	
		p-chlorotoluene	100	
		Chlorpyrifos	20	
		DCPA (dacthal)	4000	
		Diazinon	0.6	
		Dicamba	200	
		Diisopropyl methylphosphonate	600	
		Dimethyl methylphosphonate	100	
		1,3-dinitrobenzene	1	
		Diphenamid	200	
		Diphenylamine	200	
		Disulfoton	0.3	
		1,4-dithiane	80	
		Diuron	10	
		Fenamiphos	2	
		Fluometron	90	
		Fluorotrichloromethane	2000	
		Fonofos	10	
		Hexazinone	200	
		Malathion	200	
		Maleic hydrazide	4000	
		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 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Aquatic Life Protection (medium unspecified)		Acute	Chronic	Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water.
		Metals (uglL)			
		Aluminum (pH 6.5-9.0)	750		
		Arsenic	340	150	
		Beryllium		5	
		Cadmium	Hardness Dependent	Hardness Dependent	
		Chromium (III)	Hardness Dependent	Hardness Dependent	
		Chromium (VI)	16	11	
		Copper	Hardness Dependent	Hardness Dependent	
		Iron		1000	
		Lead	Hardness Dependent	Hardness Dependent	
		Mercury	1.4	0.77	
		Methylmercury	1.4	0.77	
		Nickel	Hardness Dependent	Hardness Dependent	
		Selenium		5	
		Silver	Hardness Dependent	Hardness Dependent	
		Zinc	Hardness Dependent	Hardness Dependent	
		Other Inorganic Substances (ug/L unless otherwise noted)			
		Alkalinity (minimum CaCO3)		20000	
		Ammonia	pH dependent	Temperature and pH dependent	
		Chloride	860	230	
		Chloride + sulfate	10 CSR 20-7.031(5)(L)		
		Chlorine, Total Residual (Coldwater Aquatic Habitat)		2	
		Chloride, Total Residual (Warmwater Aquatic Habitat)	19	11	
		Cyanide	22	5.2	
		Gases, Total Dissolved (% saturation)	110	110	
		Hydrogen sulfide		2	
		Oil and Grease (mg/L)		10	
		Oxygen, Dissolved (mg/L) (Coldwater Aquatic Habitat)	6 (minimum)	6 (minimum)	
		Oxygen, Dissolved (mg/L) (Coolwater Aquatic Habitat)	5 (minimum)	5 (minimum)	
		Oxygen, Dissolved (mg/L) (Warmwater Aquatic Habitat)	5 (minimum)	5 (minimum)	
		pH		6.5-9	
		Organic Substances (ug/L)			
		Ethylbenzene		320	
		PCBs		0.014	
		Tributylin (TBT)	0.46	0.072	
		2-Chloronaphthalene		4300	
		Nonylphenol	28	6.6	
		Pentachlorophenol	pH dependent	pH dependent	
		Phenol (Coldwater Aquatic Habitat)	5293	157	
		Phenol (Warmwater Aquatic Habitat)	5293	2560	
		Pesticides (ug/L)			
		4-4;-Dichlorodiphenyltrichloroethane (DDT)	1.1	0.001	
		Acrolein	3	3	
		Aldrin	3		
		Carbaryl	2.1	2.1	
		Chlordane	2.4	0.0043	
		Chlorpyrifos	0.083	0.041	
		Demeton		0.1	
		Diazinon	0.17	0.17	
		Dieldrin	0.24	0.056	
		alpha-Endosulfan (Endosulfan)	0.22	0.056	
		beta-Endosulfan (Endosulfan)	0.22	0.056	
		Endrin	0.086	0.036	
		Guthion		0.01	
		Heptachlor	0.52	0.0038	
		Heptachlor Epoxide	0.52	0.0038	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)	0.95		
		Malathion		0.1	
		Methoxychlor		0.03	
		Mirex		0.001	
		Parathion	0.065	0.013	
		Toxaphene	0.73	0.002	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Fish Consumption for Human Health Protection	Metals (uglL)		Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water.
		Antimony	4300	
		Thallium	6.3	
		Organic Substances (ug/L)		
		Benzene	71	
		Chlorobenzene	21000	
		1,2-Dichlorobenzene (ortho-Dichlorobenzene)	2600	
		1,3-Dichlorobenzene (meta-Dichlorobenzene)	2600	
		1,4-Dichlorobenzene (para-Dichlorobenzene)	2600	
		1,2,4-trichlorobenzene	940	
		1,2,4,5-tetrachlorobenzene	2.9	
		Pentachlorobenzene	4.1	
		Hexachlorobenzene	0.00074	
		Nitrobenzene	1900	
		1,1-dichloroethylene	3.2	
		1,1,2-trichloroethane	42	
		1,1,2,2-tetrachloroethane	11	
		1,2-Dichloroethane	99	
		1,2-dichloropropane	39	
		1,3-Dichloropene	1700	
		Carbon Tetrachloride	5	
		Hexachloroethane	8.7	
		Tetrachloroethylene	8.85	
		trans-1,2-Dichloroethylene	140000	
		Trichloroethylene	80	
		Chlorodibromomethane	34	
		Dichlorobromomethane	46	
		Dichlorodifluoromethane	570000	
		Methyl Bromide	4000	
		Methyl Chloride	470	
		Methylene Chloride	1600	
		tribromomethane	360	
		Trichlorofluoromethane	860000	
		Trichloromethane	470	
		Vinyl chloride	525	
		Bis-2-Chloroethyl Ether	1.4	
		Bis-2-Chloroisopropyl Ether	4360	
		Bis-Chloromethyl Ether	0.00078	
		2,3,7,8-TCDD (dioxin)	1.40E-08	
		Isophorone	2600	
		PCBs	0.000045	
		1,2-diphenylhydrazine	0.54	
		3,3;-Dichlorobenzidine	0.08	
		Acrylonitrile	0.65	
		Benzidine	0.00053	
		n-nitrosodimethylamine	8	
		N-nitrosodi-n-propylamine	1.4	
		N-Nitrosodiphenylamine	16	
		N-Nitrosopyrolidine	91.9	
		Acenaphthene	2700	
		Fluoroanethene	370	
		Fluorene	14000	
		Pyrene	11000	
		Other polynuclear aromatic hydrocarbons	0.049	
		Bis (2-Ethylhexyl) Phthalate	5.9	
		Butylbenzyl phthalate	5200	
		Diethyl phthalate	120000	
		Dimethyl phthalate	2900000	
		Di-n-butyl phthalate	12000	
		2-Chlorophenol	400	
		2-methyl-4,6-dinitrophenol	765	
		2,4-dichlorophenol	790	
		2,4-dimethylphenol	2300	
		2,4-dinitrophenol	14000	
		2,4,5-trichlorophenol	9800	
		2,4,6-trichlorophenol	6.5	
		Pentachlorophenol	8	
		2,4-dinitrotoluene	9	
		Toluene	200000	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Fish Consumption for Human Health Protection (cont.)	Pesticides (ug/L)		Not applicable, but potentially relevant and appropriate for OU-3. May be an ARAR if groundwater discharges to surface water. (cont.)
		4-4'-Dichlorodiphenyldichloroethane (DDD)	0.00084	
		4-4'-Dichlorodiphenyltrichloroethylene (DDE)	0.00059	
		4-4'-Dichlorodiphenyltrichloroethane (DDT)	0.00059	
		Acrolein	780	
		Aldrin	0.000079	
		Chlordane	0.00048	
		Dieldrin	0.00076	
		Endrin	0.0023	
		Endrin aldehyde	0.0023	
		Heptachlor	0.0002	
		Heptachlor Epoxide	0.00011	
		Hexachlorobutadiene	50	
		alpha-Hexachlorocyclohexane (alpha-BHC)	0.0074	
		beta-Hexachlorocyclohexane (beta-BHC)	0.0074	
		delta-Hexachlorocyclohexane (delta-BHC)	0.0074	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)	0.062	
		Toxaphene	0.000073	

Regulatory Citation	Chemical & Medium	Environmental Standard	Drinking Water Supply	Irrigation / Livestock and Wildlife Protection	Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5)	Water	Metals (uglL)			Not applicable, but potentially relevant and appropriate for OU-3.
		Antimony	6		
		Arsenic	50	100	
		Barium	2000		
		Beryllium	4	100	
		Boron		2000	
		Cadmium	5		
		Chromium (III)	100	100	
		Cobalt		1000	
		Copper	1300	500	
		Lead	15		
		Mercury	2		
		Nickel	100		
		Selenium	50		
		Silver	50		
		Thallium	2		
		Zinc	5000		
		Other Inorganic Substances (ug/L unless otherwise noted)			
		Asbestos	7×10^6 fibers/L		
		Chloride (mg/L)	250		
		Fluoride (mg/L)	4	4	
		Nitrate	10000		
		Sulfate (mg/L)	250		
		Organic Substances (ug/L)			
		Benzene	5		
		Chlorobenzene	100		
		1,2-Dichlorobenzene (ortho-Dichlorobenzene)	600		
		1,3-Dichlorobenzene (meta-Dichlorobenzene)	600		
		1,4-Dichlorobenzene (para-Dichlorobenzene)	75		
		1,2,4-trichlorobenzene	70		
		1,2,4,5-tetrachlorobenzene	2.3		
		Pentachlorobenzene	3.5		
		Hexachlorobenzene	1		
		Ethylbenzene	700		
		Nitrobenzene	17		
		Styrene (Vinyl Benzene)	100		
		1,1-dichloroethylene	7		
		1,1,1-trichloroethane	200		
		1,1,2-trichloroethane	5		
		1,1,2,2-tetrachloroethane	0.17		
		1,2-Dichloroethane	5		
		1,2-dichloropropane	0.52		
		1,3-Dichloropene	87		
		cis-1,2-Dichloroethylene	5		

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Water (cont.)	Carbon Tetrachloride	70	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Hexachloroethane	1.9	
		Tetrachloroethylene	0.8	
		trans-1,2-Dichloroethylene	100	
		Trichloroethylene	5	
		Chlorodibromomethane	0.41	
		Dichlorobromomethane	0.56	
		Ethylene dibromide	0.05	
		Methyl Bromide	48	
		Methyl Chloride	5	
		Methylene Chloride	4.7	
		Total Trihalomethanes (TTHMs)	80	
		tribromomethane	4.3	
		Trichloromethane	5.7	
		Vinyl chloride	2	
		Bis-2-Chloroethyl Ether	0.03	
		Bis-2-Chloroisopropyl Ether	1400	
		Bis-Chloromethyl Ether	0.00013	
		2,3,7,8-TCDD (dioxin)	1.30E-08	
		di (2-ethylhexyl) adipate	400	
		Isophorone	36	
		1,2-diphenylhydrazine	0.04	
		3,3;-Dichlorobenzidine	0.04	
		Acrylonitrile	0.058	
		Benzidine	0.00012	
		n-nitrosodimethylamine	0.0007	
		N-Nitrosodiphenylamine	5	
		Acenaphthene	1200	
		Fluoroanethene	300	
		Fluorene	1300	
		Pyrene	960	
		Other polynuclear aromatic hydrocarbons	0.0044	
		Bis (2-Ethylhexyl) Phthalate	6	
		Butylbenzyl phthalate	3000	
		Diethyl phthalate	23000	
		Dimethyl phthalate	313000	
		Di-n-butyl phthalate	2700	
		2-Chlorophenol	0.1	
		2-methyl-4,6-dinitrophenol	13	
		2,4-dichlorophenol	93	
		2,4-dimethylphenol	540	
		2,4-dinitrophenol	70	
		2,4,5-trichlorophenol	2600	
		2,4,6-trichlorophenol	2	
		Pentachlorophenol	1	
		Phenol (Coldwater Aquatic Habitat)	100	
		Phenol (Warmwater Aquatic Habitat)	100	
		2,4-dinitrotoluene	0.11	
		Toluene	1000	
		Xylenes (total)	10000	
		Pesticides (ug/L)		
		1,2-Dibromo-3-chloropropane (DBCP)	0.2	
		4-4'-Dichlorodiphenyldichloroethane (DDD)	0.00083	
		4-4'-Dichlorodiphenyldichloroethylene (DDE)	0.00059	
		4-4'-Dichlorodiphenyltrichloroethane (DDT)	0.00059	
		Acrolein	320	
		Alachlor	2	
		Aldrin	0.00013	
		Atrazine	3	
		Carbofuran	40	
		Chlordane	2	
		Chlorophenoxy Herbicide (2,4-D)	70	
		Chlorophenoxy Herbicide (2,4,5-TP)	50	
		Dalapon	200	
		Dieldrin	0.00014	
		Dinoseb	7	
		Diquat	20	
		Endothall	100	
		Endrin	2	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Water Quality Standards, 10 C.S.R. § 20 7.031(5) (cont.)	Water (cont.)	Endrin aldehyde	0.75	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		Heptachlor	0.4	
		Heptachlor Epoxide	0.2	
		Hexachlorobutadiene	0.45	
		Hexachlorocyclopentadiene	50	
		alpha-Hexachlorocyclohexane (alpha-BHC)	0.0022	
		beta-Hexachlorocyclohexane (beta-BHC)	0.0022	
		delta-Hexachlorocyclohexane (delta-BHC)	0.0022	
		gamma-Hexachlorocyclohexane (gamma-BHC; Lindane)	0.2	
		Methoxychlor	40	
		Oxamyl (vydate)	200	
		Picloram	500	
		Simazine	4	
		Toxaphene	3	
		<u>Health Advisory Levels (ug/L)</u>		
		1,1,1,2-Tetrachloroethane	70	
		1,2,3-trichloropropane	40	
		1,3-dinitrobenzene	1	
		1,4-dithiane	80	
		2,4,5-Trichlorophenoxyacetic acid	70	
		2,4,6-Trinitrotoluene	2	
		Ametryn	60	
		Baygon	3	
		Bentazon	20	
		Bis-2-Chloroisopropyl Ether	300	
		Bromacil	90	
		Bromochloromethane	90	
		Butylate	350	
		Carbaryl	700	
		Carboxin	700	
		Chloramben	100	
		ortho-Chlorotoluene	100	
		para-Chlorotoluene	100	
		Chlorpyrifos	20	
		DCPA (dacthal)	4000	
		Diazinon	0.6	
		Dicamba	200	
		Diisopropyl methylphosphonate	600	
		Dimethyl methylprosphonate	100	
		Diphenamid	200	
		Diphenylamine	200	
		Disulfoton	0.3	
		Diuron	10	
		Fenamiphos	2	
		Fluometron	90	
		Fonofos	10	
		Hexazinone	200	
		Malathion		
		Maleic hydrazide	4000	
		MCPA (2-Methyl-4-Chlorophenoxyacetic acid)	10	
		Methyl Bromide	10	
		Methyl parathion	2	
		Metolachlor	70	
		Metribuzin	100	
		Naphthalene	20	
		Nitroguanidine	700	
		para-Nitrophenol	60	
		Paraquat	30	
		Pronamide	50	
		Propachlor	90	
		Propazine	10	
		Propham	100	
		Tebuthiuron	500	
		Terbacil	90	
		Terbufos	0.9	
		Trichlorofluoromethane	2000	
		Trifluralin	5	
		Trinitroglycerol	5	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard		Reason Why Requirement May Be an ARAR
Missouri Public Drinking Water Program, Contaminant Levels and Monitoring 10 C.S.R. § 60-4	Inorganics, Synthetic Organic Compounds, Radionuclides, Secondary Contaminants, and Volatile Organic Compounds	Maximum contaminant levels for public water systems.		Not applicable, but potentially relevant and appropriate for OU-3.
		Inorganics (mg/L unless otherwise noted)		
		Antimony	0.006	
		Arsenic	0.01	
		Asbestos	7 x 10^6 fibers/L	
		Barium	2	
		Beryllium	0.004	
		Cadmium	0.005	
		Chromium	0.1	
		Cyanide	0.2	
		Fluoride	4	
		Mercury	0.002	
		Nitrate (as N)	10	
		Nitrite (as N)	1	
		Total Nitrate + Nitrite (as N)	10	
		Selenium 0.05	0.05	
		Thallium 0.002	0.002	
		Synthetic Organic Compounds (mg/L)		
		Alachlor	0.002	
		Atrazine	0.002	
		Benzo(a)pyrene	0.0002	
		Carbonfugran	0.04	
		Chlordane	0.002	
		Dalapon	0.2	
		Di(2-ethylhexyl) adipate	0.4	
		Dibromochloropropane (DBCP)	0.0002	
		Di(2-ethylhexyl) phthalate	0.006	
		Dinoseb	0.007	
		Diquat	0.02	
		Endothall	0.1	
		Endrin	0.002	
		2,4-D	0.07	
		Ethylene dibromide (EDB)	0.00005	
		Glyphosoate	0.7	
		Heptachlor	0.0004	
		Heptachlor Epoxide	0.0002	
		Hexachlorobenzene	0.001	
		Hexachlorocyclopentadiene	0.05	
		Lindane	0.0002	
		Methoxychlor	0.04	
		Oxamyl (Vydate)	0.2	
		Picloram	0.5	
		Polychlorinated biphenyls (PCBs)	0.0005	
		Pentachlorophenol	0.001	
		Simazine	0.004	
		Toxaphene	0.003	
		2,3,7,8-TCDD (Dioxin)	0.00000003	
		2,4,5-TP (Silvex)	0.05	
		Radionuclides		
		Combined $Ra^{226\ and}$ Ra^{228}	5 pCi/L	
		Gross alpha (excluding radon & uranium)	15 pCi/L	
		Uranium	30 ug/L	
		Secondary Contaminants		
		Aluminum	0.05 - 0.2 mg/L	
		Chloride	250 mg/L	
		Color	15 color units	
		Copper	1.0 mg/L	
		Corrosivity	Noncorrosive	
		Fluoride	2.0 mg/L	
		Foaming Agents	0.5 mg/L	
		Iron	0.3 mg/L	
		Manganese	0.05 mg/L	
		Odor	3 Threshold Odor Number	
		pH	6.5-8.5	
		Silver	0.1 mg/L	
		Sulfate	250 mg/L	
		Total Dissolved Solids	500 mg/L	
		Zinc	5 mg/L	
		Volatile Organic Compounds (mg/L)		
		Benzene	0.005	
		Carbon tetrachloride	0.005	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
Missouri Public Drinking Water Program, Contaminant Levels and Monitoring 10 C.S.R. § 60-4 (cont.)	Inorganics, Synthetic Organic Compounds, Radionuclides, Secondary Contaminants, and Volatile Organic Compounds (cont.)	1,2-Dichloroethane		0.005	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		1,1-Dichloroethylene		0.007	
		para-Dichlorobenzene		0.075	
		1,1,1-Trichloroethane		0.2	
		Trichloroethylene		0.005	
		Vinyl chloride		0.002	
		cis-1,2-Dichloroethylene		0.07	
		Dichloromethane		0.005	
		1,2-Dichloropropane		0.005	
		Ethylbenzene		0.7	
		Monodichlorobenzene		0.1	
		o-Dichlorobenzene		0.6	
		Styrene		0.1	
		Tetrachloroethylene		0.005	
		Toluene		1	
		1,2,4-Trichlorobenzene		0.07	
		1,1,2-Trichloroethane		0.005	
		trans-1,2-dischloroethylene		0.1	
		Xylenes (total)		10	
40 C.F.R. Part 141, National Primary Drinking Water Regulations, 40 C.F.R. § 141.50, 40 C.F.R. § 141.51, § 141.52, § 141.53, § 141.54, § 141.55	Various chemicals in water	Establishes standards including maximum contaminant levels (MCLs) and Goals (MCLGs)			Not applicable, but potentially relevant and appropriate for OU-3.
			MCL	MCLG	
		Trace metals (mg/L unless otherwise noted)			
		Antimony	0.006	0.006	
		Asbestos	7×10^6 fibers/liter	7 x 106 fibers/liter	
		Barium	2	2	
		Cyanide	0.2	0.2	
		Fluoride	4	4	
		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 (mg/L)			
		Alachlor zero	zero	0.002	
		Atrazine	0.003	0.003	
		Benzene	zero	0.005	
		Benzo(a)pyrene	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	
		cis-1,2-Dichloroethene	0.07	0.07	
		trans-1,2-Dichloroethene	0.1	0.1	
		Dichloromethane	zero	0.005	
		1,2-Dichloropropane	zero	0.005	
		Di(2-ethylhexyl) adipate	0.4	0.4	
		Di(2-ethylhexyl) phthalate	zero	0.006	
		Dinoseb	0.007	0.007	
		Dioxin (2,3,7,8-TCDD)	zero	0.00000003	
		Diquat	0.02	0.02	
		Endothall	0.1	0.1	
		Endrin	0.002	0.002	
		Ethylbenzene	0.7	0.7	
		Ethylene dibromide	zero	0.00005	
		Glyphosate	0.7	0.7	
		Heptachlor	zero	0.0004	
		Heptachlor epoxide	zero	0.0002	
		Hexachlorobenzene	zero	0.0001	
		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	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard			Reason Why Requirement May Be an ARAR
40 C.F.R. Part 141, National Primary Drinking Water Regulations, 40 C.F.R. § 141.50, 40 C.F.R. § 141.51, § 141.52, § 141.53, § 141.54, § 141.55 (cont.)	Various chemicals in water (cont.)	Pentachlorophenol	zero	0.001	Not applicable, but potentially relevant and appropriate for OU-3. (cont.)
		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	
		Radionuclides (picocuries per liter [pCi/L])			
		Alpha particles	zero	15 pCi/L	
		Beta particles and photon emitters	zero	4 millirems per year	
		Radium-226 and Radium-228 (combined)	-	5 pCi/L	
		Uranium (ug/L)	zero	30 ug/L	
10 C.S.R. 80-3.010(11)B.4	Water Quality in Water	The owner/operator of a sanitary landfill shall implement a groundwater monitoring program capable of determining the sanitary landfill's impact on the quality of groundwater underlying the sanitary landfill.			May be an ARAR if groundwater discharges to surface water.
TMDL for Missouri Load	Water Quality	Continue to monitor TMDLs			May be an ARAR if groundwater discharges to surface water.
640.100-640.140 RSMo Drinking water regulations	Water pollutants in Water	Safe Drinking Water Law and specified regulatory contaminant limits			May be an ARAR if groundwater discharges to surface water.
EPA Memo "Considering a Noncancer Oral Reference Dose for Uranium for Superfund Human Health Risk Assessments" (Dated December 1, 2016)	Soluble uranium in various matrices	This memorandum provides information and recommendations about an oral reference dose (RfD) for non-radiological toxicity of soluble uranium. This memorandum recommends the use of the ATSDR intermediate MRL for soluble uranium without further adjustment, in lieu of the RfD currently published in IRIS, for assessment of chronic exposures also. Specifically, evaluation of the non- carcinogenic risks posed by uranium should use a toxicity value of 0.0002 mg/kg-day.			May be a TBC
10 C.S.R. 80-3.010 Appendix I	Constituents for detection monitoring	Listed Constituents for Detection Monitoring:			May be an ARAR if Missouri state standard exists
		Indicator Constituents			
		COD (mg/L)			
		Chlorides (mg/L dissolved)			
		pH (units)			
		Specific Conductance (micromhos per centimeter at 25 degrees Celsius)			
		Total Dissolved Solids (mg/L)			
		Inorganic Constituents			
		Ammonia as N, (mg/L)			
		Antimony (ug/L)			
		Arsenic (ug/L)			
		Barium (ug/L)			
		Beryllium (ug/L)			
		Boron (ug/L)			
		Cadmium (ug/L)			
		Calcium (mg/L)			
		Chromium (ug/L)			
		Cobalt (ug/L)			
		Copper (ug/L)			
		Fluoride (mg/L)			
		Hardness (mg/L)			
		Lead (ug/L)			
		Magnesium (mg/L)			
		Manganese (ug/L)			
		Nickel (mg/L)			
		Nitrate/Nitrite (mg/L)			
		Phosphorus, total (mg/L)			
		Selenium (ug/L)			
		Silver (ug/L)			
		Sodium (mg/L)			
		Sulfate (mg/L)			
		Thallium (ug/L)			

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix I (cont.)	Constituents for detection monitoring (cont.)	Total Organic Carbon (TOC) (mg/L) Vanadium (ug/L) Zinc (ug/L) Organic Constituents Acetone Acrylonitrile Benzene Bromochloromethane Bromodichloromethane tribromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroethane Trichloromethane Dibromochloromethane 1,2-Dibromo-3-chloropropane 1,2-Dibromoethane 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethylene cis-1,2-Dichloroethylene trans-1,2-Dichloroetylene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone Methyl bromide Methyl Chloride methyl ethyl ketone Methyl iodide 4-Methyl-2-pentanone Styrene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene Toluene 1,1,1-Trichloroethane 1,1,20Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-trichloropropane Vinyl acetate Vinyl chloride xylenes	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix II	List of Hazardous Inorganic and Organic Constituents	Acenaphthene Acenaphthylene Acetone acetonitrile acetophenone 2-Acetylaminofluorene Acrolein Acrylonitrile Aldrin Allyl chloride 4-Aminobipheny Anthracene Antimony Arsenic Barium Benzene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Benzo(a)pylene Benzyl alcohol Beryllium alpha-BHC beta-BHC	May be an ARAR if Missouri state standard exists

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
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REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	delta-BHC gamma-Hexachlorocyclohexane (gamma-BHC; Lindane) Bis(2-chloroethoxy)methane Bis(2-chloroethyl) ether Bis(2-chloro-1-methylethyl) ether Bis(2-ethylhexyl) phthalate Bromochloromethane Bromodichloromethane tribromomethane 4-Bromophenylphenyl ether Butyl benzyl phthalate Cadmium Carbon disulfide Carbon tetrachloride Chlordane p-Chloroaniline Chlorobenzene Chlorobenzilate p-Chloro-m-cresol Chloromethane Trichloromethane 2-Chloronaphthalene 2-Chlorophenol 4-Chlorophenyl phenyl ether Chloroprene Chromium Chrysene Cobalt Copper m-Cresol o-Cresol p-cresol Cyanide 2,4-D 4-4'-DDD 4-4'-DDE 4-4'-DDT Diallate Dibenz(a,h)anthracene Dibenzofuran Dibromochloromethane 1,2-Dibromo3-chloropropane 1,2-Dibromomethane Di-n-butyl phthalate o-Dichlorobenzene m-Dichlorobenzene p-Dichlorobenzene 3,3'-dichlorobenzidine trans-1,4-Dichloro-2-butene Dichlorofluoromethane 1,1-Dichloroethane 1,2-Dichlroroethane 1,1-Dichloroethylene 1,1-Dichloroethene cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene trans-1,2-Dichloroethene 2,4-dichlorophenol 2,6-Dichlorophenol 1,2-Dichloropropane 1,3-Dichloropropane 2,2-Dichloropropane 1,1-Dichloropropene cis-1,3-Dichloropropene trans-1,3-Dichloropropene Dieldrin Diethyl phthalate O,O-Diethyl O-2 pyrazinyl Dimethoate p-(Dimethylamino)azobenzene 7,12-Dimethylbenz(a)nthracene	May be an ARAR if Missouri state standard exists (cont.)

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	3,3'-Dimethylbenzidine 2,4-dimethylphenol Dimethyl phthalate m-Dinitribenzene 4,6-Dinitro-o-cresol 4,6-Dinitro-2-methylphenol 2,4-dinitrophenol 2,4-Dinitrotoluene 2,6-Dinitrotoluene Dinoseb Di-n-octyl phthalate Diphenylamine Disulfoton Endosulfan Endosulfan Endosulfan sulfate Endrin Endrin aldehyde ethylbenzene ethyl methacrylate ethyl methanesulfonate famphur fluoroanthene fluorene heptachlor Heptachlor epoxide Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Hexachloroethane Hexachloropropene 2-Hexanone Indeno(1,2,3-cd)pyrene Isobutyl alcohol Isodrin Isophorone Isosafrole Kepone Lead Mercury Methacrylonitrile Methapyrilene Methoxychlor Methyl bromide Methyl Chloride 3-Methylchloranthrene Methyl ethyl ketone Methyl iodide Methyl methacrylate Methyl methanesulfonate 2-Methylnaphthalene Methyl parathion 4-Methyl-2-pentanone Methyl isobutyl ketone Methylene bromide Methylene Chloride Naphthalene 1,4-Naphthoquinone 1-Naphthylamine 2-Naphthylamine Nickel o-Nitroaniline m-Nitroaniline p-Nitroaniline Nitrobenzene o-Nitrophenol p-nitrophenol N-Nitrosodi-n-butylamine N-Nitrosodiethylamine N-Nitrosodimethylamine N-Nitrosodiphenylamine	May be an ARAR if Missouri state standard exists (cont.)

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix II (cont.)	List of Hazardous Inorganic and Organic Constituents (cont.)	N-Nitrosodipropylamine Di-n-propylnitrosamine N-Nitrosomethylethylamine N-Nitrosopiperidine N-Nitrosopyrrolidine 5-Nitro-o-toluidine Parathion Pentachlorobenzene Pentachlroonitrobenzene Pentachlorophenol Phenacetin Phenol p-Phenylenediamine Phorate PCBs Pronamide Propionitrile Pyrene Safrole Selenium Silver (ug/L) Silvex Styrene Sulfide 2,4-5-Trichlorophenoxyacetic acid 1,2,4,5-tetrachlorobenzene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene 2,3,4,6-Tetrachlorophenol Thallium Tin Toluene o-Toluidine Toxaphene 1,2,4-Trichlorobenzene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethylene Trichlorofluoromethane 2,4,5-trichlorophenol 2,4,6-trichlorophenol 1,2,3-trichloropropane 0,0,0-Triethyl phosphorothioate sym-Trinitrobenzene Vanadium Vinyl acetate Vinyl chloride Xylene (total) Zinc	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix III	Constituents for Detection Monitoring for Demolition Landfills	<u>Indicator Constituents</u> Aluminum Ammonia Antimony Arsenic Barium Beryllium Boron Cadmium Calcium Chemical Oxygen Demand Chloride Chromium Cobalt Copper Fluoride Hardness (mg/L) Iron Lead Magnesium Manganese	May be an ARAR if Missouri state standard exists

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
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Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
10 C.S.R. 80-3.010 Appendix III (cont.)	Constituents for Detection Monitoring for Demolition Landfills (cont.)	Mercury Nickel pH Potassium Selenium Silver (ug/L) Sodium Specific Conductance (micromhos per centimeter at 25 degrees Celsius) Sulfate Thallium Total Dissolved Solids Total Organic Carbon Total Organic Halogens Zinc	May be an ARAR if Missouri state standard exists (cont.)
10 C.S.R. 80-3.010 Appendix IV	Constituents for Assessment Monitoring for Demolition Landfills	Inorganic Constituents Nitrate/Nitrite (mg/L) Phosphorus, total (mg/L) Vanadium Zinc Organic Constituents Acetone Acrylonitrile Benzene Bromochloromethane Bromodichloromethane tribromomethane Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroethane Trichloromethane Dibromochloromethane 1,2-Dibromo-3-chloropropane 1,2-Dibromomethane o-Dichlorobenzene p-Dichlorobenzene trans-1,4-Dichloro-2-butene 1,1,-Dichloroethane 1,2-Dichloroethane 1,1,-Dichloroethylene Vinylidene chloride cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone Methyl bromide Methyl Chloride Methylene bromide Methylene Chloride Methyl ethyl ketone Methyl iodide 4-Methyl-2-pentanone Styrene 1,1,1,2-Tetrachloroethane 1,1,2,2-tetrachloroethane Tetrachloroethylene Toluene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethylene Trichlorofluoromethane 1,2,3-trichloropropane Vinyl acetate Vinyl chloride Xylenes	

TABLE 3-6. PRELIMINARY CHEMICAL SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Regulatory Citation	Chemical & Medium	Environmental Standard	Reason Why Requirement May Be an ARAR
OSWER 4283.1- 14 ("Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites")	Radionuclides in groundwater	OSWER Directive 9283.1-14 addresses the use of uranium drinking water standards for groundwater remediation at CERCLA sites. This directive specifies that both the uranium MCL (40 CFR 141) and the UMTRCA standards (40 CFR 192) are potentially relevant and appropriate. This directive also provides guidance on the groundwater point of compliance standard in 40 C.F.R. 192.02(c)(4) relative to the CERCLA approach for conducting groundwater responses.	May be TBC

TABLE 3-7. PRELIMINARY ACTION SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Citation	Action	Medium	Requirement	Preliminary Determination
Resource Conservation and Recovery Act (RCRA) Subtitle C (40 C.F.R. 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 C.F.R. 261) Standards for Generators of hazardous wastes (40 C.F.R. 262) Standards for Transporters of hazardous wastes (40 C.F.R. 263) Use and Management of Containers (40 C.F.R. 264 Subpart I) Land Disposal Restrictions (40 C.F.R. 264 Subpart N) Staging Piles (40 C.F.R. 264.554) Specifically, must determine if solid waste is a hazardous waste using the following method: ·Should first determine if waste is excluded from regulation under 40 C.F.R. 261.4; and ·Must then determine if waste is listed as a hazardous waste under subpart D 40 C.F.R. part 261 or whether the waste is (characteristic waste) identified in subpart C of 40 C.F.R. part 261 by either: (1)Testing the waste according to the methods set forth in subpart C of 40 C.F.R. part 261, or according to an equivalent method approved by the Administrator under 40 C.F.R. §260.21; or (2)Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used. A generator may accumulate hazardous waste at the facility provided that (accumulation of RCRA hazardous waste on site as defined in 40 C.F.R. §260.10): ·waste is placed in containers that comply with 40 C.F.R. 265.171–173; and ·the date upon which accumulation begins is clearly marked and visible for inspection on each container; ·container is marked with the words “hazardous waste”; or ·container may be marked with other words that identify the contents if accumulation of 55 gal. or less of RCRA hazardous waste or one quart of acutely hazardous waste listed in §261.33(e) at or near any point of generation.	Potentially applicable in the event that hazardous wastes or
CERCLA Offsite Rule 40 C.F.R. 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
DOT and NRC regulations for shipment of radioactive materials 49 C.F.R. Parts 171-180 and 10 C.F.R. 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.
CERCLA Offsite Rule 40 C.F.R. 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

TABLE 3-7. PRELIMINARY ACTION SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Citation	Action	Medium	Requirement	Preliminary Determination
DOT and NRC regulations for shipment of radioactive materials 49 C.F.R. Parts 171-180 and 10 C.F.R. 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.
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.
40 C.F.R. Part 131 (Water Quality Standards) 40 C.F.R. § 131.36	Sets forth requirements and procedures for developing, reviewing, revising and approving water quality standards by the States as authorized by the Clean Water Act	Groundwater	40 C.F.R. Part 131 describes the requirements and procedures for developing, reviewing, revising, and approving water quality standards by the States as authorized by section 303(c) of the Clean Water Act. 40 C.F.R. Part 131 does not lay out specific standards to be applied, but rather serves as a framework by which States must develop water quality standards for water bodies, including uses that may be made of such bodies, and standards to promote the safety of water as used. It also provides for the process by which EPA reviews, revises and approves of water quality standards developed by States.	Not applicable, but potentially relevant and appropriate for OU-3.
644.051.1	Release of Pollutants to Waters of the State		1 It is unlawful for any person to cause pollution of any waters of the state or to place or cause or permit to be placed any water contaminant in a location where it is reasonably certain to cause pollution of any waters of the state. Unlawful to pollute waters of the state reduce quality below water quality standards, violate pretreatment and toxic material control regulations, discharge radiological, chemical or biological gen or high-level radioactive wastes into waters of the state.	Substantive elements of these chapters may be applicable if implementing a remedial action to include a groundwater treatment remedy.
10 C.S.R. 80-3.010(12)(C)	Corrective Measures		Requirement related to the establishment and implementation of a corrective action groundwater monitoring program.	Not applicable to CERCLA sites, but may be relevant and appropriate if water pollutants are present in groundwater or any water discharge.

TABLE 3-7. PRELIMINARY ACTION SPECIFIC ARARs
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Citation	Action	Medium	Requirement	Preliminary Determination
10 C.S.R. 23-4 Monitoring Well Construction Code	Installation of observation or monitoring wells		Regulates drilling, construction, registration, and abandonment of monitoring wells in Missouri	Substantive portions of Division 23 may be relevant and appropriate if wells are constructed and/or abandoned as part of the remedy, but will mostly be administrative.
4 C.S.R. 145-1.010 Board of Geologist Registration	Practice of geology		Regulates practice	Substantive portions of 4 C.S.R. 145-1.010 may be relevant and appropriate if a PG stamp and seal on drawings are necessary as part of the remedy. Otherwise mostly administrative.
10 C.S.R. 23-3.110 Plugging of Wells	Abandonment of unused domestic supply wells		Regulates activity	Although abandonment of unused domestic supply wells are not envisioned; could be relevant and appropriate if monitoring wells are required to be abandoned.
L.1991 S.B.221, an Act RSMo 256.621	Groundwater tracing		All persons engaged in groundwater or surface water tracing, for any purpose, shall register with the division. The registrant shall report in writing all proposed injections of tracers to the division prior to actual injection. Written and graphical documentation of traces shall be provided to the division within thirty days of completion of each trace. The division shall maintain records of all injections and traces reported and will provide this information to interested parties upon request.	If groundwater tracing is required, this might be considered an ARAR, but note that this activity is not part of the proposed RI activities.
Hazardous Waste Management Law 260.350- 260.1039 Hazardous Waste Regulations 10 C.S.R. 25-1 through 19.	Hazardous Waste Generation, storage, treatment, transportation and disposal		Follow all applicable state and federal hazardous waste laws and regulations	Substantive portions of Division 25 may be Relevant and Appropriate if hazardous waste is required to be managed under the selected remedial options.

TABLE 3-8. PRELIMINARY IDENTIFICATION OF POTENTIAL LOCATION-SPECIFIC ARARS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Location Subject to Requirement	Requirement	Reason Why Requirement May Be an ARAR	Regulatory Citation
Fee Fee Creek Watershed	Effluent Limitations for Metropolitan No-Discharge Streams. Discharge is prohibited except as specifically permitted under the Water Quality Standards 10 C.S.R 20-7031(7).	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.015(5) (A) Discharge to metropolitan no-discharge streams is prohibited, except as specifically permitted under the Water Quality Standards 10 C.S.R 20-7.031 and noncontaminated storm water flows.
Waters of the State of Missouri	Protection of designated uses.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(2)(A)-(C) (2) Designation of Uses. (A) Rebuttable presumption. (B) Presumed Uses. All waters described in subsection (2)(A) shall also be assigned Livestock and wildlife protection and Irrigation designated uses, as defined in this rule. (C) Other Uses
Waters of the State of Missouri	Waters of the state are subject to applicable Anti- Degradation Tiers 1 & 2.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(3) The antidegradation policy shall provide three (3) levels of protection.
Waters of the State of Missouri	General criteria are applicable to all waters of the state at all times, including mixing zones.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(4) The following water quality criteria shall be applicable to all waters of the state at all times including mixing zones.
Mixing Zones	Where mixing zones are applicable, they will be based on 7Q10 low flow.	To ensure existing or proposed discharges are in compliance.	10 C.S.R 20-7.031(5)(A) Specific Criteria. The specific criteria shall apply to waters contained in Tables G and H of this rule and the Missouri Use Designation Dataset. Protection of drinking water supply is limited to surface waters designated for raw drinking water supply and aquifers. Protection of whole body contact recreation is limited to waters designated for that use. (A) The maximum chronic toxicity criteria in Tables A and B shall apply to waters designated for the indicated uses given in the Missouri Use Designation Dataset and Tables G and H.

TABLE 5-1. PRELIMINARY MONITORING WELL INVENTORY
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Well ID	DTW (ft bmp)	TD (ft bmp)	Construction	Comments
D-13	40.19	135.57	2" SCH 80 PVC	SILTY, WATERRA
I-65	11.61	38.48	2" SCH 40 PVC	WATERRA
I-65	11.68	41.14	2" SCH 40 PVC	SOFT, WATERRA
I-67	11.53	40.56	2" SCH 40 PVC	
D-12	49.63	148.55	2" SCH 80 PVC	WATERRA
S-10	49.98	56.63	2" SCH 40 PVC	WATERRA
I-11	49.95	94.48	2" SCH 80 PVC	WATERRA
D-6	17.35	108.09	2" SCH 80 PVC	WATERRA
I-9	20.5	56.8	2" SCH 40 PVC	STICK UP MISLABELED, WATERRA
S-82	19.73	26.42	2" SCH 40 PVC	WATERRA
D-93	19.6	114.52	2" SCH 40 PVC	STICK UP MISLABELED, WATERRA
MW-103	8.42	14.35	2" SCH 40 PVC	WATERRA
I-62	16.1	44.78	2" SCH 40 PVC	WATERRA
D-83	18.4	98.09	2" SCH 40 PVC	WATERRA
D-3	37.57	107.7	2" SCH 80 PVC	WATERRA
I-4	34.91	35.9	2" SCH 40 PVC	PINCHED CASING, WATERRA
S-5	34.19	43.43	2" SCH 40 PVC	WATERRA
D-89	26.25	50.46	2" SCH 40 PVC	NO SURVEY DATA
D-81	20.05	62.56	2" SCH 40 PVC	NO SURVEY DATA
D-87	34.2	115.25	2" SCH 40 PVC	

Notes:
DTW - depth to water
ft bmp - feet below measuring point
TD - total depth
SCH - schedule
PVC - polyvinyl chloride
WATERRA - contains Waterra check valve and tubing

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Borehole Diameter (inches)	Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
MW	213	AS	MW-213-AS	23	448	12	2-inch double nested Sch. 40 PVC	I-67	2, 3, 5, 6, 7, 9	No shallow alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	213	AD	MW-213-AD	111	451	12	2-inch double nested Sch. 80 PVC	I-67	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	302	AD	MW-302-AD	111	451	9/6	2-inch Sch. 80 PVC	PZ-302-AS, PZ-302-AI	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	303	AI	MW-303-AI	53	448	12	2-inch double nested Sch. 40 PVC	MW-104, PZ-303-AS, LR-105	2, 3, 5, 6, 7, 9	No intermediate alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	303	AD	MW-303-AD	111	451	12	2-inch double nested Sch. 80 PVC	MW-104, PZ-303-AS, LR-105	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	304	AD	MW-304-AD	111	451	9	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	304	SS	MW-304-SS	151	451	9/6	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	304	SD	MW-304-SD	211	451	9/6	2-inch Sch. 80 PVC	PZ-304 Cluster	2, 3, 5, 6, 7, 9	No deep or bedrock wells exist at PZ-304 cluster	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	306	AI	MW-306-AI	53	448	12	2-inch double nested Sch. 40 PVC	MW-103	2, 3, 5, 6, 7, 9	No intermediate alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	306	AD	MW-306-AD	109	451	12	2-inch double nested Sch. 80 PVC	MW-103	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	400	AS	MW-400-AS	26	446	12	2-inch triple nested Sch. 40 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
MW	400	AI	MW-400-AI	51	446	12	2-inch triple nested Sch. 40 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
MW	400	AD	MW-400-AD	106	446	12	2-inch triple nested Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
MW	400	SS*	MW-400-SS*	146	446	9/6	2-inch Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
MW	400	SD	MW-400-SD	206	446	9/6	2-inch Sch. 80 PVC	S-61, MW-102, D-6	2, 3, 5, 6, 7, 9	S-61 and MW-102 abandoned, D-6 slated for abandonment	Sonic/Continuous Core	AAA Trailers
MW	401	AS	MW-401-AS	25	445	12	2-inch triple nested Sch. 40 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
MW	401	AI	MW-401-AI	50	445	12	2-inch triple nested Sch. 40 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
MW	401	AD	MW-401-AD	105	445	12	2-inch triple nested Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	Additional Area 2 perimeter well	Sonic/Continuous Core	AAA Trailers
MW	401	SS*	MW-401-SS*	145	445	9/6	2-inch Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	No bedrock wells exist at this location	Sonic/Continuous Core	AAA Trailers
MW	401	SD	MW-401-SD	205	445	9/6	2-inch Sch. 80 PVC	S-8, I-62, D-83	2, 3, 5, 6, 7, 9	No bedrock wells exist at this location	Sonic/Continuous Core	AAA Trailers
MW	402	AS	MW-402-AS	34	454	12	2-inch triple nested Sch. 40 PVC	I-66, D-13	2, 3, 5, 6, 7, 9, 10	No shallow alluvial well exists at this location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	402	AI	MW-402-AI	59	454	12	2-inch triple nested Sch. 40 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	Supplemental intermediate alluvial well to I-66	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	402	AD	MW-402-AD	114	454	12	2-inch triple nested Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	Supplemental deep alluvial well to D-13	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	402	SS*	MW-402-SS*	154	454	9/6	2-inch Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC
MW	402	SD	MW-402-SD	214	454	9/6	2-inch Sch. 80 PVC	I-66, D-13	2, 3, 5, 6, 7, 9	No bedrock wells exist at this on-site location	Sonic/Continuous Core	Bridgeton Landfill, LLC

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Borehole Diameter (inches)	Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
MW	403	AS	MW-403-AS	21	440	12	2-inch triple nested Sch. 40 PVC	I-65	2, 3, 5, 6, 7, 9	No shallow alluvial well exists at this location	Sonic/Continuous Core	City of Bridgeton Right of Way
MW	403	AI	MW-403-AI	53	448	12	2-inch triple nested Sch. 40 PVC	I-65	2, 3, 5, 6, 7, 9	Supplemental intermediate alluvial well to I-65	Sonic/Continuous Core	City of Bridgeton Right of Way
MW	403	AD	MW-403-AD	109	448	12	2-inch triple nested Sch. 80 PVC	I-65	2, 3, 5, 6, 7, 9	No deep alluvial well exists at this location	Sonic/Continuous Core	City of Bridgeton Right of Way
MW	500	AS	MW-500-AS	19	439	12	2-inch triple nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	500	AI	MW-500-AI	44	439	12	2-inch triple nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	500	AD	MW-500-AD	99	439	12	2-inch triple nested Sch. 40 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	500	SS*	MW-500-SS*	139	439	9/6	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	500	SD	MW-500-SD	199	439	9/6	2-inch Sch. 80 PVC	SG-500*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	501	AS	MW-501-AS	18	438	12	2-inch triple nested Sch. 40 PVC	SG-400*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	501	AI	MW-501-AI	43	438	12	2-inch triple nested Sch. 40 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	501	AD	MW-501-AD	98	438	12	2-inch triple nested Sch. 40 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	501	SS*	MW-501-SS*	138	438	9/6	2-inch Sch. 80 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	501	SD	MW-501-SD	198	438	9/6	2-inch Sch. 80 PVC	SG-400*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Earth City Right-of-Way
MW	502	AS	MW-502-AS	25	445	12	2-inch triple nested Sch. 40 PVC	USGS St. Charles Missouri River Gauge, SG-502*	2, 3, 5, 6, 8, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
MW	502	AI	MW-502-AI	50	445	12	2-inch triple nested Sch. 40 PVC	USGS St. Charles Missouri River Gauge, SG-502*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
MW	502	AD	MW-502-AD	105	445	12	2-inch triple nested Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
MW	502	SS*	MW-502-SS*	145	445	9/6	2-inch Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
MW	502	SD	MW-502-SD	205	445	9/6	2-inch Sch. 80 PVC	USGS St. Charles Missouri River Gauge, SG-502*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	R T GROUP II LLC
MW	503	AS	MW-503-AS	21	440	12	2-inch triple nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Company
MW	503	AI	MW-503-AI	46	441	12	2-inch triple nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Company
MW	503	AD	MW-503-AD	101	441	12	2-inch triple nested Sch. 90 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	Sensory Effects Flavor Company
MW	504	AS	MW-504-AS	21	440	12	2-inch triple nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems, Inc.
MW	504	AI	MW-504-AI	46	441	12	2-inch triple nested Sch. 40 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems, Inc.
MW	504	AD	MW-504-AD	101	441	12	2-inch triple nested Sch. 80 PVC	SG-503*	2, 3, 5, 6, 9,10	Evaluate nature and extent of impacts and regional gradient	Sonic/Continuous Core	DST Systems, Inc.

TABLE 5-2. PROPOSED MONITORING WELL RATIONALE
WEST LAKE LANDFILL OU3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Prefix	Series	Zone	Borehole ID	Total Depth (ft bgs)	Ground Surface Elevation (ft msl)	Borehole Diameter (inches)	Well Construction	Nearby Wells/Piezometers/ Staff Gauges	Data Gaps Addressed	Additional Rationale	Drilling Method	Property Owner
MW	600	AS	MW-600-AS	25	445	12	2-inch triple nested Sch. 40 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	600	AI	MW-600-AI	50	445	12	2-inch triple nested Sch. 40 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	600	AD*	MW-600-AD*	105	445	12	2-inch triple nested Sch. 80 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	601	AS	MW-601-AS	20	440	12	2-inch triple nested Sch. 40 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	601	AI	MW-601-AI	45	440	12	2-inch triple nested Sch. 40 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	601	AD	MW-601-AD	100	440	12	2-inch triple nested Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	Maryland Heights Right of Way
MW	602	AS	MW-602-AS	14	434	12	2-inch triple nested Sch. 40 PVC	SG-600*	2, 3, 5, 6, 8, 9,10	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	EarthCity Right-of-Way
MW	602	AI	MW-602-AI	39	434	12	2-inch triple nested Sch. 40 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	EarthCity Right-of-Way
MW	602	AD*	MW-602-AD*	94	434	12	2-inch triple nested Sch. 80 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background alluvial groundwater quality	Sonic/Continuous Core	EarthCity Right-of-Way
MW	602	SS*	MW-602-SS*	134	434	9/6	2-inch Sch. 80 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	EarthCity Right-of-Way
MW	602	SD	MW-602-SD	194	434	9/6	2-inch Sch. 80 PVC	SG-600*	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	EarthCity Right-of-Way
MW	603	SS	MW-603-SS	232	532	9/6	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
MW	603	SD	MW-603-SD	292	532	9/6	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
MW	604	SS	MW-604-SS	214	514	9/6	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton
MW	604	SD	MW-604-SD	274	514	9/6	2-inch Sch. 80 PVC	N/A	2, 3, 4, 5, 6, 9	Evaluate background bedrock groundwater quality	Sonic/Continuous Core	City of Bridgeton

Notes:

Data Gaps

1 Adequacy, usability, and status of existing and abandoned on-site and perimeter monitoring wells and associated data
2 Aquifer properties, including recharge/discharge rates and hydraulic conductivities
3 Regional and localized hydraulic gradients and flow directions within and between the alluvial aquifer and shallow and deep units (upper and lower intervals) of the bedrock aquifer system (Missi
4 Background groundwater quality of aquifers located at and near the Site
5 Occurrence and extent of groundwater impacts
6 Groundwater geochemistry parameters, redox couples, and organic content
7 Effects of the Bridgeton Landfill related infrastructure (leachate extraction system, EVOH cover, etc.) and hydraulic characteristics of landfill material on the groundwater system, and leachate chemistry/occurrence
8 Vapor intrusion
9 Temporal variability in groundwater levels and flow direction
10 Temporal and spatial water elevation effects from nearby surface water features (Missouri River) a

Zone Explanation

AS Shallow Alluvial
AI Intermediate Alluvial
AD Deep Alluvial
SS Deep St. Louis/Shallow Salem Formation
SD Salem Formation
KS Keokuk Formation

Series Explanation

100 Immediately adjacent to the perimeter of the active sanitary landfill
200 Within 500 feet of the active sanitary landfill
300 Adjacent to inactive landfill areas in western portion of site
400 Within 500 feet of Area 2
500 Offsite
600 Background

* - To be installed in formation if encountered in this location.
All boreholes drilled using sonic drilling techniques and monitoring wells constructed using 0.005-inch factory slotted PVC screen
PVC - polyvinyl chloride
Sch. - Schedule
N/A - not applicable
TBD - to be determined if deep alluvium present at this location
Alluvial samples will be collected from deepest hole at each location and submitted for laboratory analysis
Total depth is approximate
New wells subject to access agreement with property owner

TABLE 5-3. PROPOSED MONITORING WELL NETWORK
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

86 Existing Monitoring Wells					64 Proposed Monitoring Wells				
Prefix	**Series**	**Zone**	**Well ID**	**Current Monitoring Status**	**Location**	**Prefix**	**Series**	**Zone**	**Well ID**
PZ	112	AS	PZ-112-AS	A		MW	213	AS	MW-213-AS
PZ	113	AS	PZ-113-AS	A		MW	213	AD	MW-213-AD
PZ	114	AS	PZ-114-AS	A		MW	302	AD	MW-302-AD
PZ	205	AS	PZ-205-AS	A		MW	303	AI	MW-303-AI
PZ	207	AS	PZ-207-AS	A		MW	303	AD	MW-303-AD
S	84	AS	S-84	A	On-site	MW	304	AD	MW-304-AD
MW	103	AS	MW-103	I		MW	304	SS	MW-304-SS
MW	104	AS	MW-104	I		MW	304	SD	MW-304-SD
MW	1201	AS	MW-1201	I		MW	306	AI	MW-306-AI
PZ	302	AS	PZ-302-AS	I		MW	306	AD	MW-306-AD
PZ	303	AS	PZ-303-AS	I		MW	400	AS	MW-400-AS
PZ	304	AS	PZ-304-AS	I		MW	400	AI	MW-400-AI
S	5	AS	S-5**	I		MW	400	AD	MW-400-AD
S	8	AS	S-8	I		MW	400	SS*	MW-400-SS*
S	10	AS	S-10**	I		MW	400	SD	MW-400-SD
S	53	AS	S-53	I		MW	401	AS	MW-401-AS
S	82	AS	S-82	I		MW	401	AI	MW-401-AI
I	68	AI	I-68	A		MW	401	AD	MW-401-AD
I	73	AI	I-73	A	On-site / Near-site	MW	401	SS*	MW-401-SS*
D	89	AI	D-89	I		MW	401	SD	MW-401-SD
I	4	AI	I-4**	I		MW	402	AS	MW-402-AS
I	9	AI	I-9	I		MW	402	AI	MW-402-AI
I	11	AI	I-11**	I		MW	402	AD	MW-402-AD
I	62	AI	I-62**	I		MW	402	SS*	MW-402-SS*
I	65	AI	I-65	I		MW	402	SD	MW-402-SD
I	66	AI	I-66	I		MW	403	AS	MW-403-AS
I	67	AI	I-67	I		MW	403	AI	MW-403-AI
PZ	302	AI	PZ-302-AI	I		MW	403	AD	MW-403-AD
PZ	304	AI	PZ-304-AI	I		MW	500	AS	MW-500-AS
PZ	305	AI	PZ-305-AI	I		MW	500	AI	MW-500-AI
I	7	AI	I-7	U		MW	500	AD	MW-500-AD
D	85	AD	D-85	A		MW	500	SS*	MW-500-SS*
PZ	113	AD	PZ-113-AD	A		MW	500	SD	MW-500-SD
D	3	AD	D-3**	I		MW	501	AS	MW-501-AS
D	6	AD	D-6**	I		MW	501	AI	MW-501-AI
D	12	AD	D-12**	I		MW	501	AD	MW-501-AD
D	13	AD	D-13**	I		MW	501	SS*	MW-501-SS*
D	81	AD	D-81	I		MW	501	SD	MW-501-SD
D	83	AD	D-83**	I	Off-site	MW	502	AS	MW-502-AS
D	87	AD	D-87	I		MW	502	AI	MW-502-AI
D	93	AD	D-93	I		MW	502	AD	MW-502-AD
LR	100	LR	LR-100	I		MW	502	SS*	MW-502-SS*
LR	103	LR	LR-103	I		MW	502	SD	MW-502-SD
LR	104	LR	LR-104	I		MW	503	AS	MW-503-AS
LR	105	LR	LR-105	I		MW	503	AI	MW-503-AI
PZ	100	SS	PZ-100-SS	A		MW	503	AD	MW-503-AD
PZ	101	SS	PZ-101-SS	A		MW	504	AS	MW-504-AS
PZ	102	SS	PZ-102R-SS	A		MW	504	AI	MW-504-AI
PZ	102	SS	PZ-102-SS	A		MW	504	AD	MW-504-AD

TABLE 5-3. PROPOSED MONITORING WELL NETWORK
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

86 Existing Monitoring Wells					64 Proposed Monitoring Wells				
Prefix	**Series**	**Zone**	**Well ID**	**Current Monitoring Status**	**Location**	**Prefix**	**Series**	**Zone**	**Well ID**
PZ	103	SS	PZ-103-SS	A	Background	MW	600	AS	MW-600-AS
PZ	104	SS	PZ-104-SS	A		MW	600	AI	MW-600-AI
PZ	105	SS	PZ-105-SS	A		MW	600	AD	MW-600-AD
PZ	106	SS	PZ-106-SS	A		MW	601	SS	MW-601-SS
PZ	107	SS	PZ-107-SS	A		MW	601	SD	MW-601-SD
PZ	109	SS	PZ-109-SS	A		MW	602	SS	MW-602-SS
PZ	111	SS	PZ-111-SS	A		MW	602	SD	MW-602-SD
PZ	113	SS	PZ-113-SS	A		MW	603	AS	MW-603-AS
PZ	115	SS	PZ-115-SS	A		MW	603	AI	MW-603-AI
PZ	116	SS	PZ-116-SS	A		MW	603	AD*	MW-603-AD*
PZ	200	SS	PZ-200-SS	A		MW	603	SS*	MW-603-SS*
PZ	201	SS	PZ-201A-SS	A		MW	603	SD	MW-603-SD
PZ	202	SS	PZ-202-SS	A		MW	604	AS	MW-604-AS
PZ	203	SS	PZ-203-SS	A		MW	604	AI	MW-604-AI
PZ	204A	SS	PZ-204A-SS	A		MW	604	AD	MW-604-AD
PZ	204	SS	PZ-204-SS	A					
PZ	205	SS	PZ-205-SS	A					
PZ	206	SS	PZ-206-SS	A					
PZ	208	SS	PZ-208-SS	A					
PZ	209	SS	PZ-209-SS	A					
PZ	210	SS	PZ-210-SS	A					
PZ	211	SS	PZ-211-SS	A					
PZ	212	SS	PZ-212-SS	A					
PZ	110	SS	PZ-110-SS	I					
MW	1204	SD	MW-1204	A					
PZ	100	SD	PZ-100-SD	A					
PZ	104	SD	PZ-104-SD	A					
PZ	106	SD	PZ-106-SD	A					
PZ	111	SD	PZ-111-SD	A					
PZ	209	SD	PZ-209-SD	A					
PZ	210	SD	PZ-210-SD	A					
PZ	211	SD	PZ-211-SD	A					
PZ	212	SD	PZ-212-SD	A					
PZ	100	KS	PZ-100-KS	A					
PZ	104	KS	PZ-104-KS	A					
PZ	106	KS	PZ-106-KS	A					
PZ	111	KS	PZ-111-KS	A					

I - Intermediate
D - Deep
LR - Leachate Riser
MW - Monitoring Well
PZ - Piezometer

I - Inactive
U - Unknown
P - Proposed

Hydrological Zone
AS - Shallow Alluvial
AI - Intermediate Alluvial
AD - Deep Alluvial
LR - Leachate Riser
SS - Upper Salem/St. Louis Formation
SD - Salem Formation
KS - Keokuk Formation
* - Installed if zone encountered at proposed location
** - monitoing well may be in the footprint of OU-1 removal activities
Samples will not be collected from well I-4 due to compromised casing

TABLE 5-4. WELLS PROPOSED FOR SLUG TESTING
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

64 Proposed Wells, October 2019					34 Existing Wells				
Location	Prefix	Series	Zone	Well ID	Prefix	Series	Zone	Well ID	Current Monitoring Status
On-site	MW	213	AS	MW-213-AS	S	84	AS	S-84	A
	MW	213	AD	MW-213-AD	I	73	AI	I-73	A
	MW	302	AD	MW-302-AD	PZ	102	SS	PZ-102-SS	A
	MW	303	AI	MW-303-AI	PZ	111	SS	PZ-111-SS	A
	MW	303	AD	MW-303-AD	PZ	203	SS	PZ-203-SS	A
	MW	304	AD	MW-304-AD	PZ	209	SS	PZ-209-SS	A
	MW	304	SS	MW-304-SS	PZ	210	SS	PZ-210-SS	A
	MW	304	SD	MW-304-SD	PZ	211	SS	PZ-211-SS	A
	MW	306	AI	MW-306-AI	PZ	212	SS	PZ-212-SS	A
	MW	306	AD	MW-306-AD	MW	1204	SD	MW-1204	A
On-site / Near-site	MW	400	AS	MW-400-AS	PZ	209	SD	PZ-209-SD	A
	MW	400	AI	MW-400-AI	PZ	210	SD	PZ-210-SD	A
	MW	400	AD	MW-400-AD	PZ	211	SD	PZ-211-SD	A
	MW	400	SS*	MW-400-SS*	PZ	212	SD	PZ-212-SD	A
	MW	400	SD	MW-400-SD	MW	103	AS	MW-103	I
	MW	401	AS	MW-401-AS	MW	104	AS	MW-104	I
	MW	401	AI	MW-401-AI	MW	1201	AS	MW-1201	I
	MW	401	AD	MW-401-AD	S	5	AS	S-5	I
	MW	401	SS*	MW-401-SS*	S	8	AS	S-8	I
	MW	401	SD	MW-401-SD	S	10	AS	S-10	I
	MW	402	AS	MW-402-AS	S	53	AS	S-53	I
	MW	402	AI	MW-402-AI	S	82	AS	S-82	I
	MW	402	AD	MW-402-AD	D	89	AI	D-89	I
	MW	402	SS*	MW-402-SS*	I	62	AI	I-62	I
	MW	402	SD	MW-402-SD	I	65	AI	I-65	I
	MW	403	AS	MW-403-AS	I	66	AI	I-66	I
	MW	403	AI	MW-403-AI	I	67	AI	I-67	I
	MW	403	AD	MW-403-AD	D	81	AD	D-81	I
Off-site	MW	500	AS	MW-500-AS	D	83	AD	D-83	I
	MW	500	AI	MW-500-AI	D	87	AD	D-87	I
	MW	500	AD	MW-500-AD	LR	100	LR	LR-100	I
	MW	500	SS*	MW-500-SS*	LR	103	LR	LR-103	I
	MW	500	SD	MW-500-SD	LR	104	LR	LR-104	I
	MW	501	AS	MW-501-AS	LR	105	LR	LR-105	I
	MW	501	AI	MW-501-AI					
	MW	501	AD	MW-501-AD					
	MW	501	SS*	MW-501-SS*					
	MW	501	SD	MW-501-SD					
	MW	502	AS	MW-502-AS					
	MW	502	AI	MW-502-AI					
	MW	502	AD	MW-502-AD					
	MW	502	SS*	MW-502-SS*					
	MW	502	SD	MW-502-SD					
	MW	503	AS	MW-503-AS					
	MW	503	AI	MW-503-AI					
	MW	503	AD	MW-503-AD					
	MW	504	AS	MW-504-AS					
	MW	504	AI	MW-504-AI					
	MW	504	AD	MW-504-AD					
Background	MW	600	AS	MW-600-AS					
	MW	600	AI	MW-600-AI					
	MW	600	AD	MW-600-AD					
	MW	601	SS	MW-601-SS					
	MW	601	SD	MW-601-SD					
	MW	602	SS	MW-602-SS					
	MW	602	SD	MW-602-SD					
	MW	603	AS	MW-603-AS					
	MW	603	AI	MW-603-AI					
	MW	603	AD*	MW-603-AD*					
	MW	603	SS*	MW-603-SS*					
	MW	603	SD	MW-603-SD					
	MW	605	AS	MW-605-AS					
	MW	605	AI	MW-605-AI					
	MW	605	AD	MW-605-AD					

Note:
* - slug tested if monitoring zone encountered during well installation

TABLE 5-5. WELL LOCATIONS TO CONSIDER FOR DATALOGGER PLACEMENT
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

NEW ONSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-304			X	X	X	
MW-306		X	X			

NEW ONSITE / NEAR-SITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-400	X	X	X	X	X	
MW-401	X	X	X	X	X	
MW-402	X	X	X	X	X	

NEW OFFSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
MW-500	X	X	X	X*	X	
MW-501	X	X	X	X*	X	
MW-502	X	X	X	X*	X	
MW-503	X	X	X			
MW-504	X	X	X			
MW-602	X	X	X	X	X	
MW-603				X	X	
MW-604				X	X	

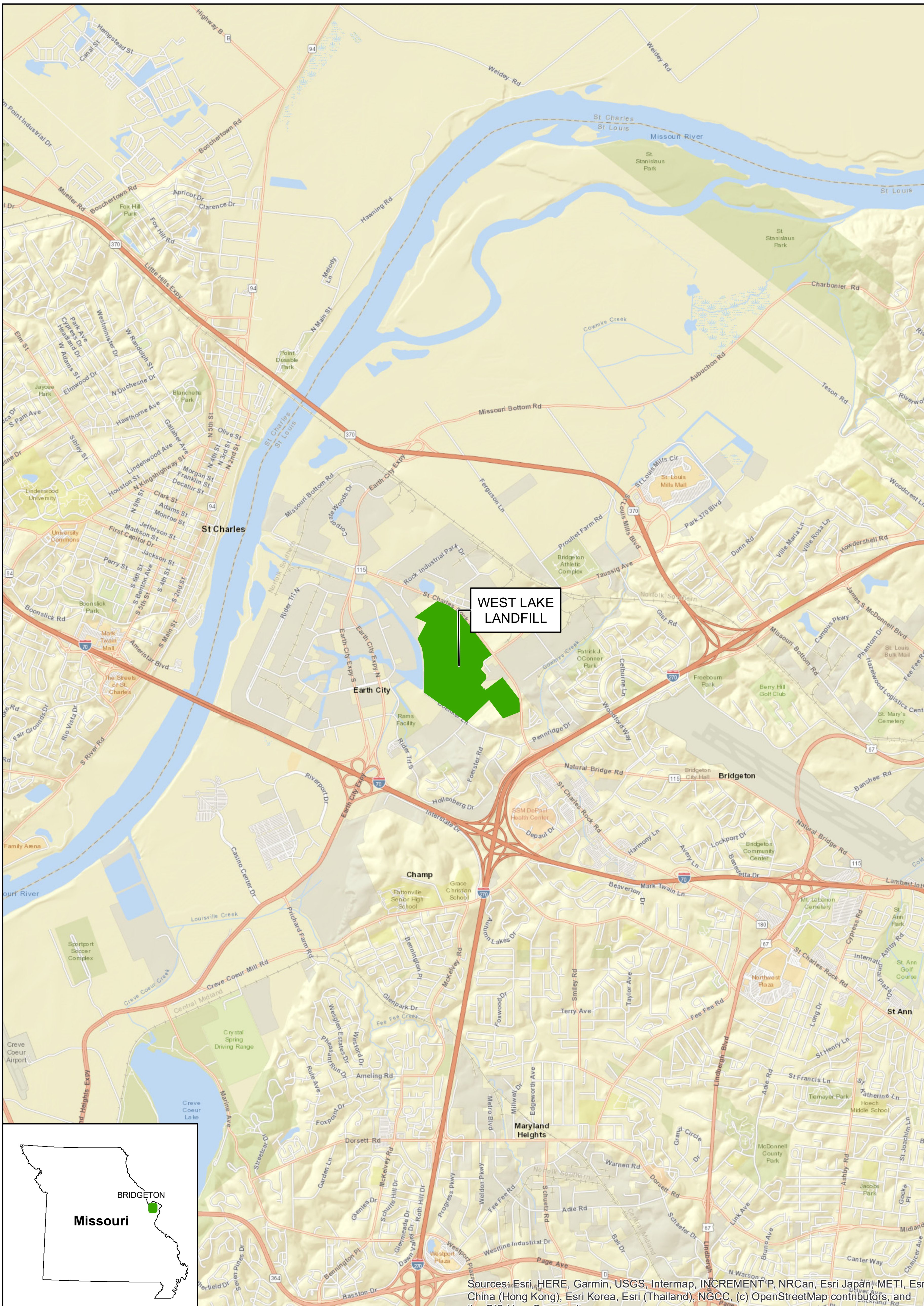
TABLE 5-5. WELL LOCATIONS TO CONSIDER FOR DATALOGGER PLACEMENT
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

EXISTING ONSITE WELL LOCATIONS

	Aquifer Monitoring Intervals					
Well ID	**AS**	**AI**	**AD**	**SS**	**SD**	**KS**
S-8	X					
I-62		X				
D-83			X			
S-82	X					
I-9		X				
D-93			X			
PZ-202				X		
PZ-209				X	X	
PZ-211				X	X	
PZ-113	X		X	X		
PZ-100				X	X	X
PZ-304	X	X				
MW-103	X					

Notes:
AS = Shallow Alluvium
AI = Intermediate Alluvium
AD = Deep Alluvium
SS = St. Louis and Upper Salem Formations
SD = The base of the Salem Formation
KS = Keokuk Formation
* = deployed if proposed zone encountered during well installation

FIGURES



EXPLANATION

LANDFILL BOUNDARY

LATITUDE: 38.768106
LONGITUDE: -90.444574
LATITUDE AND LONGITUDE ARE IN NAD83

N

0 4,000 '

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FIGURE 1-1

SITE LOCATION MAP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 4,000 '	Date: 10/28/19	File: 1-1_SiteLocation_Fig1-1.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\1-1_SITELOCATION_FIG1-1.MXD

EXPLANATION

- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY
- OPERABLE UNIT 1

N

0 1,000'

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FIGURE 1-2

SITE LAYOUT MAP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 1,000 '	Date: 11/5/19	File: 1-2_SiteLayout_Fig1-2.mxd

M:\WTO\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\1-2_SITELAYOUT_FIG1-2.MXD

EXPLANATION

- SUPERFUND SITE BOUNDARY
- LANDFILL BOUNDARY
- LEACHATELAGOON
- OPERABLE UNIT 1

N

0 500 '

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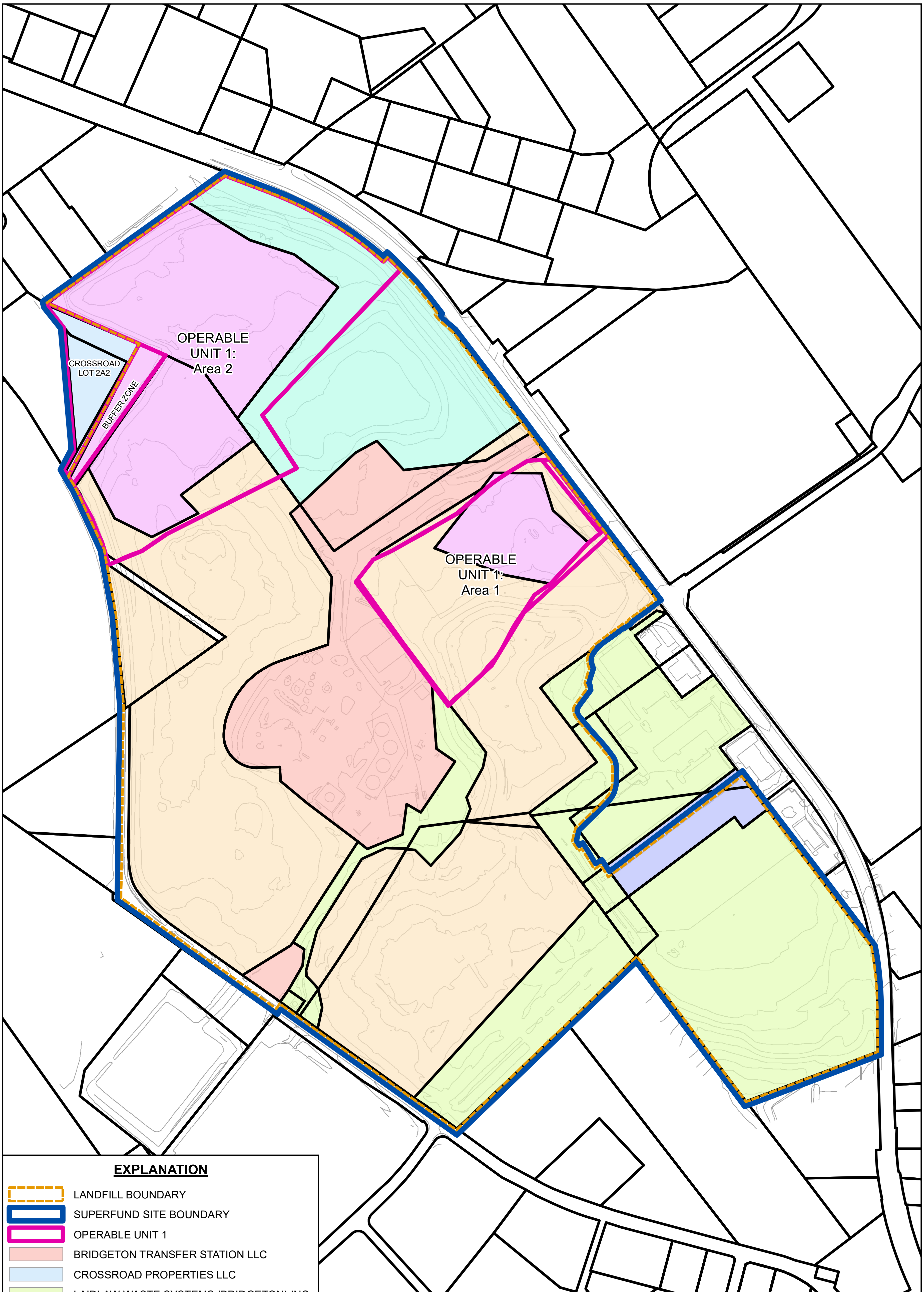
FIGURE 2-1

AREAS OF LANDFILL OPERATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 10/30/19	File: 2-1_LandfillOperations_Fig2-1.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\2-1_LANDFILLOPERATIONS_FIG2-1.MXD



EXPLANATION

- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY
- OPERABLE UNIT 1
- BRIDGETON TRANSFER STATION LLC
- CROSSROAD PROPERTIES LLC
- LAIDLAW WASTE SYSTEMS (BRIDGETON) INC.
- ROCK ROAD INDUSTRIES, INC.
- WEST LAKE ACRES FACILITIES ASSN.
- WEST LAKE LANDFILL, INC.
- WEST LAKE LANDFILL, INC. ET AL.

NOTE:

LANDOWNER PARCEL DATA DOWNLOADED FROM SAINT LOUIS COUNTY GIS SERVICE CENTER

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FIGURE 2-2

LANDFILL PROPERTY OWNERSHIP

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 10/30/19	File: 2-2_LandfillPropertyOwnership_Fig2-2.mxd

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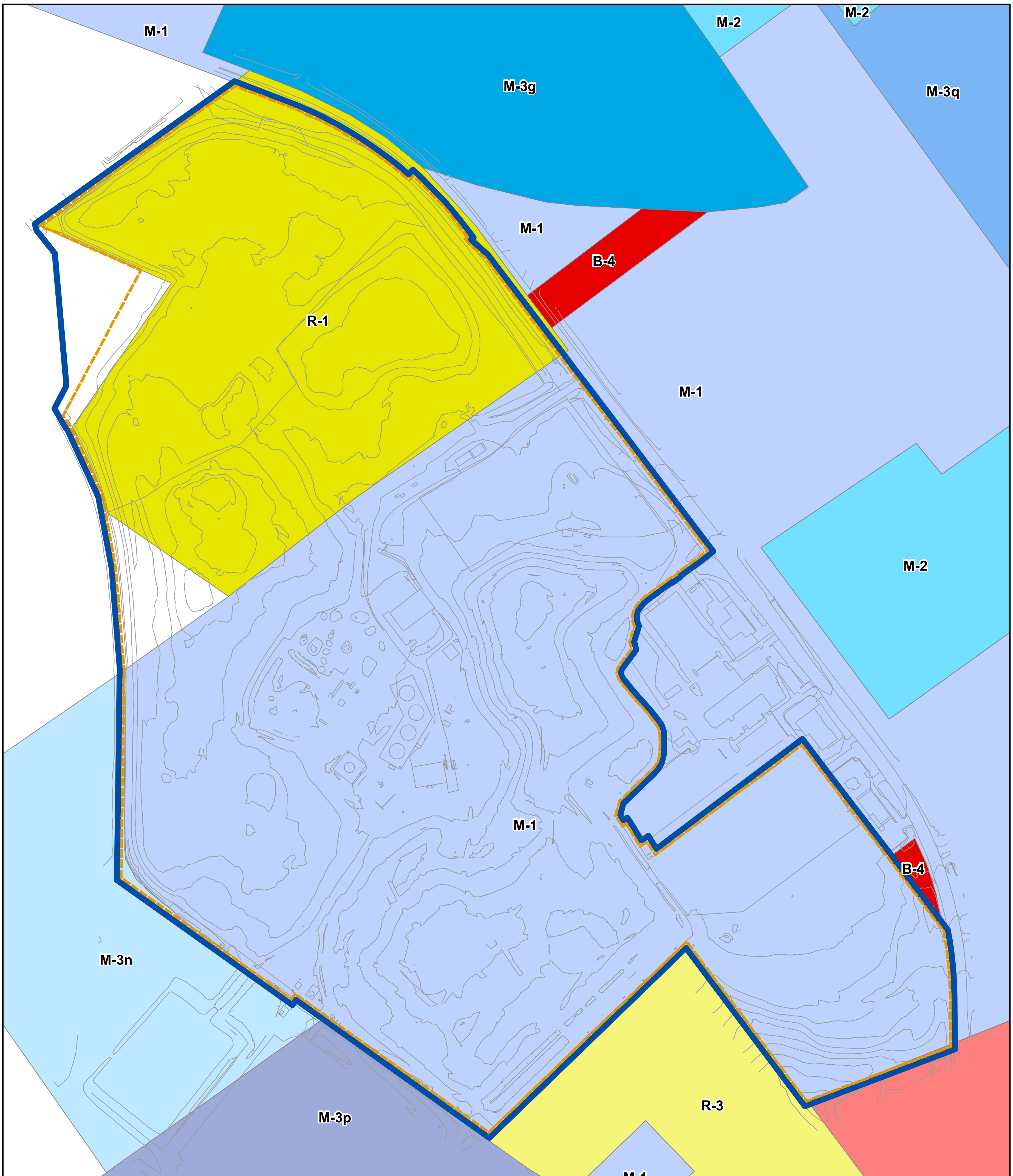

EXPLANATION

- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY
- B-3 = TRAVEL / ENTERTAINMENT SERVICES DISTRICT
- B-4 = GENERAL COMMERCIAL DISTRICT
- M-1 = MANUFACTURING DISTRICT, LIMITED
- M-2 = MANUFACTURING DISTRICT
- M-3A = PLANNED MANUFACTURING DISTRICT (HOLLENBERG BUSINESS PARK)
- M-3G = PLANNED MANUFACTURING DISTRICT (NORTHWEST INDUSTRIAL SUBDIVISION)
- M-3N = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3O = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3P = PLANNED MANUFACTURING DISTRICT (CORPORATE EXCHANGE PLAT)
- M-3Q = PLANNED MANUFACTURING DISTRICT (NORTHWEST INDUSTRIAL PARK)
- R-1 = SINGLE FAMILY DWELLING DISTRICT
- R-3 = SINGLE FAMILY DWELLING DISTRICT

NOTES:

1. LANDOWNER PARCEL DATA DOWNLOADED FROM SAINT LOUIS COUNTY GIS SERVICE CENTER
2. ZONING DATA FROM CITY OF BRIDGETON ZONING MAP AMENDED 9/20/2017

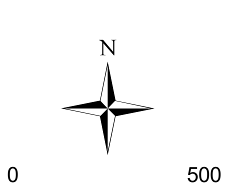

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FIGURE 2-3

LANDFILL AND SURROUNDING AREA ZONING

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 10/28/19	File: 2-3_Zoning_Fig2-3.mxd

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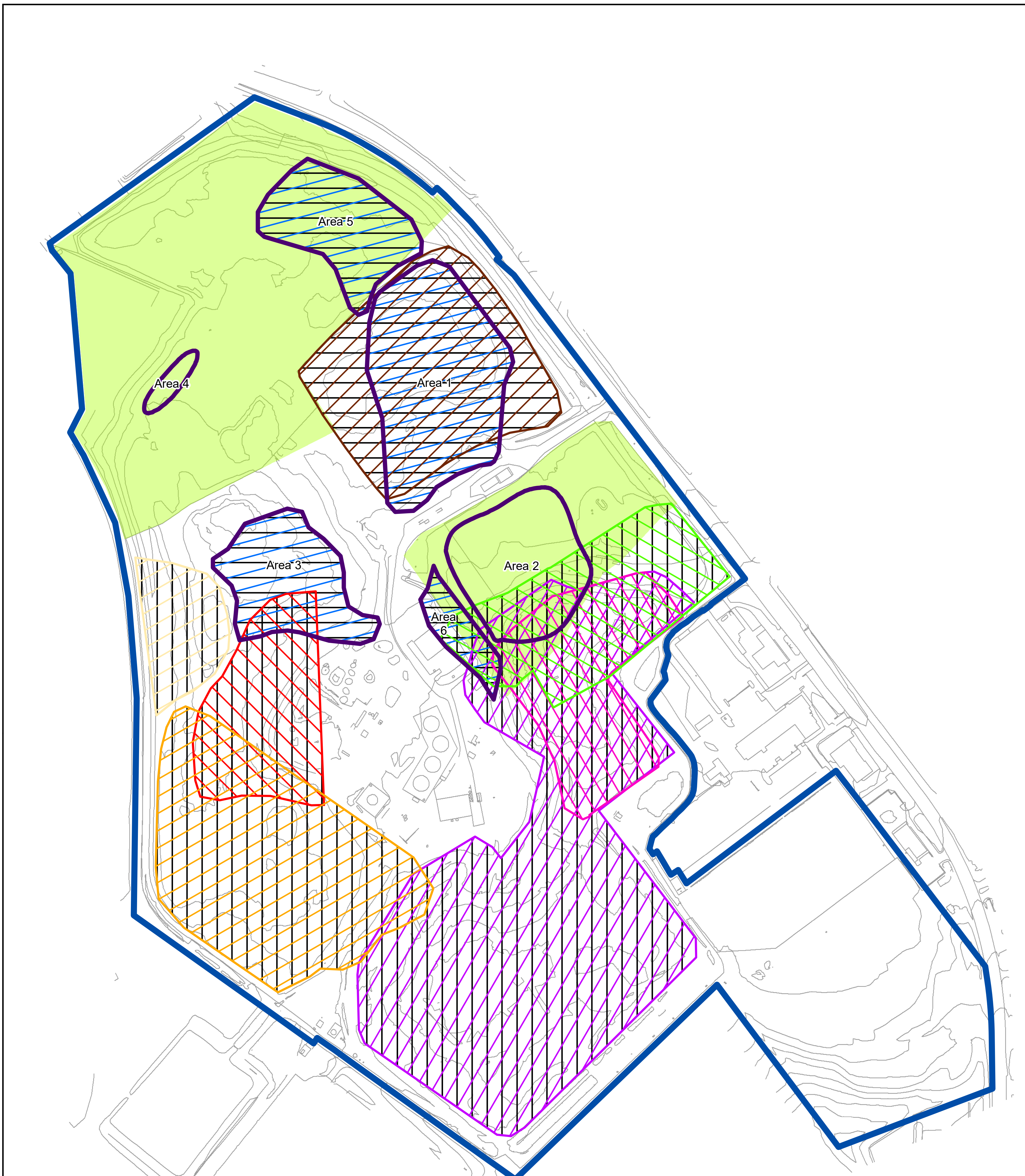

EXPLANATION

Legend	Description
SUPERFUND SITE BOUNDARY	
MDNR AREA	
DEMOLITION	
SANITARY	
PERMIT 118903, 1/27/1976	ACTUAL AUTHORIZATION GRANTED ON 8/27/1974
PERMIT 218903, 1/27/1976	USED FOR SANITARY WASTE DISPOSAL PRIOR TO ISSUANCE OF DEMOLITION FILL PERMIT
PERMIT 118903, 5/23/1978	EXPANSION OF ORIGINAL 25 ACRE TRACT
PERMIT 118906, 1/22/1979	
PERMIT 118908, 8/27/1980	
PERMIT 118909, 8/20/1981	
PERMIT 218912, 9/18/1984	
PERMIT 118912, 11/18/1985	SUPERSEDES PERMIT 118909 AND 118906, PLUS 33 ACRES, PER EXPANSION
OPERABLE UNIT 1	

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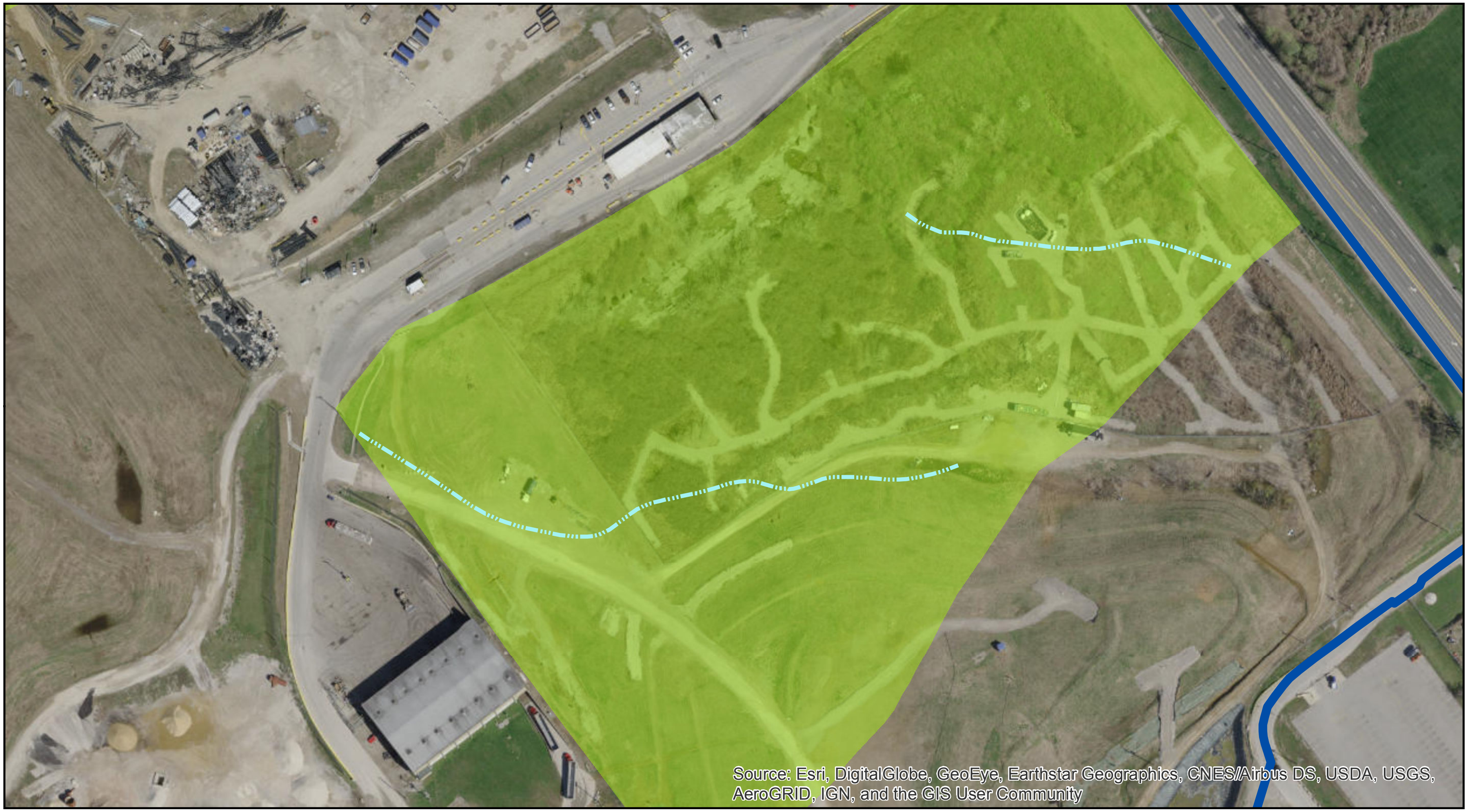
FIGURE 2-4

MDNR PERMITTED AREAS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 10/30/19	File: 2-4_PermittedAreas_Fig2-4.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\2-4_PERMITTEDAREAS_FIG2-4.MXD



EXPLANATION

APPROXIMATE LOCATION OF DRAINAGE STRUCTURE

SUPERFUND SITE BOUNDARY

OPERABLE UNIT 1

N

0 200 '

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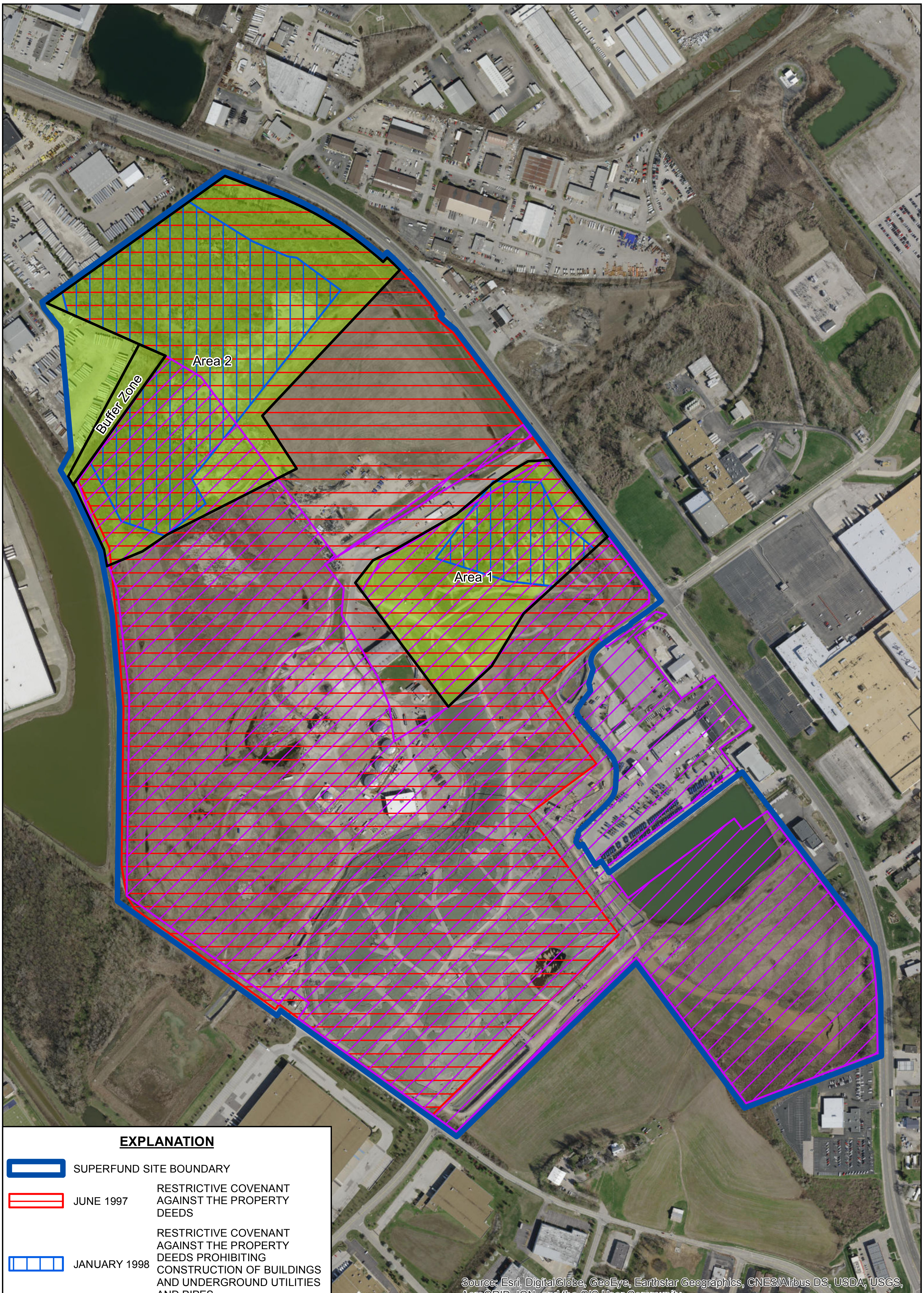
FIGURE 2-5

APPROXIMATE LOCATION OF DRAINAGE STRUCTURES

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 200 '	Date: 11/8/19	File: 2-5_DrainageStructures_Fig2-5.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\2-5_DRAINAGESTRUCTURES_FIG2-5.MXD



EXPLANATION

	SUPERFUND SITE BOUNDARY	
	JUNE 1997	RESTRICTIVE COVENANT AGAINST THE PROPERTY DEEDS
	JANUARY 1998	RESTRICTIVE COVENANT AGAINST THE PROPERTY DEEDS PROHIBITING CONSTRUCTION OF BUILDINGS AND UNDERGROUND UTILITIES AND PIPES
	AUGUST 2005	NEGATIVE EASEMENT AND RESTRICTIVE COVENANTS PROHIBITING ADDITIONAL DEPOSITING OR DUMPING
	OCTOBER 2016	SUPPLEMENTAL AND PARTIALLY RESTATED COVENANTS AND RESTRICTIONS
	OPERABLE UNIT 1	

N

0 500'

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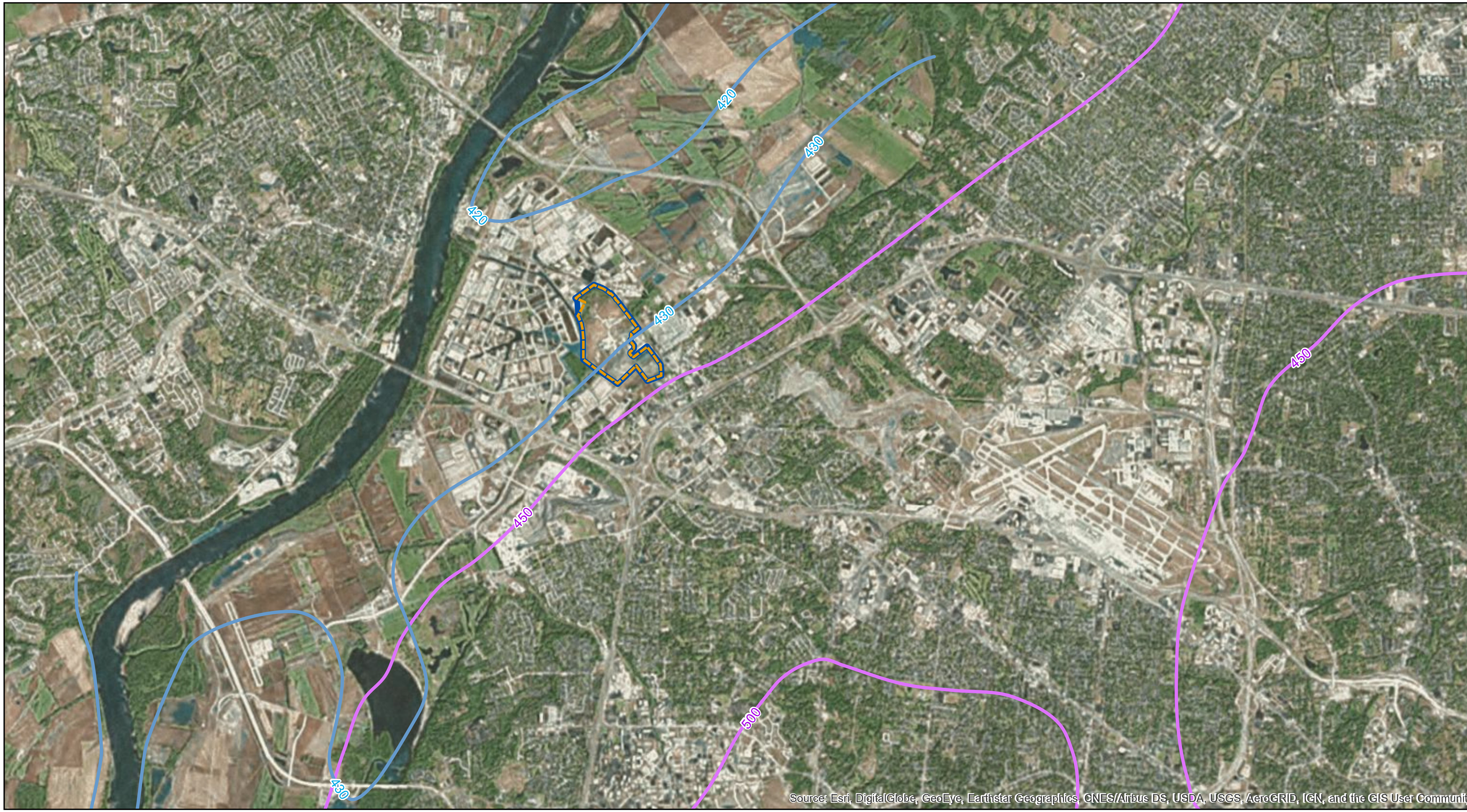
FIGURE 2-6

LAND USE RESTRICTIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS	Scale: 1 " = 500 '	Date: 11/8/19	File: 2-6_LandRestrictions_Fig2-6.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\2-6_LANDRESTRICTIONS_FIG2-6.MXD



EXPLANATION

1966 ALLUVIAL WATER TABLE CONTOUR
MISSISSIPPIAN-AGE ROCKS POTENTIOMETRIC SURFACE CONTOUR
LANDFILL BOUNDARY
SUPERFUND SITE BOUNDARY

NOTES:

1. 1966 WATER TABLE CONTOURS DIGITIZED FROM EMMETT & JEFFERY, USGS 1968.
2. MISSISSIPPIAN-AGE ROCKS POTENTIOMETRIC SURFACE DIGITIZED FROM IMES 1990
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
4. USGS = U.S. GEOLOGICAL SURVEY

N

0 5,000 '

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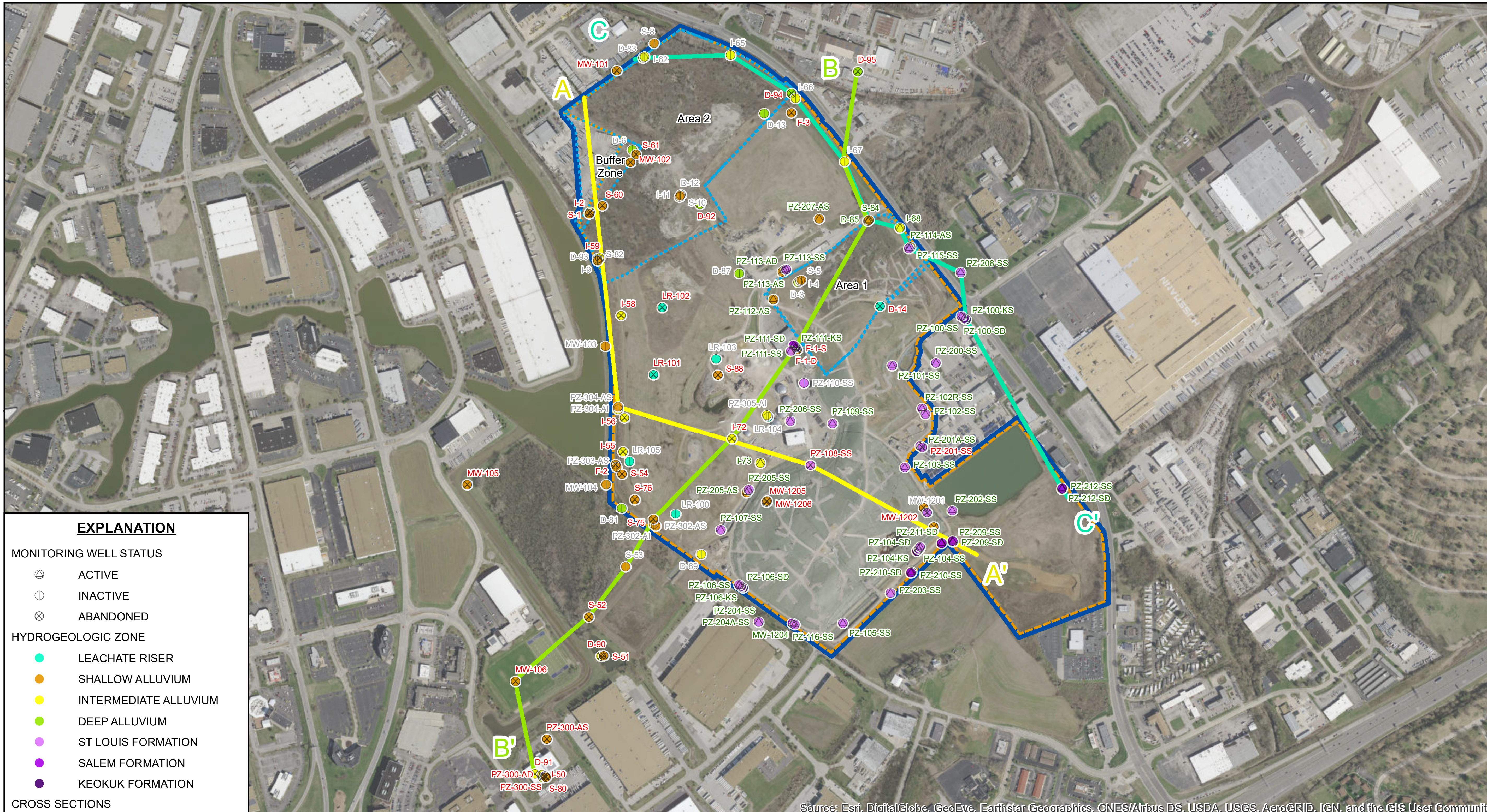
FIGURE 3-1

REGIONAL POTENTIOMETRIC SURFACE MAPS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 5,000 '	Date: 10/30/19	File: 3-1_RegionalPS_Fig3-1.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\3-1_REGIONALPS_FIG3-1.MXD



EXPLANATION

MONITORING WELL STATUS
- ACTIVE
- INACTIVE
- ABANDONED

HYDROGEOLOGIC ZONE
- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION

CROSS SECTIONS
- CROSS SECTION A
- CROSS SECTION B
- CROSS SECTION C

SITE FEATURES
- OU-1
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

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FIGURE 3-2

CROSS SECTION LOCATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 800 '	Date: 10/30/19	File: 3-2_X-S_Fig3-2.mxd

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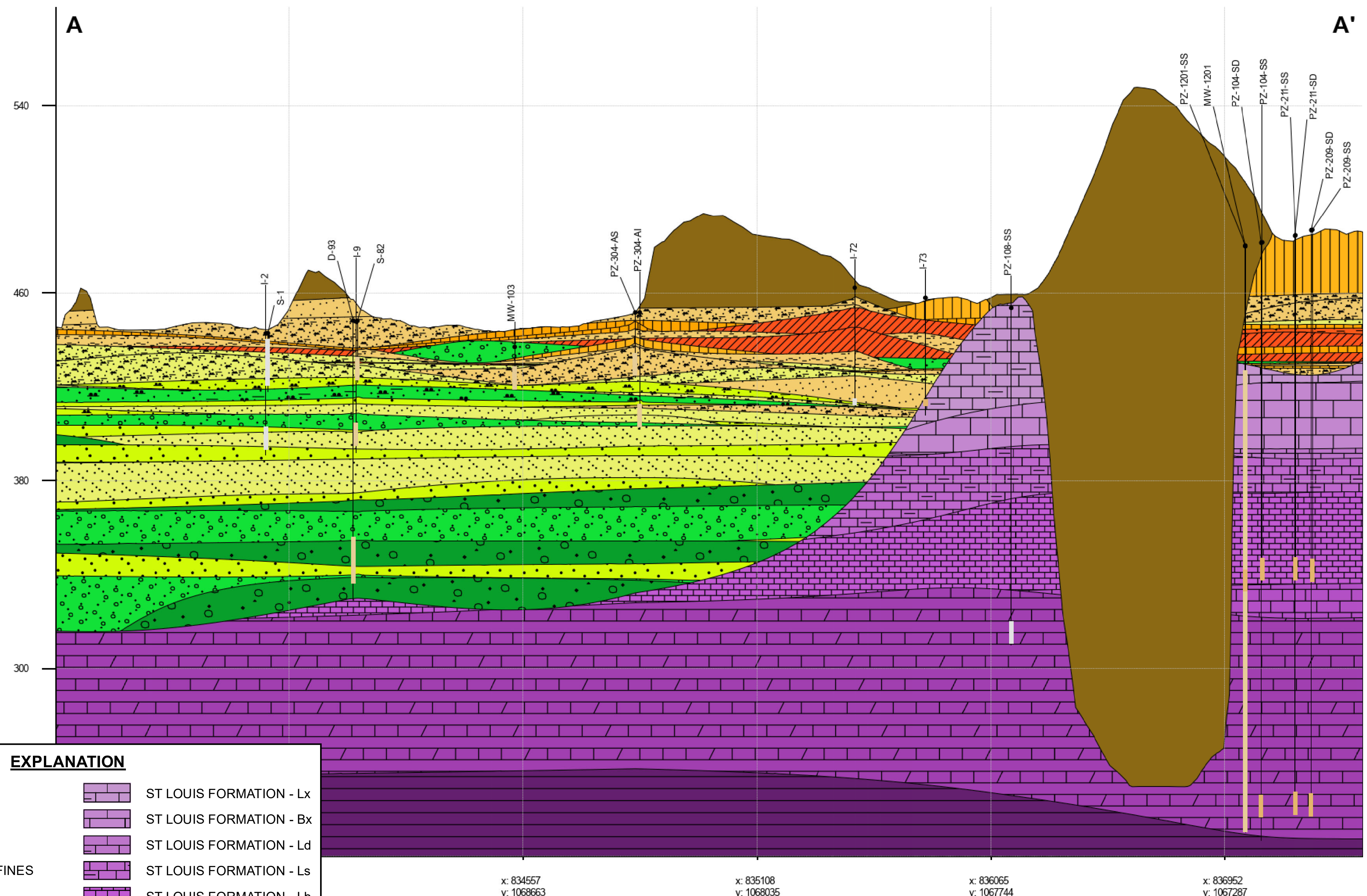

EXPLANATION

- REFUSE
- CLAY
- SILT
- FINE SAND WITH FINES
- FINE SAND
- MEDIUM SAND WITH FINES
- MEDIUM SAND
- COARSE SAND WITH FINES
- COARSE SAND
- FINES WITH FINE GRAVEL
- FINE GRAVEL
- COARSE GRAVEL
- ST LOUIS FORMATION - Lx
- ST LOUIS FORMATION - Bx
- ST LOUIS FORMATION - Ld
- ST LOUIS FORMATION - Ls
- ST LOUIS FORMATION - Lb
- ST LOUIS FORMATION - Lc
- SALEM FORMATION
- WARSAW FORMATION
- KEOKUK FORMATION

NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY

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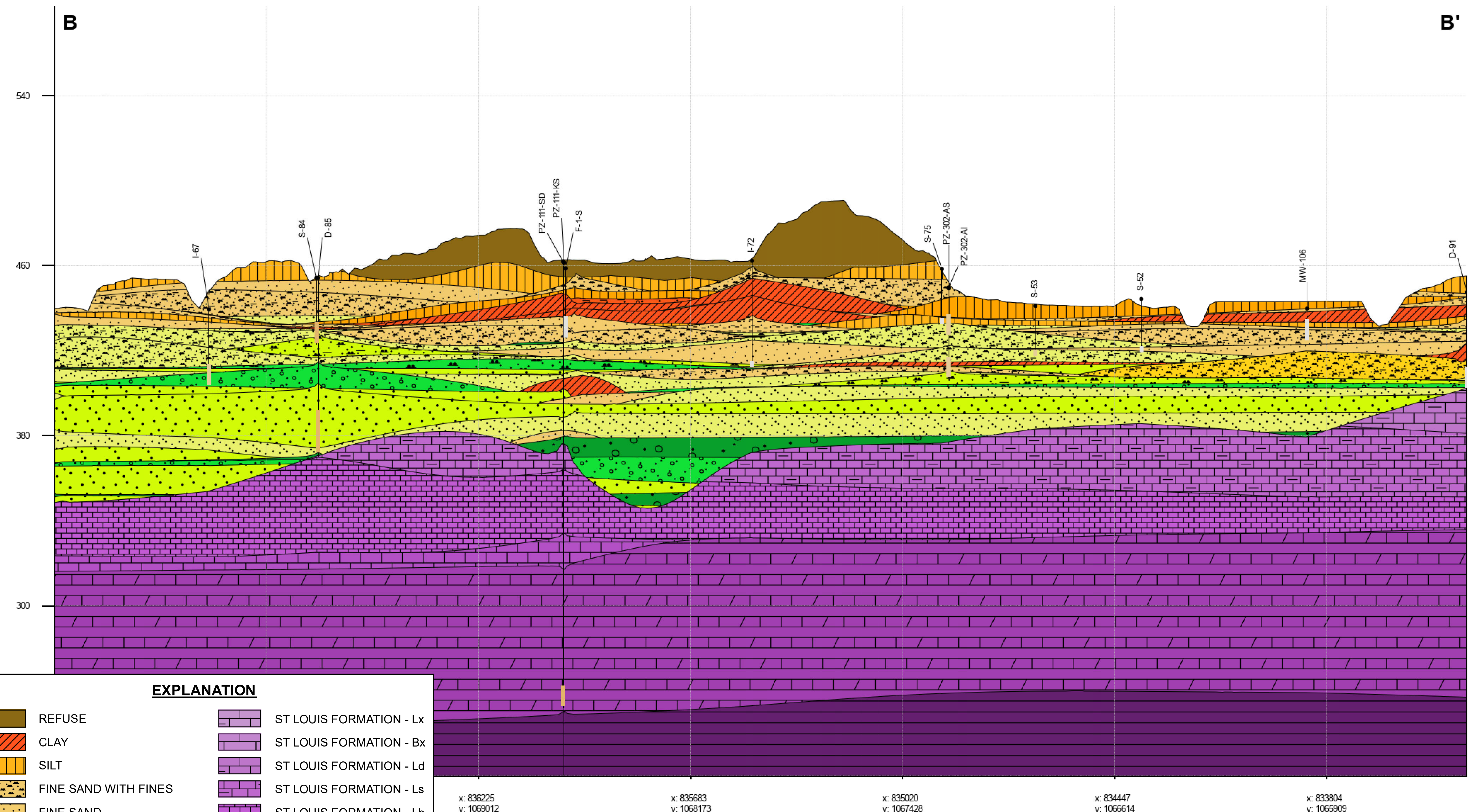
FIGURE 3-3

CROSS SECTION A

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 10/28/19	File: 3-3_X-SA_Fig3-3.mxd



EXPLANATION

- REFUSE
- CLAY
- SILT
- FINE SAND WITH FINES
- FINE SAND
- MEDIUM SAND WITH FINES
- MEDIUM SAND
- COARSE SAND WITH FINES
- COARSE SAND
- FINES WITH FINE GRAVEL
- FINE GRAVEL
- COARSE GRAVEL
- ST LOUIS FORMATION - Lx
- ST LOUIS FORMATION - Bx
- ST LOUIS FORMATION - Ld
- ST LOUIS FORMATION - Ls
- ST LOUIS FORMATION - Lb
- ST LOUIS FORMATION - Lc
- SALEM FORMATION
- WARSAW FORMATION
- KEOKUK FORMATION

NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY

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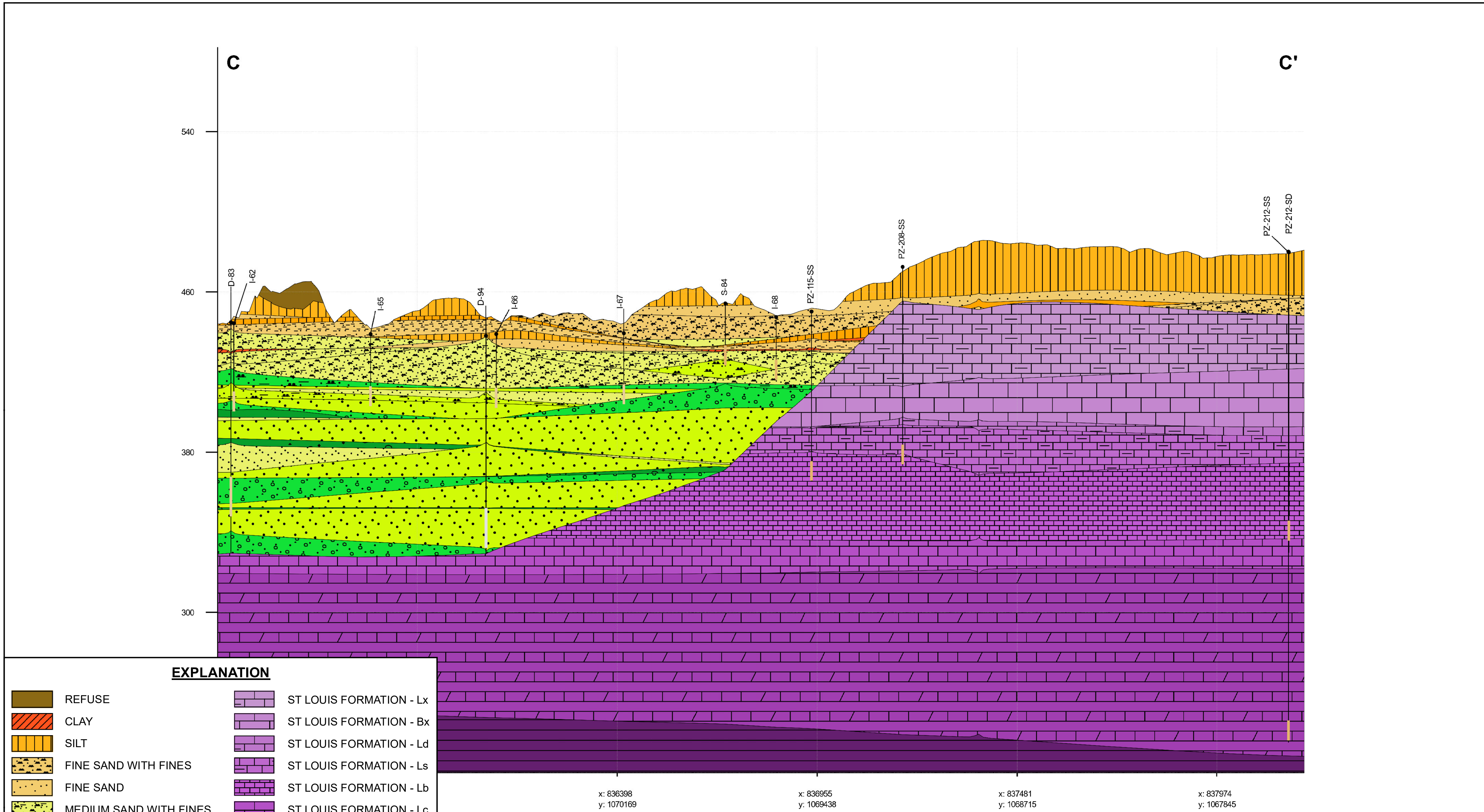
FIGURE 3-4

CROSS SECTION B

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 10/28/19	File: 3-4_X-SB_Fig3-4.mxd



NOTES:

1. 10 x VERTICAL EXAGGERATION
2. ACTIVE SCREENED INTERVALS SHOWN IN BROWN
3. ABANDONED SCREENED INTERVALS SHOWN IN GRAY

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FIGURE 3-5

CROSS SECTION C

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: As Shown	Date: 10/28/19	File: 3-5_X-SC_Fig3-5.mxd

EXPLANATION

- EDGE OF ALLUVIAL VALLEY
- OU-1
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 1,500 '

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FIGURE 3-6

EDGE OF THE ALLUVIAL VALLEY

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 1,500 '	Date: 10/30/19	File: 3-6_EdgeAV_Fig3-6.mxd

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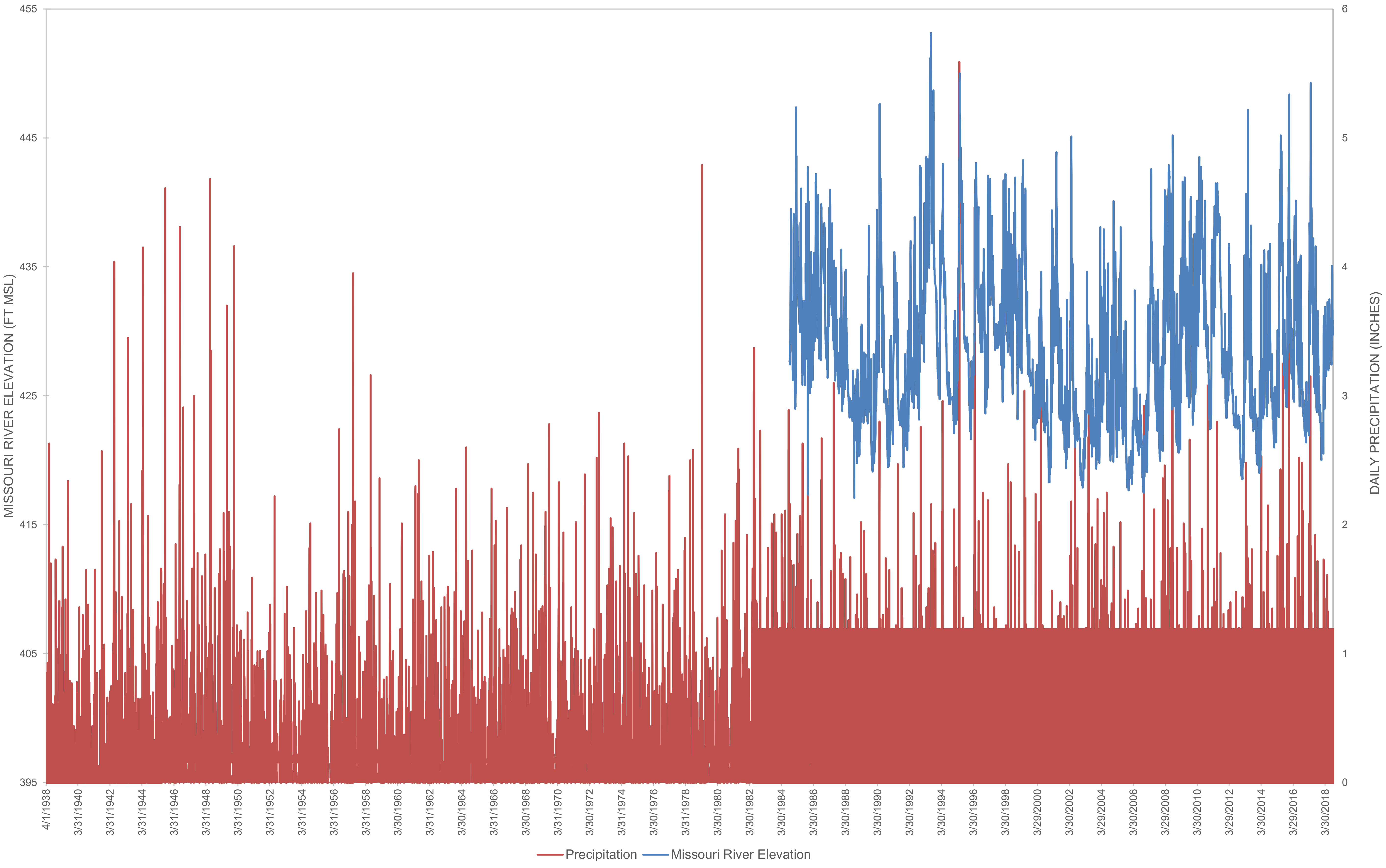
FIGURE 3-7

SURFACE WATER AND PRECIPITATION GAUGES

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 2,000 '	Date: 10/28/19	File: 3-7_SW_Precip_Fig3-7.mxd

FIGURE 3-8. MISSOURI RIVER ELEVATIONS AT ST CHARLES USGS GAUGE AND DAILY PRECIPITATION AT LAMBERT ST LOUIS
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN



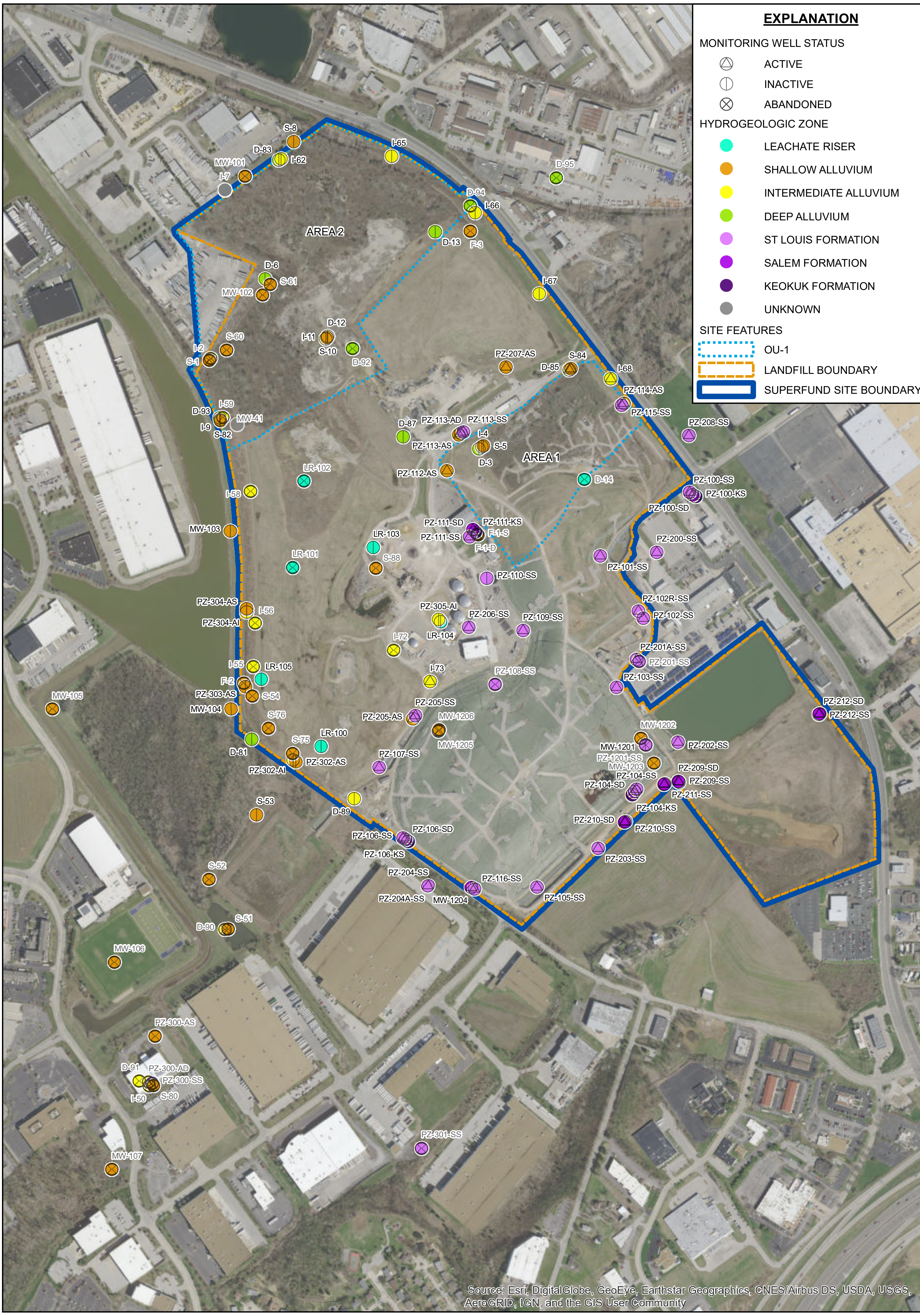


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FIGURE 3-9

MONITORING WELL STATUS AND HYDROGEOLOGIC ZONE

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-9_MWStatus_Fig3-9.mxd

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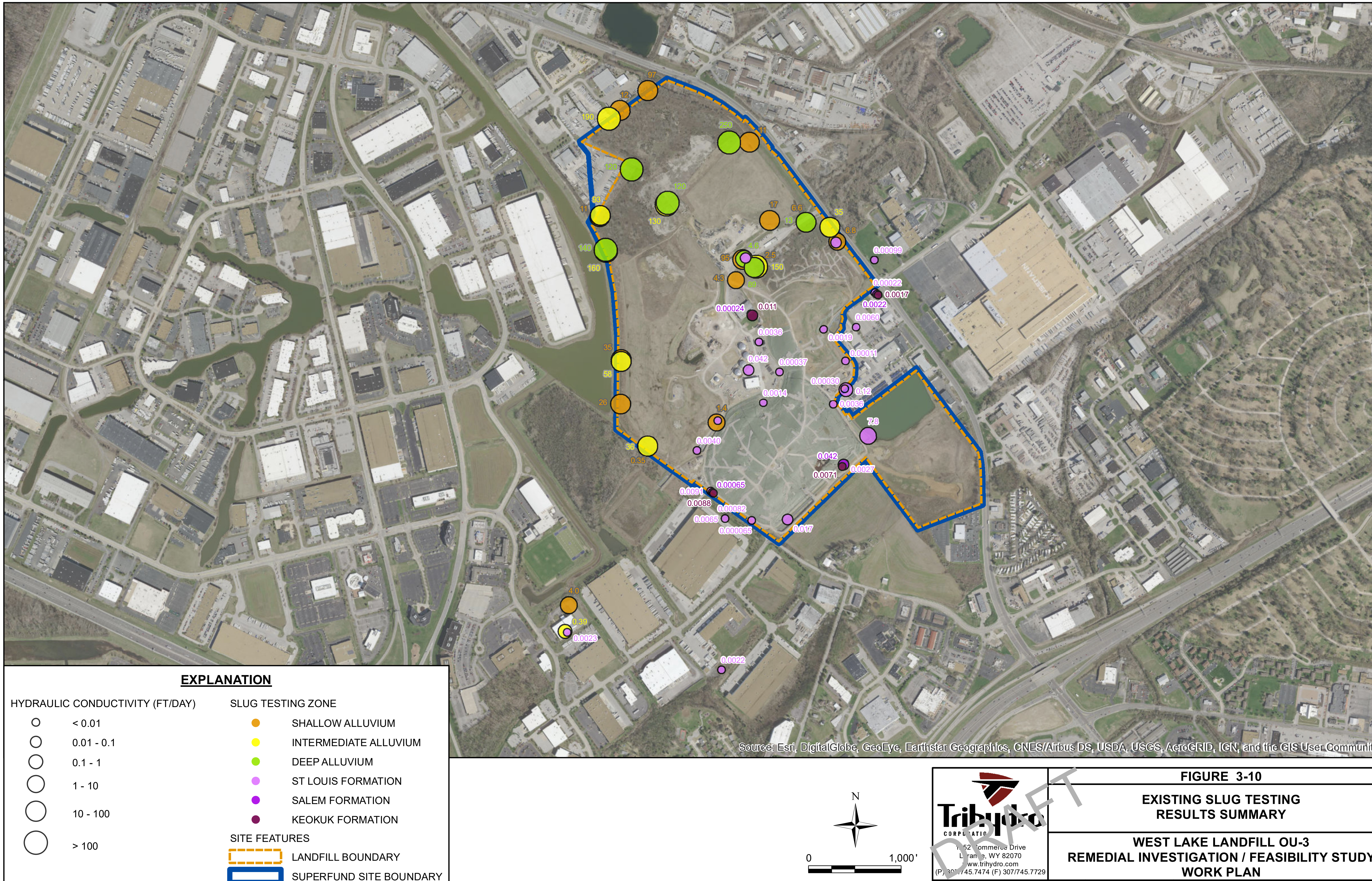

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FIGURE 3-10

EXISTING SLUG TESTING RESULTS SUMMARY

**WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN**

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 1,000 '	Date: 10/28/19	File: 3-10_K_Fig3-10.mxd

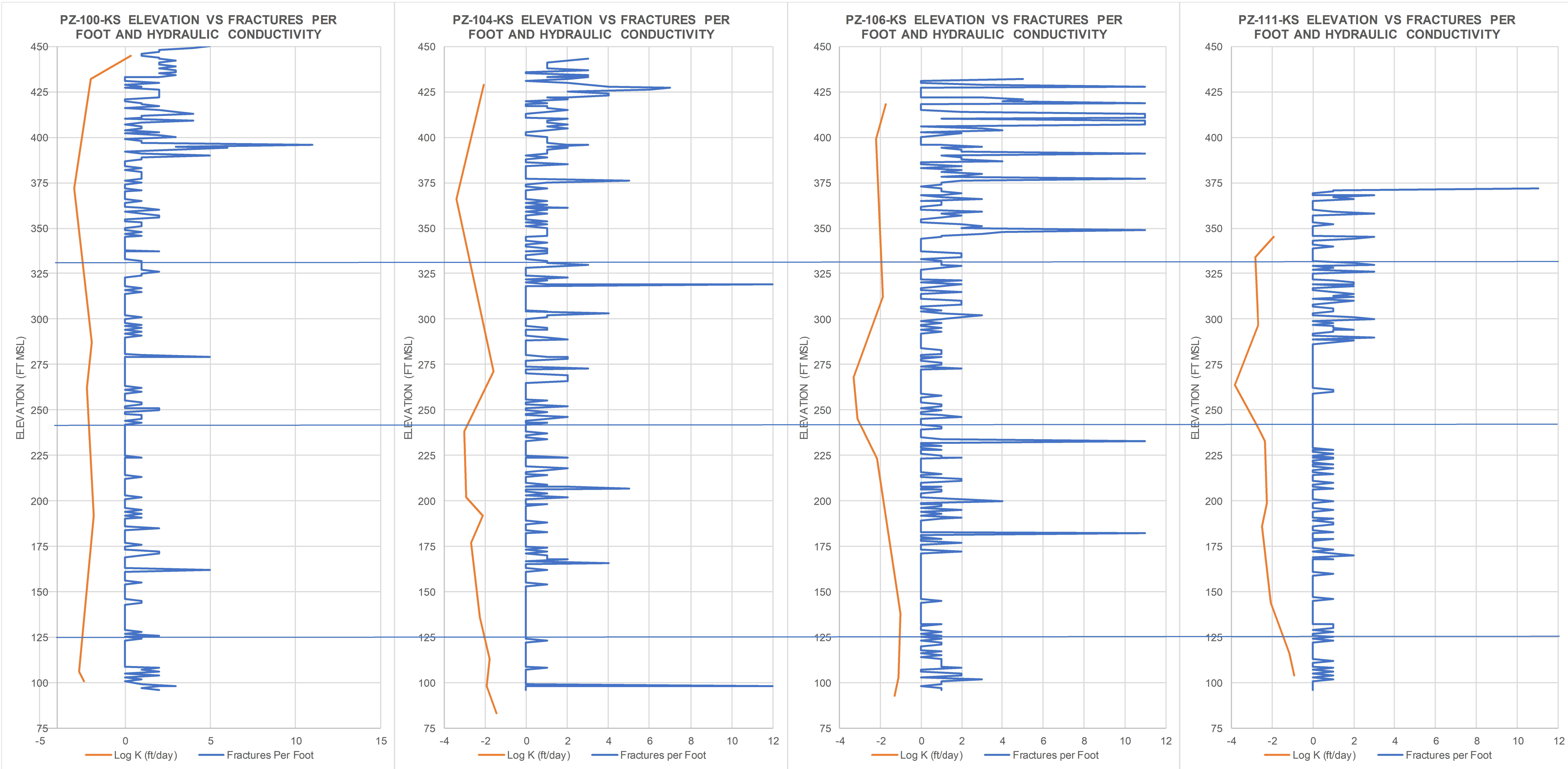

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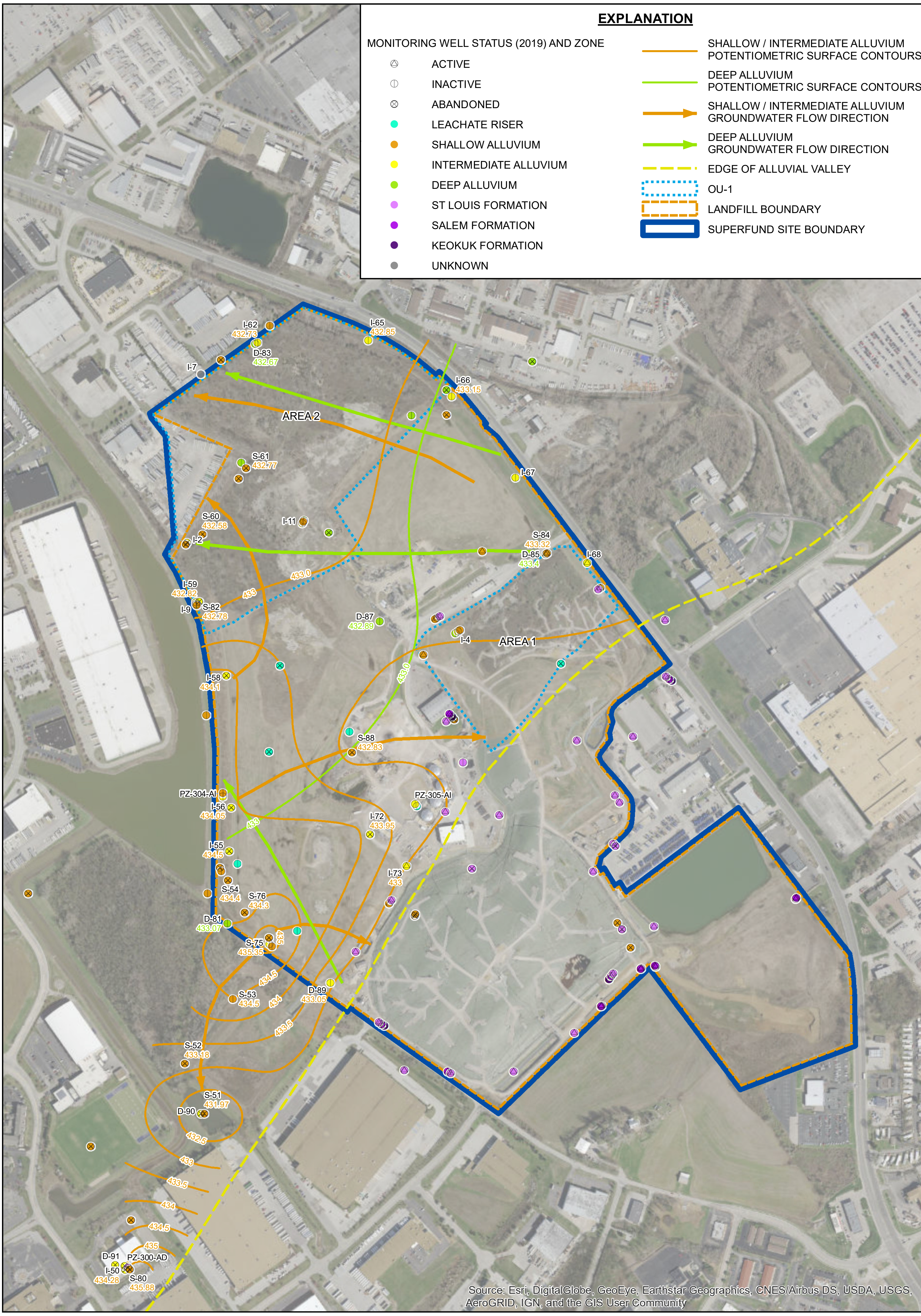
FIGURE 3-11

EXISTING PACKER TESTING RESULTS SUMMARY

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: REP	Checked By: MH	Scale: NONE	Date: 5/9/19	File: 63N-RIFSWP_PACKERRESULTS_20190509



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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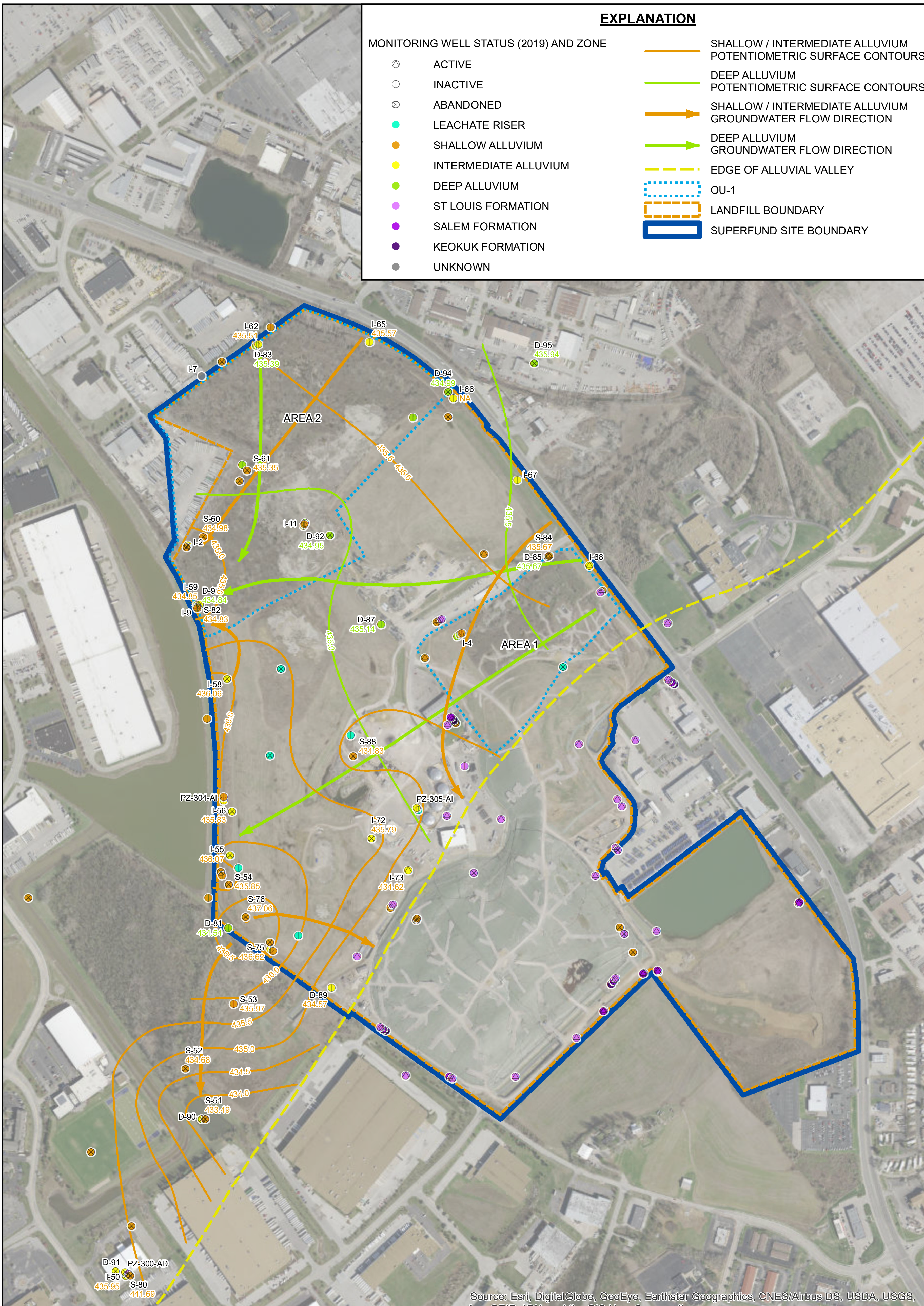
FIGURE 3-12
MISSOURI RIVER ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP OCTOBER 26, 1984

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-12_19841026PS_Fig3-12.mxd

\\TRIHYDRO.COM\CLIENTS\WTO2\WESTLAKELANDFILL\GISMAPPING\201911_RIFS_WP\3-12_19841026PS_FIG3-12.MXD



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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FIGURE 3-13
MISSOURI RIVER ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP
APRIL 25, 1985

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-13_19850425PS_Fig3-13.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GISMAPPING\201911_RIFS_WP\3-13_19850425PS_FIG3-13.MXD

NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. MONITORING WELLS S-5 AND PZ-302-AI NOT CONTOURED
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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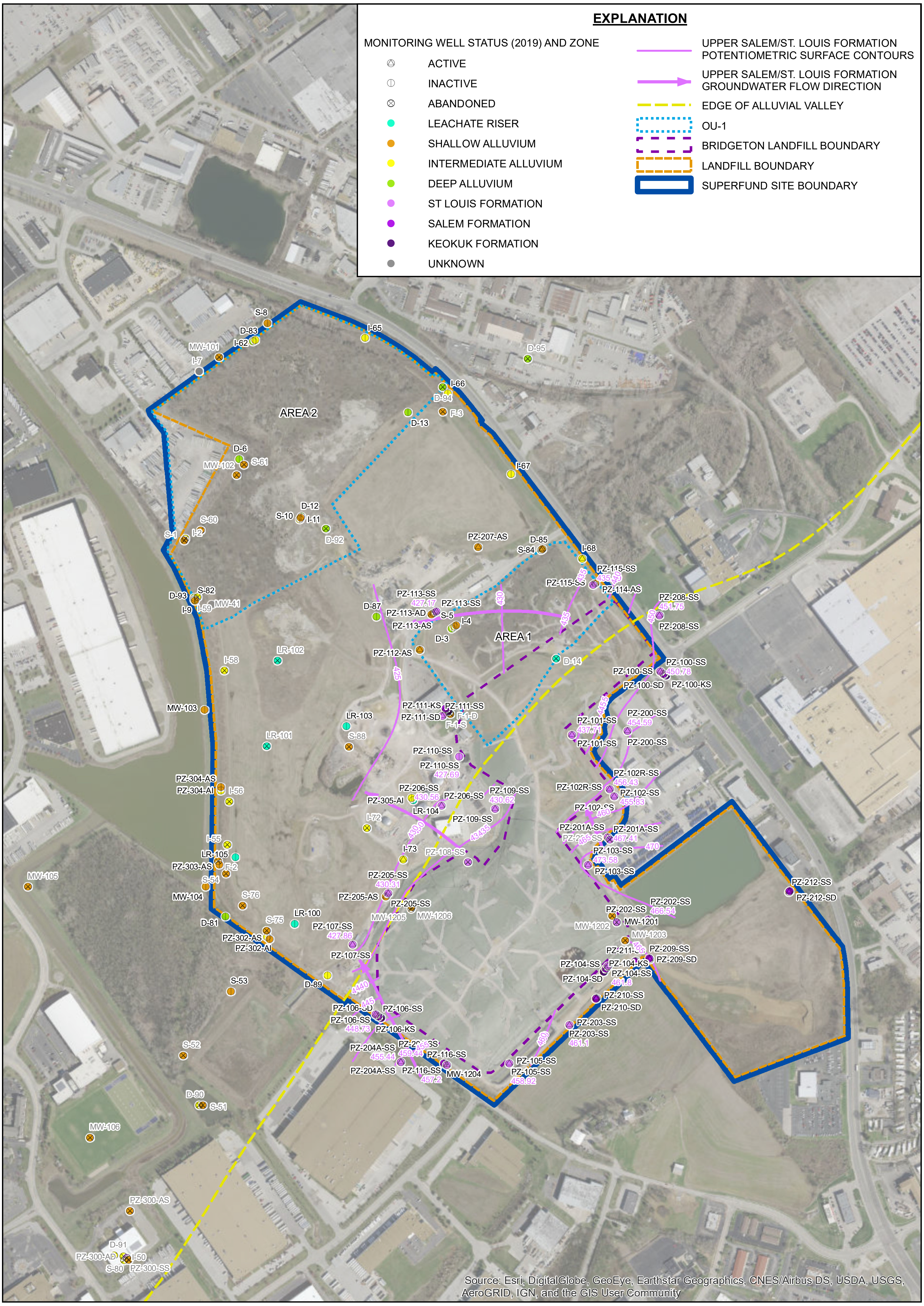
FIGURE 3-14a

MISSOURI RIVER ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-14a_201304MA_Fig3-14.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\3-14A_201304MA_FIG3-14.MXD



\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\3-14B_201304SS_FIG3-14.MXD

NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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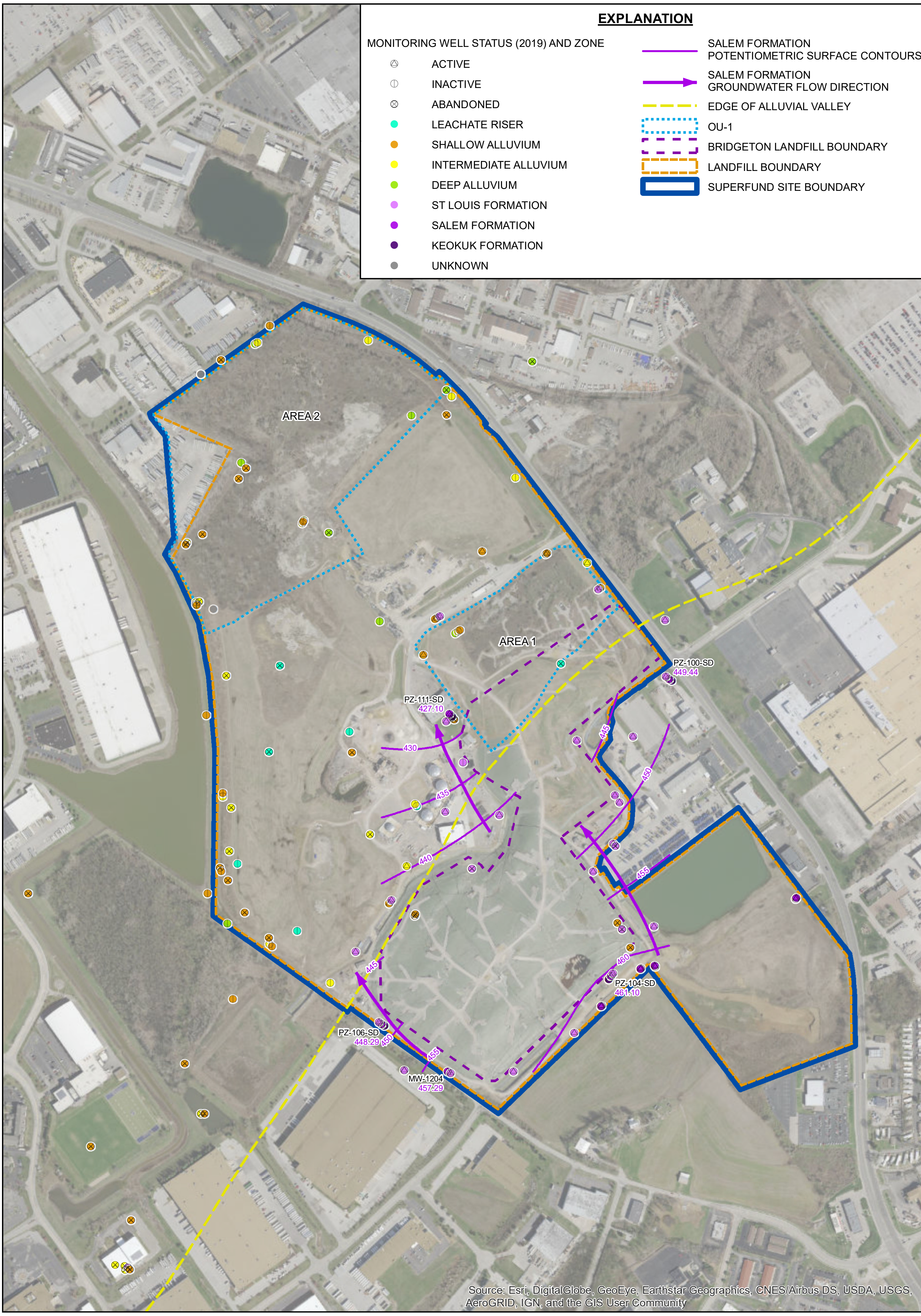
FIGURE 3-14b

UPPER SALEM/ST. LOUIS FORMATION GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-14b_201304SS_Fig3-14.mxd



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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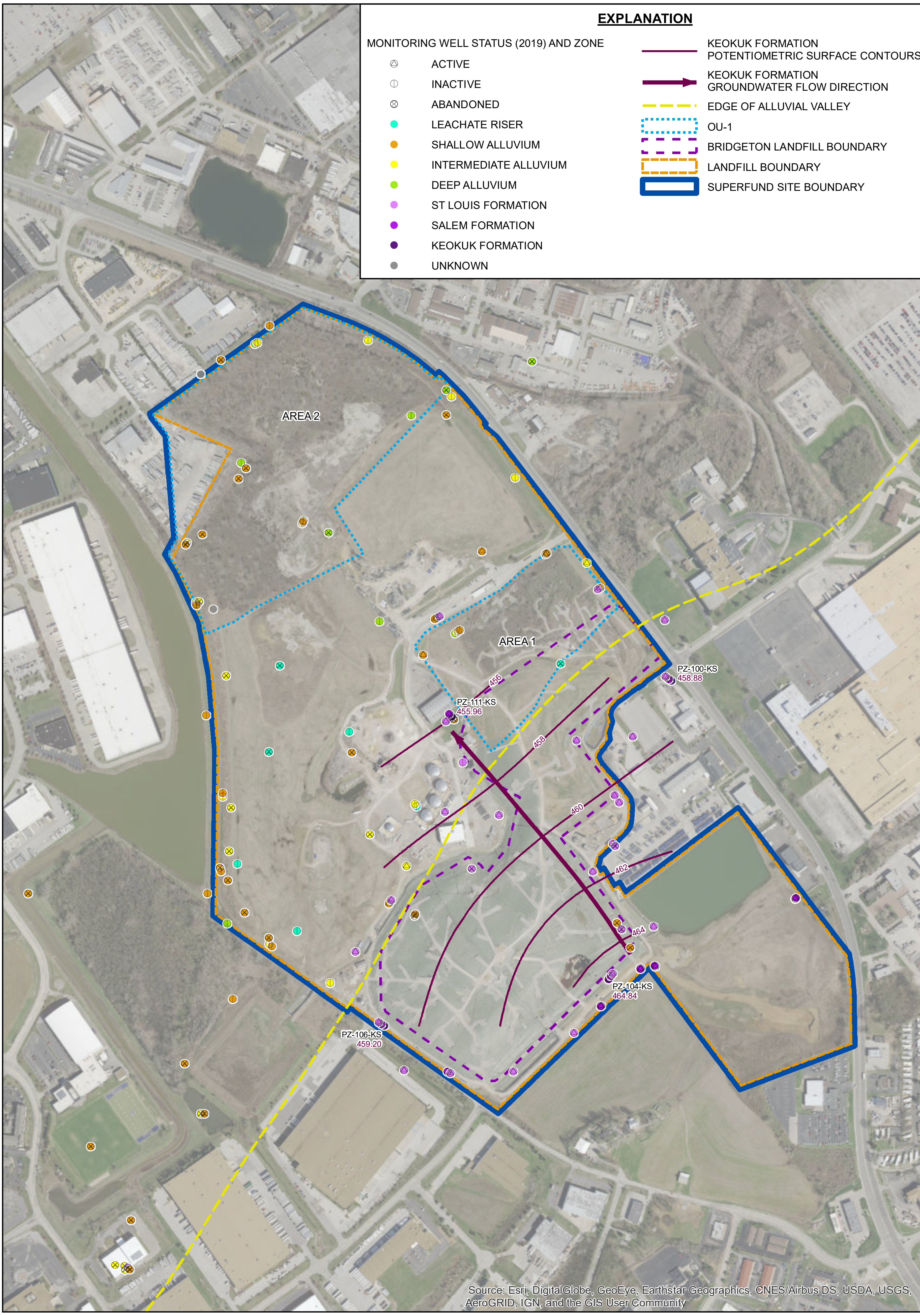
FIGURE 3-14c

SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP APRIL 2, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-14c_201304SD_Fig3-14.mxd



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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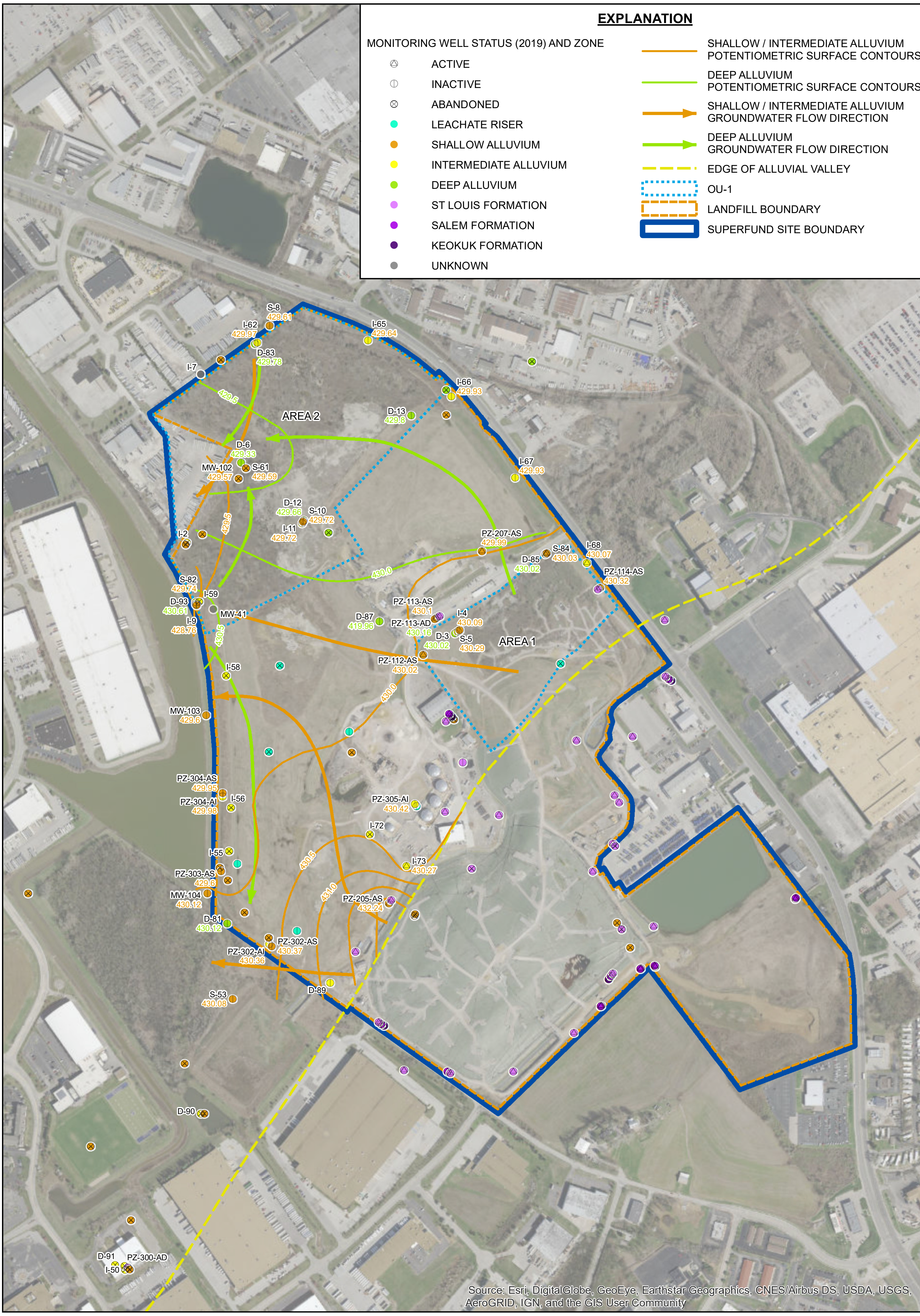
FIGURE 3-14d
KEOKUK FORMATION
GROUNDWATER ELEVATION CONTOUR MAP
APRIL 2, 2013

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-14d_201304KS_Fig3-14.mxd



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. MONITORING WELL D-87 NOT CONTOURED DUE TO POSSIBLE GAUGING ERROR
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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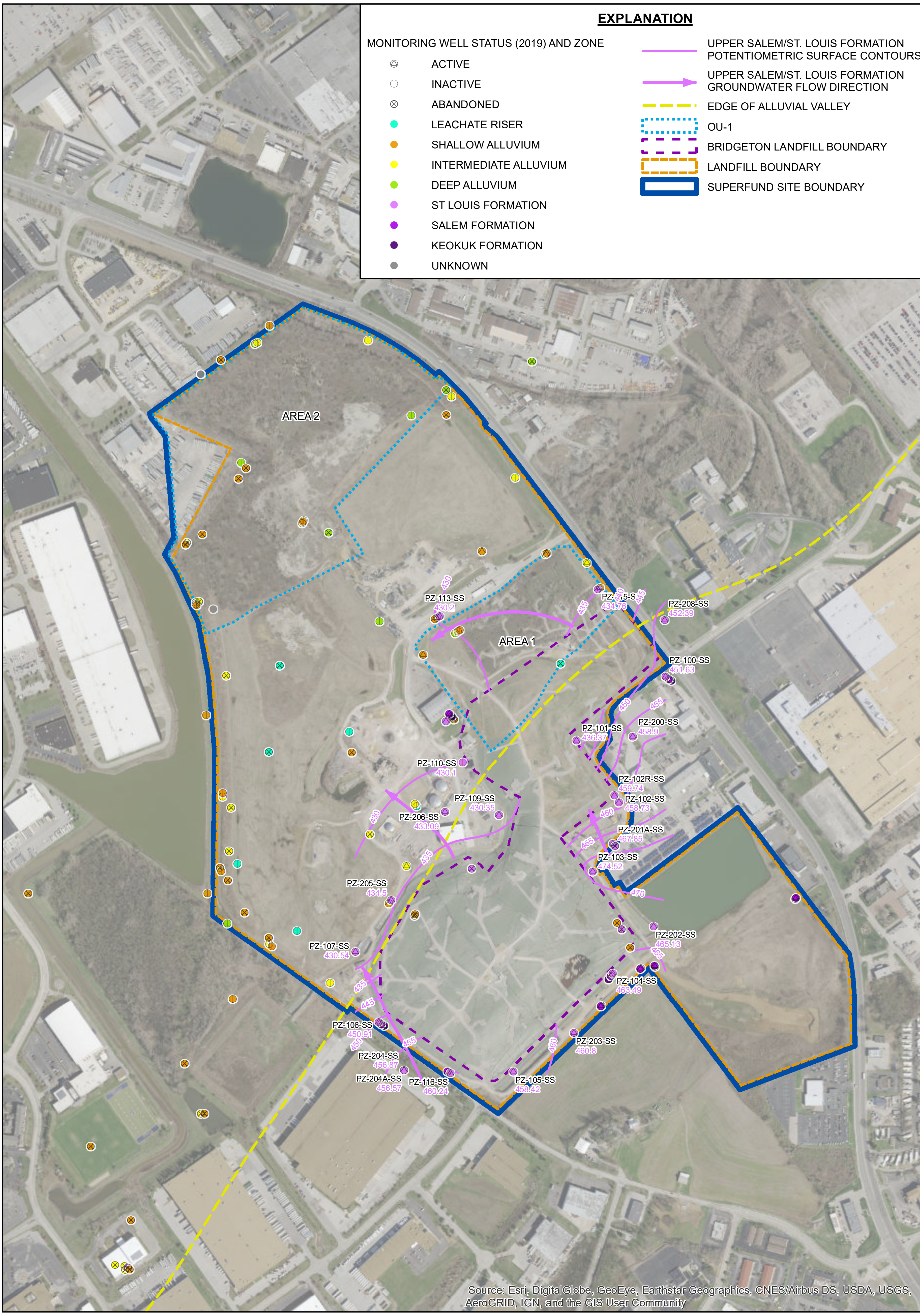
FIGURE 3-15a
MISSOURI RIVER ALLUVIUM GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-15a_201309MA_Fig3-15a.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GISMAPPING\201911_RIFS_WP\3-15A_201309MA_FIG3-15A.MXD



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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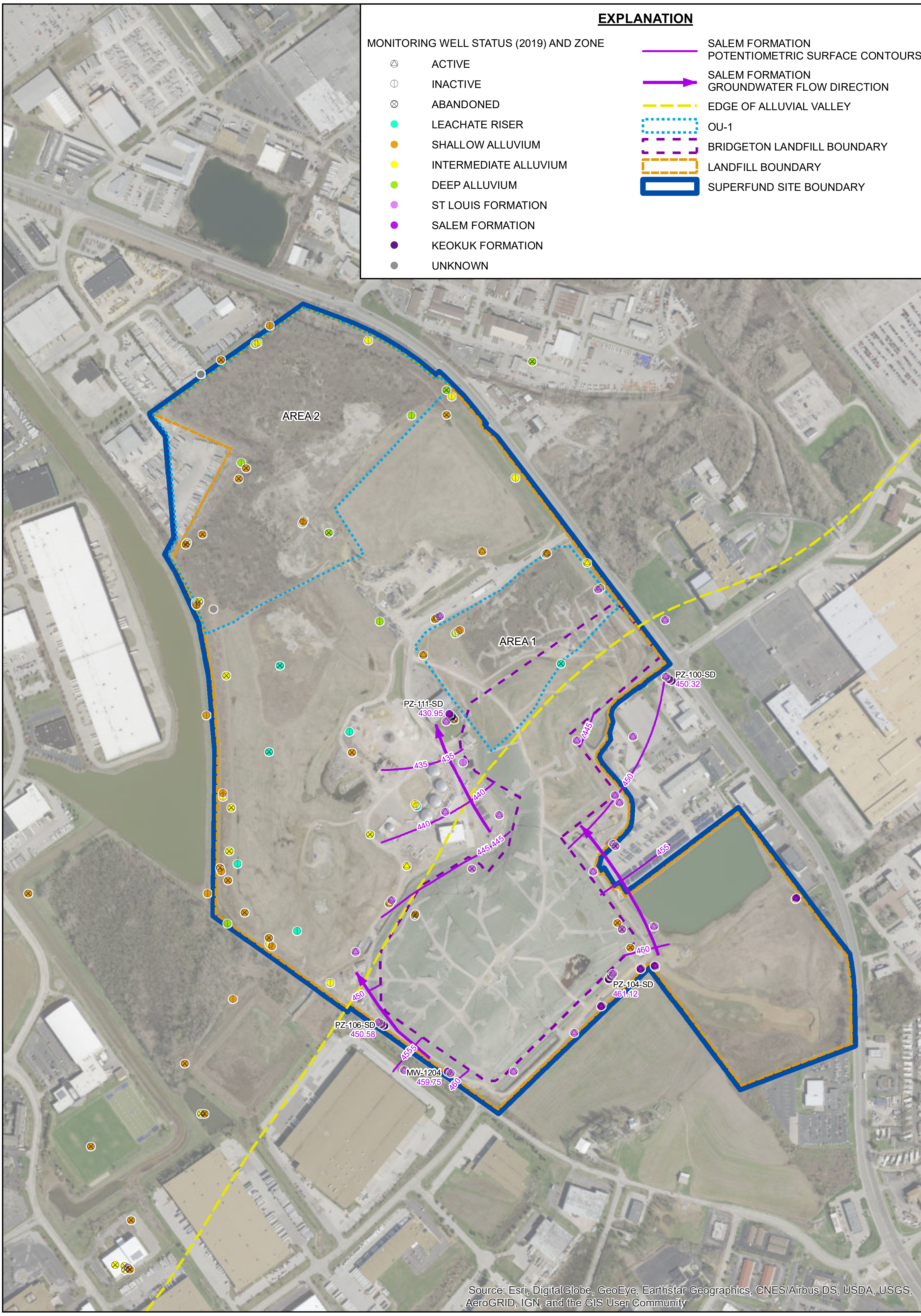
FIGURE 3-15b

UPPER SALEM/ST. LOUIS FORMATION GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-15b_201309SS_Fig3-15b.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\3-15B_201309SS_FIG3-15B.MXD



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. NOT CONTOURED WITHIN BOUNDARY OF BRIDGETON LANDFILL WHERE FORMATION WAS QUARRIED
3. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

N

0 600 '

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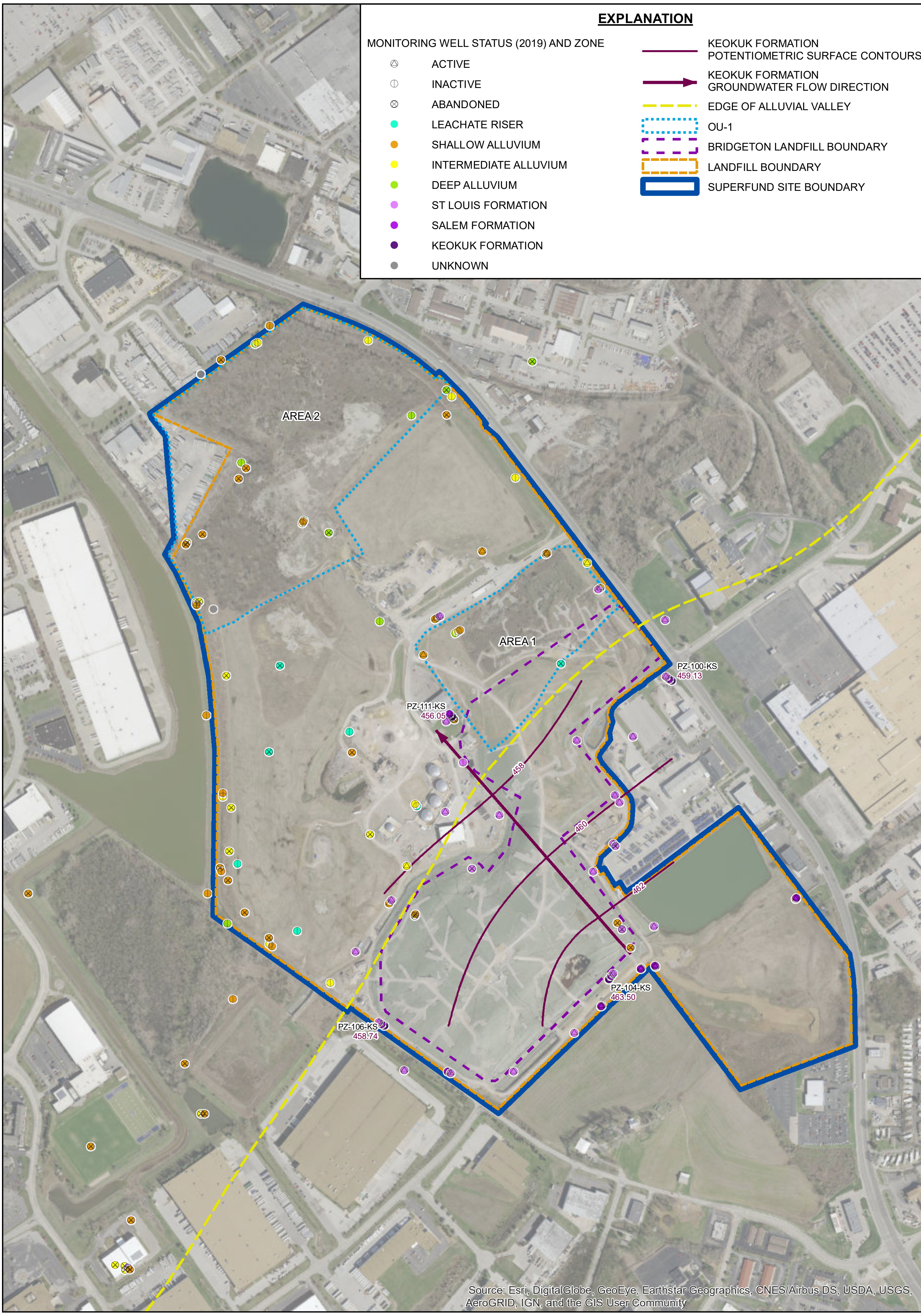
FIGURE 3-15c

SALEM FORMATION GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-15c_201309SD_Fig3-15c.mxd



NOTES:

1. CONTOURS GENERATED USING SURFER AND MANUALLY RENDERED
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

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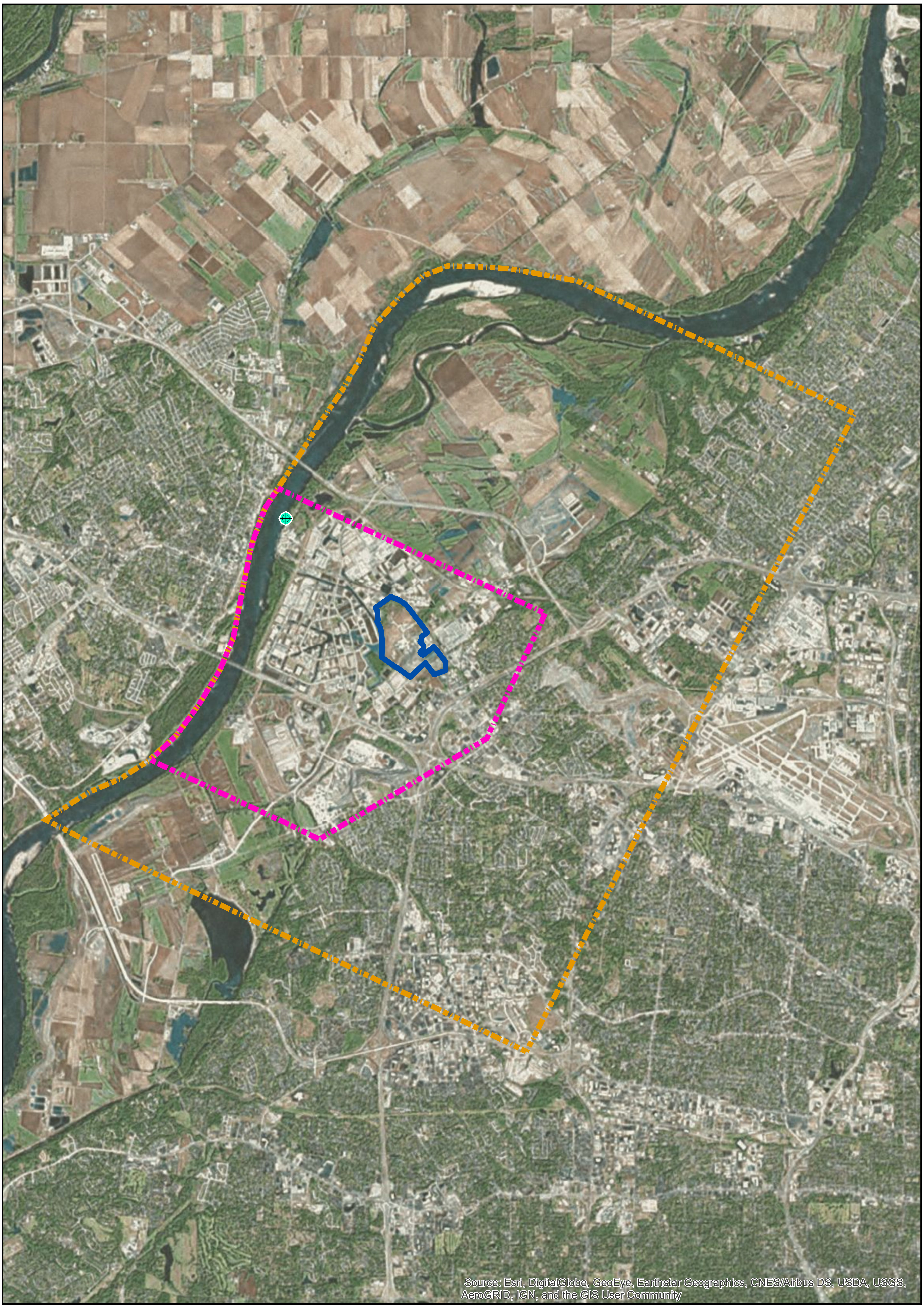
FIGURE 3-15d

KEOKUK FORMATION GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER 30, 2013

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 600 '	Date: 10/30/19	File: 3-15d_201309KS_Fig3-15d.mxd



EXPLANATION

- USGS06935965
- STUDY AREA
- PRELIMINARY GROUNDWATER MODELING DOMAIN
- SUPERFUND SITE BOUNDARY

N

0 5,000 '

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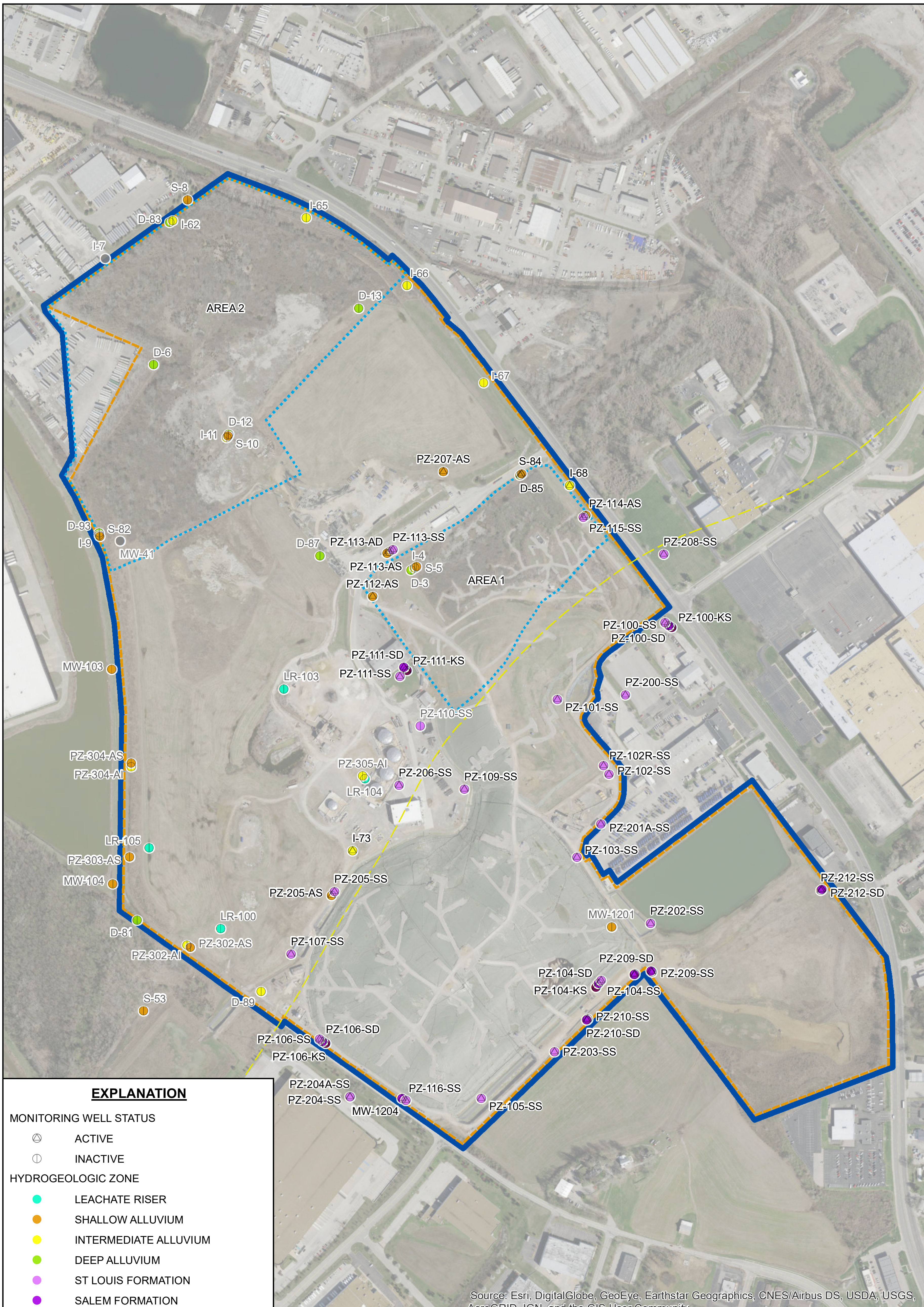
FIGURE 3-16

OU-3 STUDY AREA AND PRELIMINARY GROUNDWATER MODELING DOMAIN

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: WC	Scale: 1 " = 6,000 '	Date: 10/30/19	File: 3-16_OU-3_Fig3-16.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\3-16_OU-3_FIG3-16.MXD



EXPLANATION

MONITORING WELL STATUS

- ACTIVE
- INACTIVE

HYDROGEOLOGIC ZONE

- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION
- UNKNOWN
- EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

- OU-1
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 500 '

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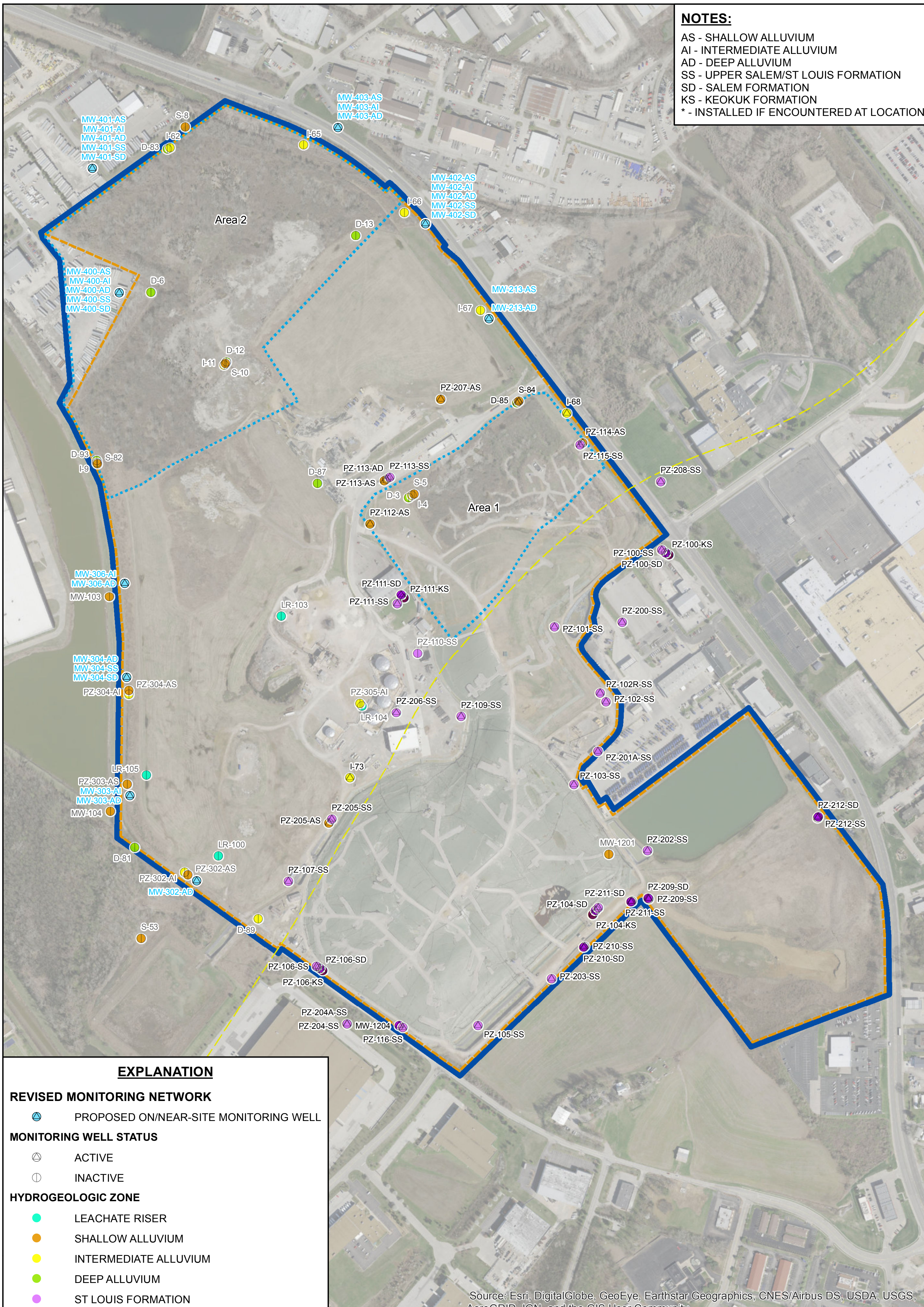
FIGURE 5-1

CURRENT MONITORING WELL NETWORK

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 500 '	Date: 10/30/19	File: 5-1_MWNetwork_Fig5-1.mxd

\\TRIHYDRO.COM\CLIENTS\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-1_MWNETWORK_FIG5-1.MXD



NOTES:

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

REVISED MONITORING NETWORK

PROPOSED ON/NEAR-SITE MONITORING WELL

MONITORING WELL STATUS

ACTIVE
INACTIVE

HYDROGEOLOGIC ZONE

LEACHATE RISER
SHALLOW ALLUVIUM
INTERMEDIATE ALLUVIUM
DEEP ALLUVIUM
ST LOUIS FORMATION
SALEM FORMATION
KEOKUK FORMATION
EDGE OF ALLUVIUM (APPROXIMATE)

SITE FEATURES

OU-1
LANDFILL BOUNDARY
SUPERFUND SITE BOUNDARY

N

0 500'

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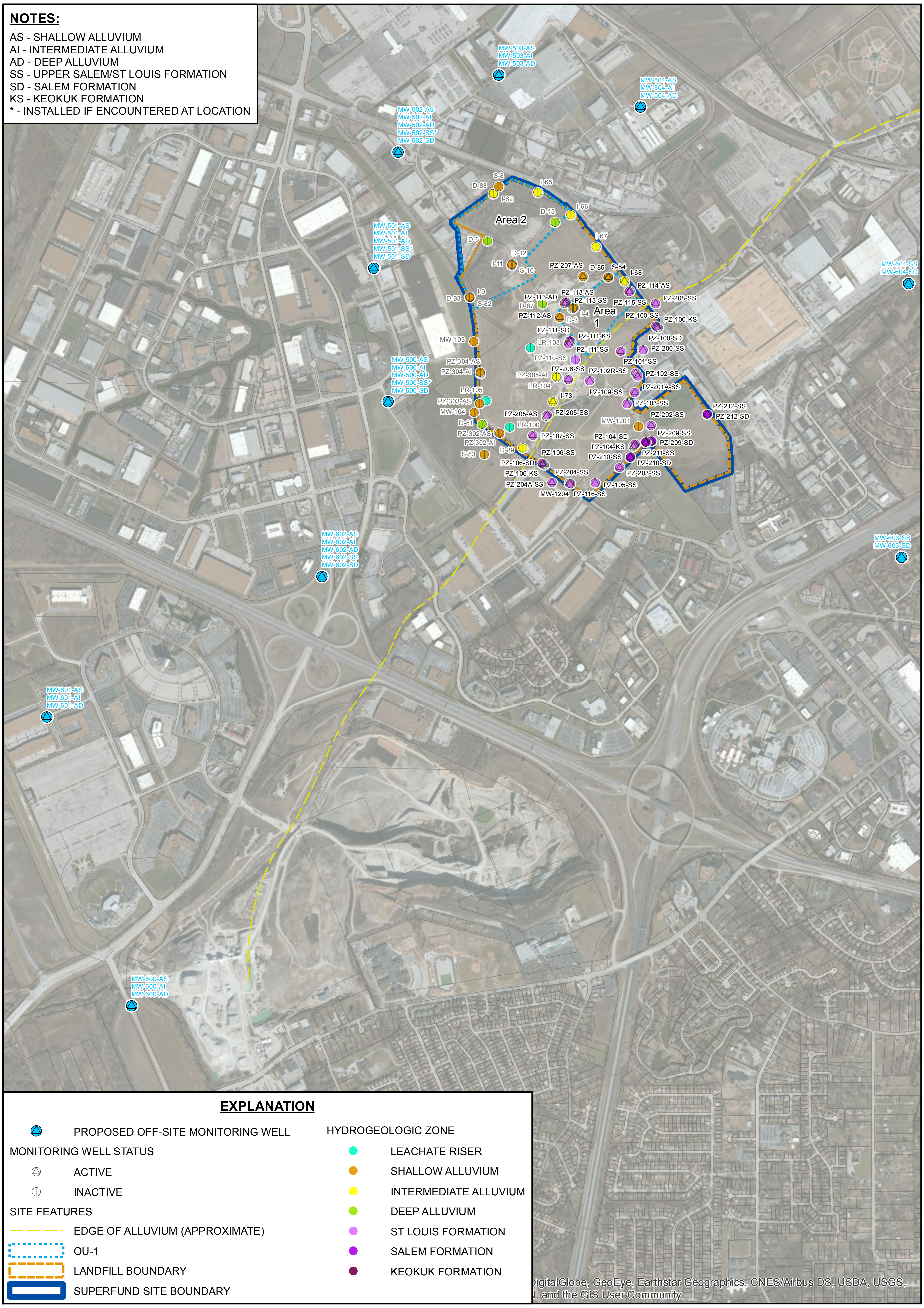
FIGURE 5-2

PROPOSED ON-SITE AND NEAR-SITE MONITORING WELLS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 500 '	Date: 10/30/19	File: 5-2_On-SiteMW-Fig-5-2.mxd

M:\WTO\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WPS-2_ON-SITEMW-FIG-5-2.MXD



NOTES:

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED OFF-SITE MONITORING WELL

MONITORING WELL STATUS
- ACTIVE
- INACTIVE

SITE FEATURES
- EDGE OF ALLUVIUM (APPROXIMATE)
- OU-1
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

HYDROGEOLOGIC ZONE
- LEACHATE RISER
- SHALLOW ALLUVIUM
- INTERMEDIATE ALLUVIUM
- DEEP ALLUVIUM
- ST LOUIS FORMATION
- SALEM FORMATION
- KEOKUK FORMATION

NOTES:

PROPOSED WELL LOCATIONS SUBJECT TO CHANGE
DUE TO THE POTENTIAL FOR BURIED UTILITIES
AND LACK OF ACCESS BY LANDOWNERS

N

0 1,500 '

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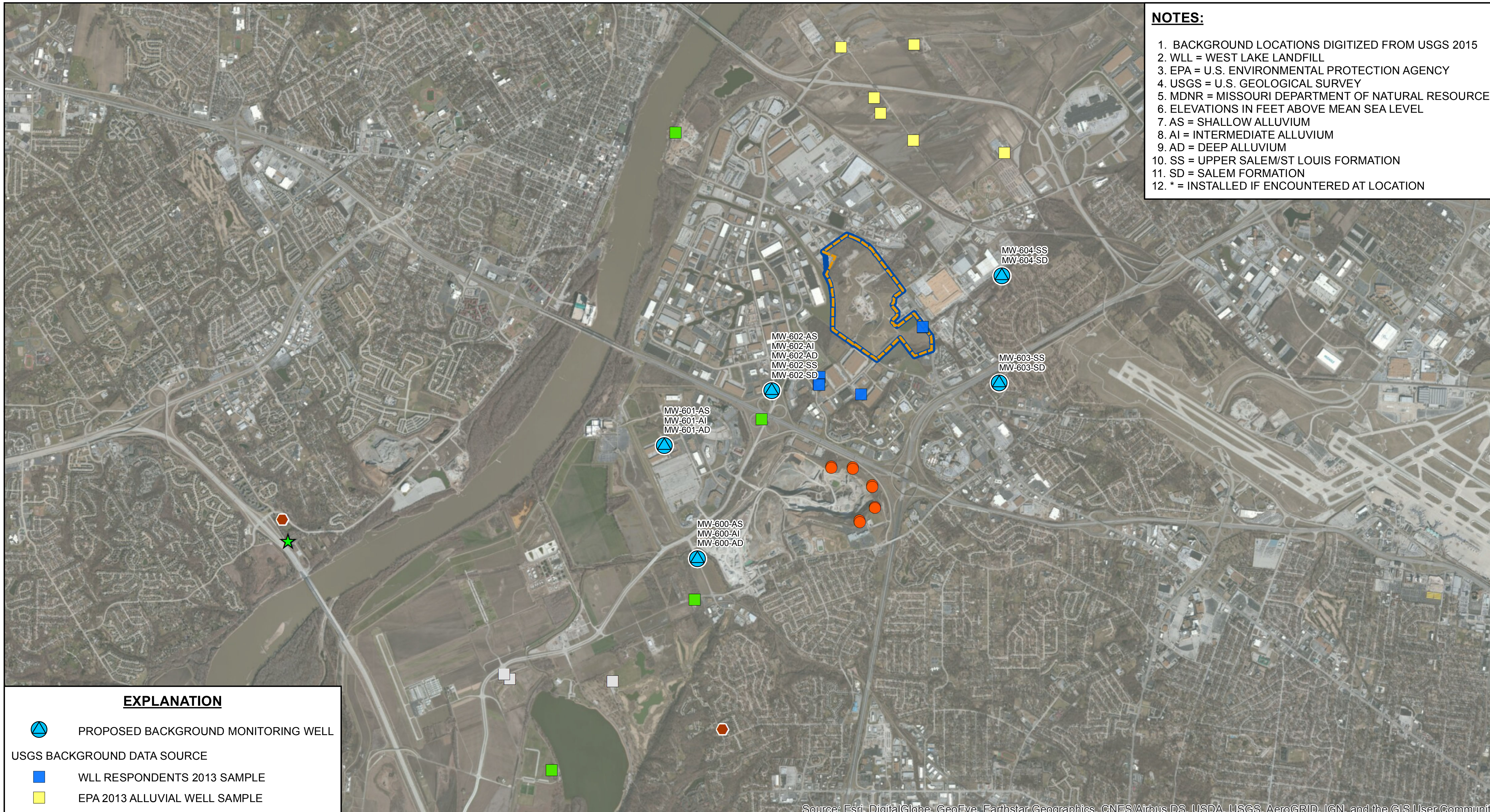
FIGURE 5-3

PROPOSED OFF-SITE MONITORING WELLS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 1,500 '	Date: 10/30/19	File: 5-3_Off-SiteMW-Fig-5-3.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-3_OFF-SITEMW-FIG-5-3.MXD



NOTES:

1. BACKGROUND LOCATIONS DIGITIZED FROM USGS 2015
2. WLL = WEST LAKE LANDFILL
3. EPA = U.S. ENVIRONMENTAL PROTECTION AGENCY
4. USGS = U.S. GEOLOGICAL SURVEY
5. MDNR = MISSOURI DEPARTMENT OF NATURAL RESOURCES
6. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
7. AS = SHALLOW ALLUVIUM
8. AI = INTERMEDIATE ALLUVIUM
9. AD = DEEP ALLUVIUM
10. SS = UPPER SALEM/ST LOUIS FORMATION
11. SD = SALEM FORMATION
12. * = INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED BACKGROUND MONITORING WELL

USGS BACKGROUND DATA SOURCE

WLL RESPONDENTS 2013 SAMPLE
EPA 2013 ALLUVIAL WELL SAMPLE
USGS-RP 2013 ALLUVIAL WELL SAMPLE
USGS-RP 2013 BEDROCK SAMPLE
MDNR CHAMP LANDFILL EXPANSION SAMPLE
HISTORICAL USGS DATA
MDNR PUBLIC-DRINKING WATER BRANCH
LANDFILL BOUNDARY
SUPERFUND SITE BOUNDARY

N

0 4,000 '

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FIGURE 5-4

PROPOSED BACKGROUND MONITORING WELLS

**WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN**

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 4,000 '	Date: 10/30/19	File: 5-4_BGMW_Fig5-4.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-4_BGMW_FIG5-4.MXD

NOTES:

AS - SHALLOW ALLUVIUM
AI - INTERMEDIATE ALLUVIUM
AD - DEEP ALLUVIUM
SS - UPPER SALEM/ST LOUIS FORMATION
SD - SALEM FORMATION
KS - KEOKUK FORMATION
* - INSTALLED IF ENCOUNTERED AT LOCATION

EXPLANATION

PROPOSED MONITORING WELL

MONITORING WELL STATUS

ACTIVE

SITE FEATURES

EDGE OF ALLUVIUM (APPROXIMATE)

OU-1

LANDFILL BOUNDARY

SUPERFUND SITE BOUNDARY

HYDROGEOLOGIC ZONE

LEACHATE RISER

SHALLOW ALLUVIUM

INTERMEDIATE ALLUVIUM

DEEP ALLUVIUM

ST LOUIS FORMATION

SALEM FORMATION

KEOKUK FORMATION

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NOTES:

PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES AND LACK OF ACCESS BY LANDOWNERS

N

0 1,500 '

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FIGURE 5-5

PROPOSED MONITORING WELL NETWORK

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS | Checked By: AMR | Scale: 1 " = 1,500 ' | Date: 10/30/19 | File: 5-5_RevMW-Fig-5-5.mxd

M:\WTO\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-5_REVMW-FIG-5-5.MXD

EXPLANATION

- PROPOSED STAFF GAUGE
- USGS06935965
- LANDFILL BOUNDARY
- SUPERFUND SITE BOUNDARY

N

0 1,500 '

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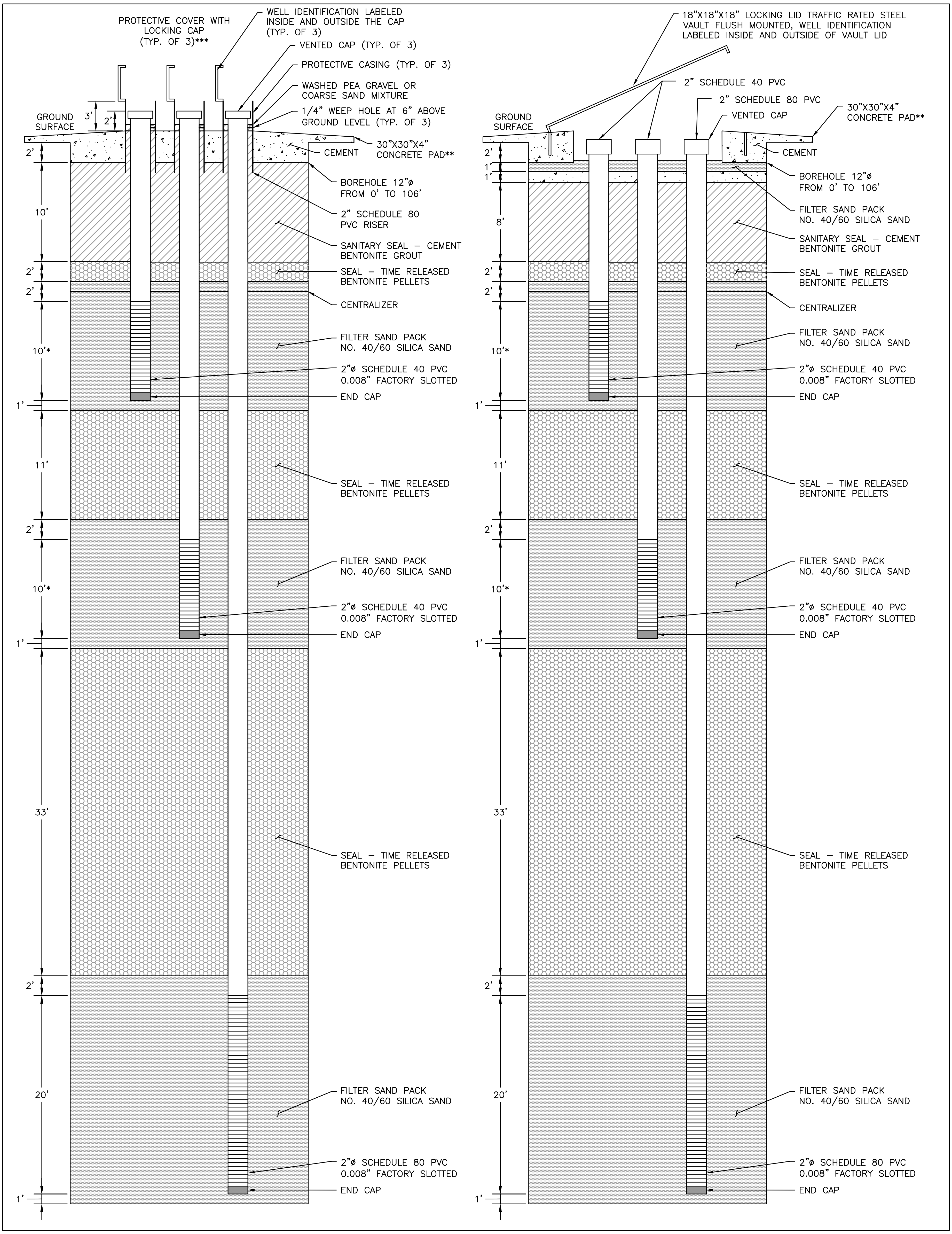
FIGURE 5-6

PROPOSED STAFF GAUGE LOCATIONS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: SLL	Scale: 1 " = 1,500 '	Date: 10/30/19	File: 5-6_ProposedStaffGauge_Fig5-6.mxd

M:\WTO\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-6_PROPOSEDSTAFFGAUGE_FIG5-6.MXD



NOTES:

1. DRAWING IS SCALED VERTICALLY TO SHOW DEPTH. HORIZONTAL SCALE IS ADJUSTED TO SHOW FEATURES AND IS INDEPENDENT OF VERTICAL SCALE.
2. BGS = BELOW GROUND SURFACE
3. ACTUAL INTERVALS MAY VARY BASED ON FIELD CONDITIONS.
4. * = SCREEN SIZE MAY RANGE FROM 10' TO 15'
5. ALL MONITORING WELLS WILL BE CONSTRUCTED ACCORDING TO MISSOURI DEPARTMENT OF NATURAL RESOURCES MONITORING WELL CONSTRUCTION CODE (10 CSR 23-4) AND WILL BE PERMITTED PRIOR TO CONSTRUCTION WHERE APPLICABLE.
6. ALL MONITORING WELLS WILL BE INSTALLED BY A LICENSED WELL CONTRACTOR AND OVERSEEN BY AN ENVIRONMENTAL OR ENGINEERING ENTITY WITH A RESTRICTED MONITORING WELL CONTRACTOR'S PERMIT.
7. ** = SURFACE COMPLETIONS ARE NOT TO SCALE
8. *** = NESTED WELLS MAY BE CONSTRUCTED WITH AN ABOVE-GROUND VAULT SURFACE COMPLETION.

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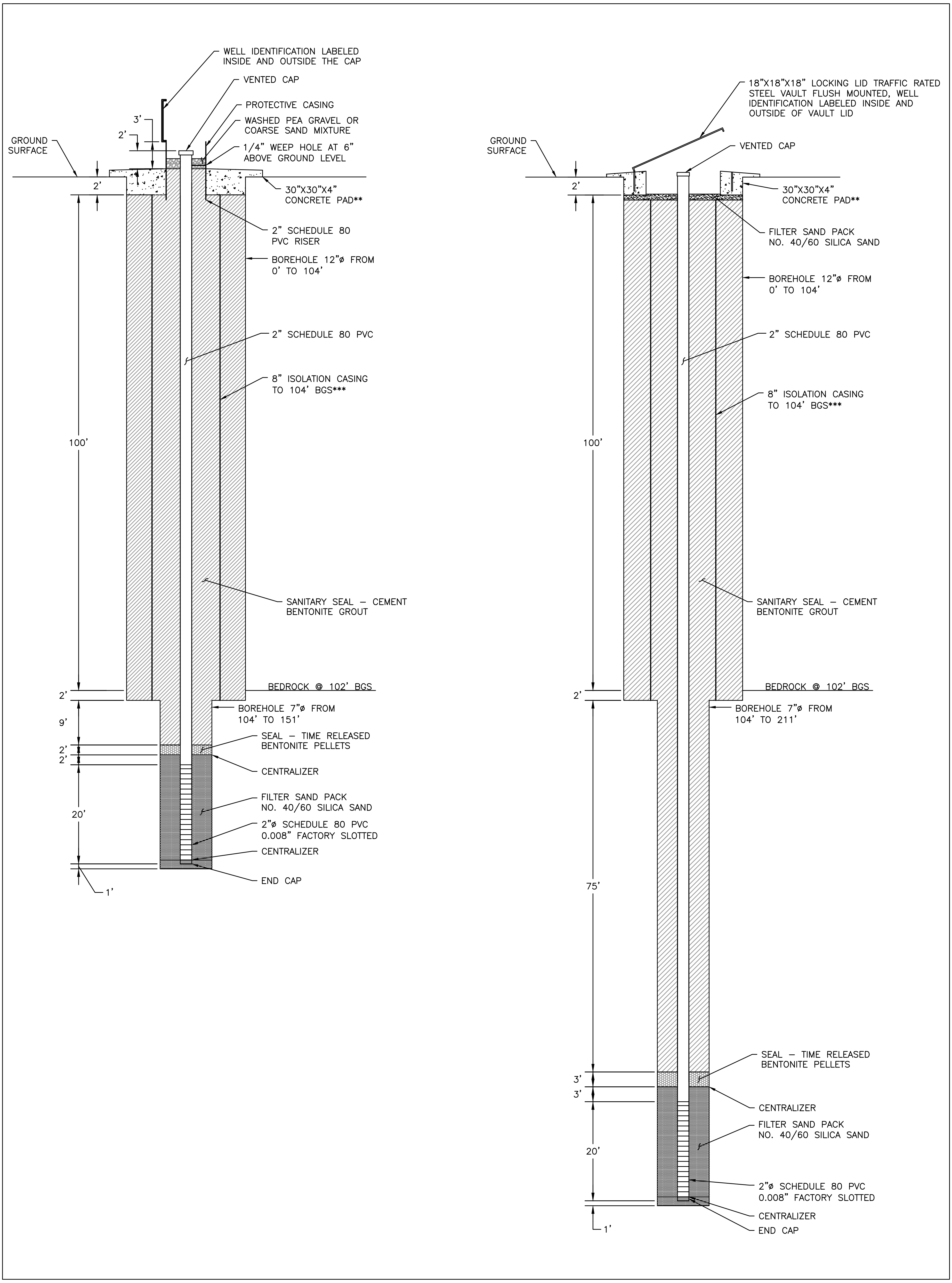
FIGURE 5-7a
EXAMPLE MONITORING WELL CONSTRUCTION DETAILS
ALLUVIAL AQUIFER MONITORING WELLS

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DMB	Checked By: MGS	Scale: NONE	Date: 11/5/2019	File: 63N_MONWELLDETAIL201910

M:\WTOZ\WESTLAKELANDFILL\CADD\SINGLEFIGURES\63N_MONWELLDETAIL201910



NOTES:

1. DRAWING IS SCALED VERTICALLY TO SHOW DEPTH. HORIZONTAL SCALE IS ADJUSTED TO SHOW FEATURES AND IS INDEPENDENT OF VERTICAL SCALE.
2. BGS = BELOW GROUND SURFACE
3. ACTUAL INTERVALS MAY VARY BASED ON FIELD CONDITIONS.
4. ALL MONITORING WELLS WILL BE CONSTRUCTED ACCORDING TO MISSOURI DEPARTMENT OF NATURAL RESOURCES MONITORING WELL CONSTRUCTION CODE (10 CSR 23-4) AND WILL BE PERMITTED PRIOR TO CONSTRUCTION WHERE APPLICABLE.
5. ALL MONITORING WELLS WILL BE INSTALLED BY A LICENSED WELL CONTRACTOR AND OVERSEEN BY AN ENVIRONMENTAL OR ENGINEERING ENTITY WITH A RESTRICTED MONITORING WELL CONTRACTOR'S PERMIT.
6. ** = SURFACE COMPLETION IS NOT TO SCALE
7. *** = 8" ISOLATION CASTING TO 2' BELOW BEDROCK SURFACE

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FIGURE 5-7b

EXAMPLE MONITORING WELL CONSTRUCTION DETAILS BEDROCK AQUIFER MONITORING WELLS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DMB	Checked By: MGS	Scale: NONE	Date: 11/5/2019	File: 63N_MONWELLDETAIL201910

NOTE:

PROPOSED WELL LOCATIONS SUBJECT TO CHANGE DUE TO THE POTENTIAL FOR BURIED UTILITIES AND LACK OF ACCESS BY LANDOWNERS

N

0 100 '

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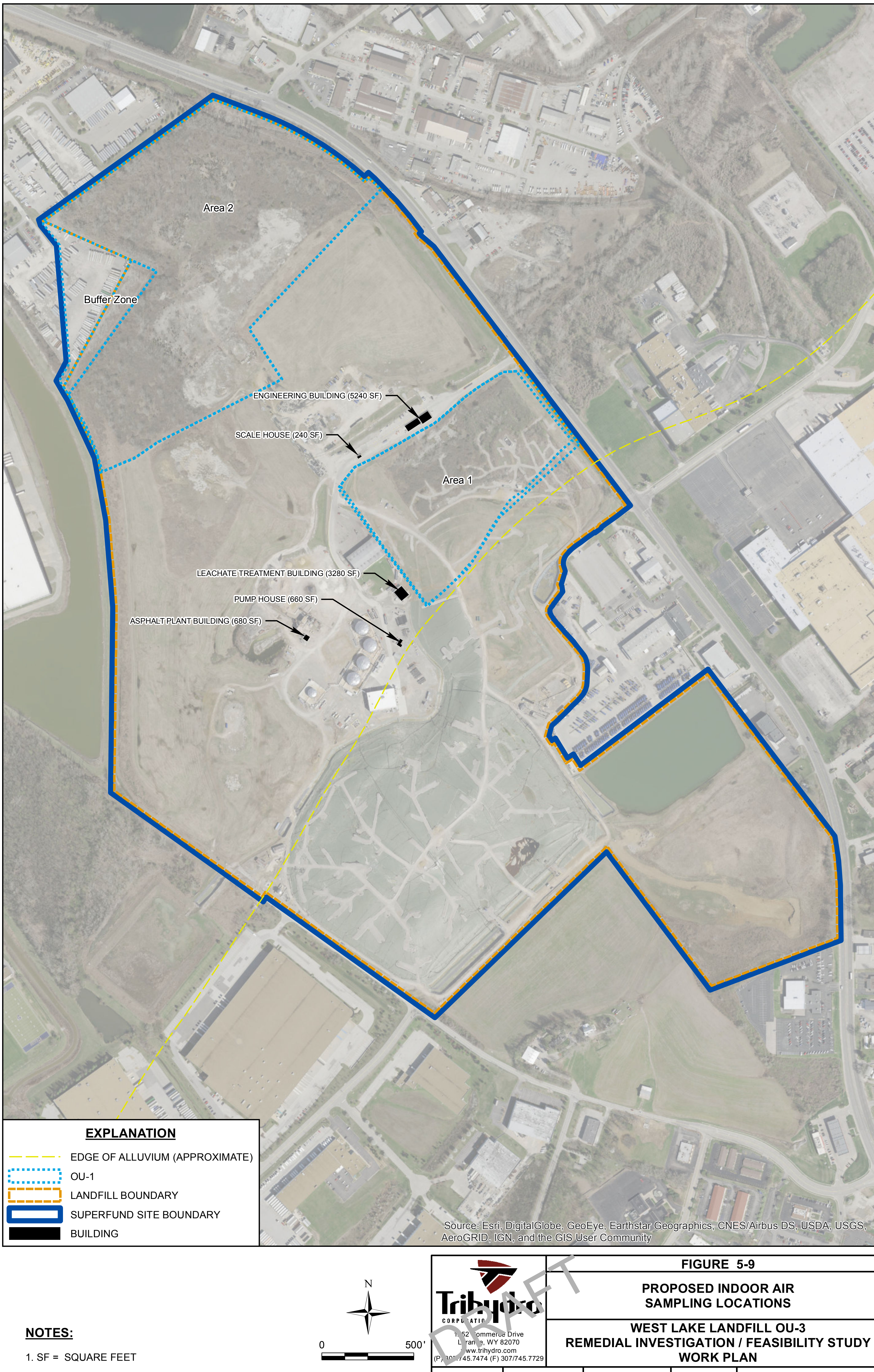
FIGURE 5-8

PROPOSED HYDRAULIC PROFILING TOOL TRANSECT

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: MGS	Checked By: AMR	Scale: 1 " = 100 '	Date: 11/5/19	File: 5-8_ProposedHPTFig5-8.mxd

M:\WTO\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-8_PROPOSEDHPTFIG5-8.MXD



NOTES:

1. SF = SQUARE FEET

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FIGURE 5-9

PROPOSED INDOOR AIR SAMPLING LOCATIONS

WEST LAKE LANDFILL OU-3 REMEDIAL INVESTIGATION / FEASIBILITY STUDY WORK PLAN

Drawn By: DH	Checked By: AR	Scale: 1 " = 500 '	Date: 11/12/19	File: 5-9_IndoorAirLoc_Fig5-9.mxd

M:\WTOZ\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\5-9_INDOORAIRLOC_FIG5-9.MXD

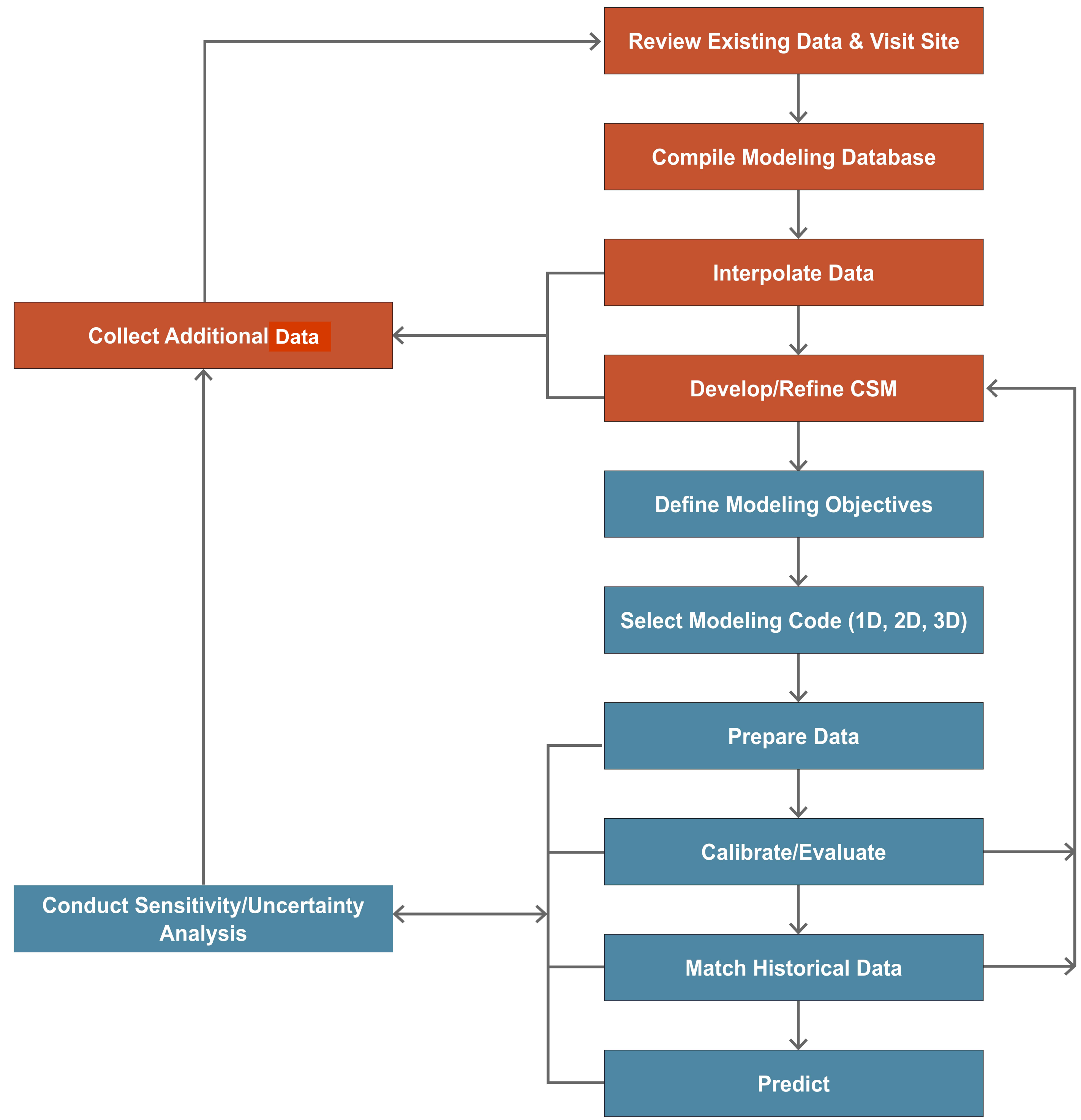

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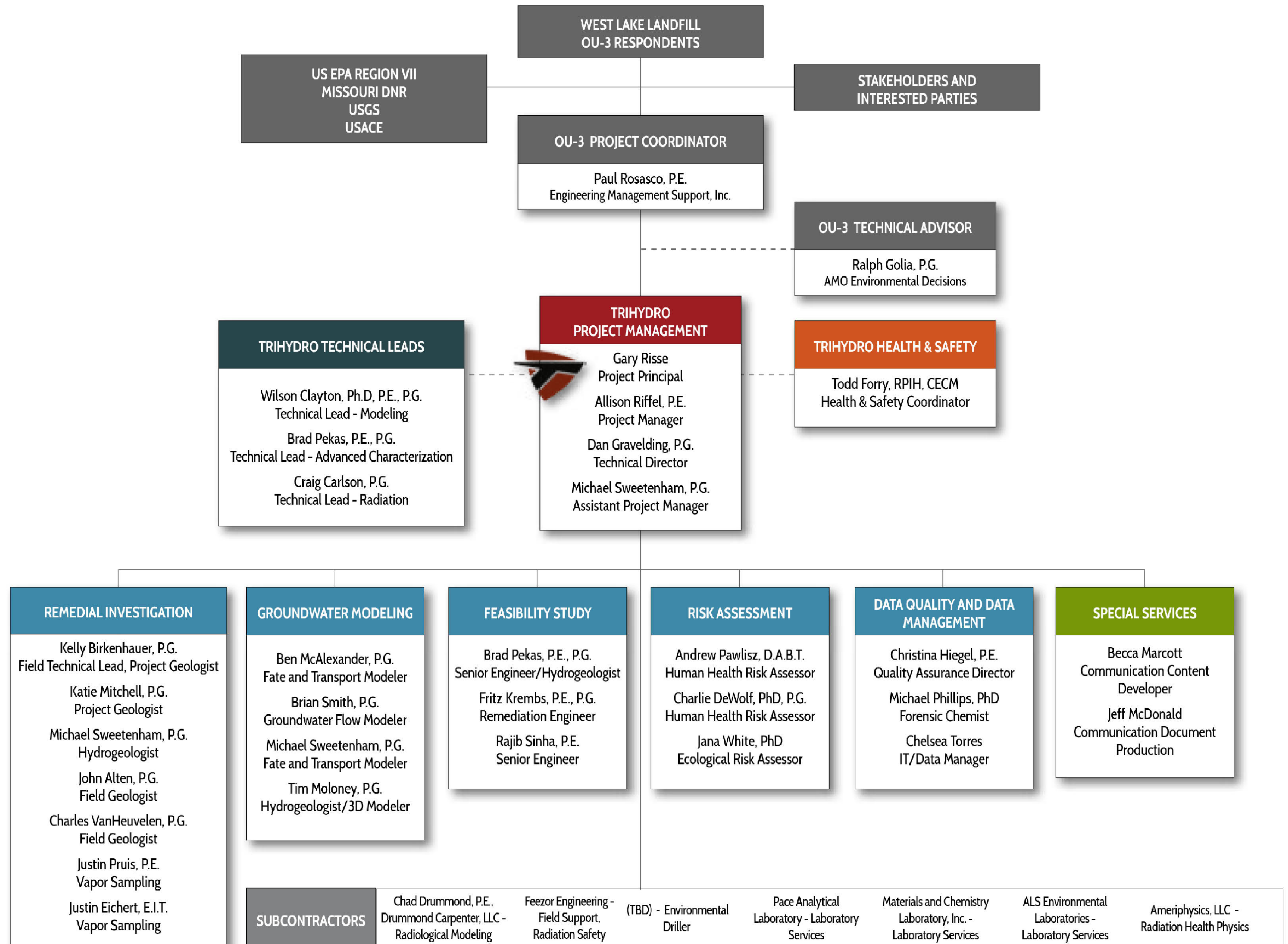
FIGURE 5-10

GROUNDWATER MODELING PROCESS
FLOW DIAGRAM

WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: REP	Checked By: MH	Scale: NONE	Date: 5/9/19	File: 63N-RIFSWP_FLOWCHART_201905

M:\WTOZ\WESTLAKELANDFILL\CADD\201906_RIFS_WP\63N-RIFSWP_FLOWCHART_201905



NOTES:

US EPA - UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
DNR - DEPARTMENT OF NATURAL RESOURCES
USGS - UNITED STATES GEOLOGICAL SURVEY
OU-3 - OPERABLE UNIT 3
P.E. - PROFESSIONAL ENGINEER
P.G. - PROFESSIONAL GEOLOGIST
USACE – UNITED STATES ARMY CORP. OF ENGINEERS
RPIH - REGISTERED PROFESSIONAL INDUSTRIAL HYGIENIST
CECM - CERTIFIED ENVIRONMENTAL COMPLIANCE MANAGER
USACE – UNITED STATES ARMY CORP. OF ENGINEERS

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FIGURE 10-1

PROJECT ORGANIZATIONAL CHART

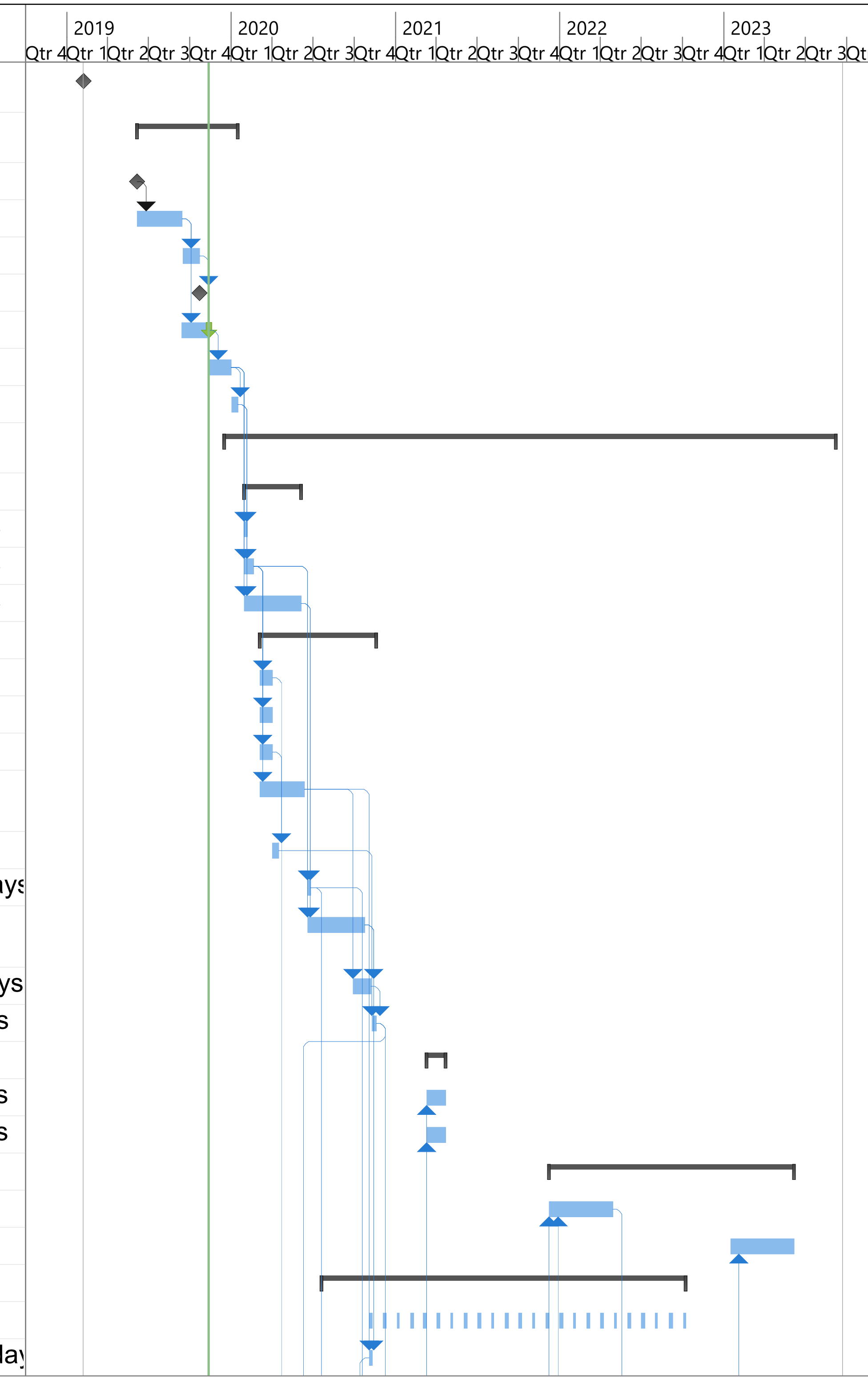
WEST LAKE LANDFILL OU-3
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WORK PLAN

Drawn By: KEJ	Checked By: MS		Date: 11/12/19	File: 10-1_OrgChart_Fig10-1.mxd

M:\WTO2\WESTLAKELANDFILL\GIS\MAPPING\201911_RIFS_WP\ORGCHART\10-1_ORGCHART_FIG10-1.MXD

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**OU-3 RI/FS Order Effective Date**	0 days	Wed 2/6/19	Wed 2/6/19	
2		**OU-3 RI/FS Work Plan**	**154 days**	**Wed 6/5/19**	**Wed 1/15/20**	
3		Submit Draft Work Plan	0 days	Wed 6/5/19	Wed 6/5/19	
4		USEPA Review of Work Plan and Issuance of Comments Letter	72 days	Thu 6/6/19	Fri 9/13/19	3
5		Prepare Response to Comments Letter	27 days	Mon 9/16/19	Tue 10/22/19	4
6		Submit Response to Comments Letter	0 days	Tue 10/22/19	Tue 10/22/19	5
7		Prepare and Submit Draft Final Work Plan	43 days	Fri 9/13/19	Tue 11/12/19	4
8		USEPA Reviews and Issues Final Approval	30 days	Wed 11/13/19	Tue 12/31/19	7
9		Submit Final Work Plan	10 days	Thu 1/2/20	Wed 1/15/20	8
10		**OU-3 RI Implementation**	**944 days**	**Tue 12/17/19**	**Wed 9/6/23**	
11		**Prepatory Activities**	**90 days**	**Thu 1/30/20**	**Thu 6/4/20**	
12		Notifications	5 days	Thu 1/30/20	Wed 2/5/20	8,9FS+10 days
13		Subcontracting	15 days	Thu 1/30/20	Wed 2/19/20	8,9FS+10 days
14		Right-of-Way Permitting and Access Agreements	90 days	Thu 1/30/20	Thu 6/4/20	8,9FS+10 days
15		**Field Activities**	**183 days**	**Thu 3/5/20**	**Wed 11/18/20**	
16		Well Survey and Inventory (86 Existing Wells)	20 days	Thu 3/5/20	Wed 4/1/20	13FS+10 days
17		Offsite Well Inventory and Data Collection (as necessary)	20 days	Thu 3/5/20	Wed 4/1/20	13FS+10 days
18		Existing Well Redevelopment (Max 86 Wells)	20 days	Thu 3/5/20	Wed 4/1/20	13FS+10 days
19		Onsite Well Installation and Development (28 Wells), Geophysics, Geotechnical Sampling, Soil and Bedrock Sampling	70 days	Thu 3/5/20	Thu 6/11/20	13FS+10 days
20		Slug Test Existing Wells (34 Wells) and Transducer Installation	10 days	Thu 4/2/20	Wed 4/15/20	18
21		Staff Gauge Installation (9 Staff Gauges)	5 days	Fri 6/19/20	Thu 6/25/20	13,14FS+10 days
22		Offsite Well Installation and Development (36 Wells), Geophysics, Geotechnical Sampling, Soil and Bedrock Sampling	90 days	Fri 6/19/20	Fri 10/23/20	13,14FS+10 days
23		Slug Testing New Wells (64 Wells)	30 days	Mon 9/28/20	Fri 11/6/20	19,22FS-20 days
24		Transducer Installation at New Wells (64 Wells)	8 days	Mon 11/9/20	Wed 11/18/20	23,20FS-8 days
25		**Implement RI/FS Addendum Activities**	**30 days**	**Thu 3/11/21**	**Wed 4/21/21**	
26		Aquifer Pumping Test (Piezometer Installation, Testing, Evaluation)	30 days	Thu 3/11/21	Wed 4/21/21	107FS+60 days
27		Additional Activities (To Be Determined)	30 days	Thu 3/11/21	Wed 4/21/21	107FS+60 days
28		**Data Evaluation Activities**	**379 days**	**Wed 12/8/21**	**Mon 6/5/23**	
29		Develop Groundwater Model	100 days	Wed 12/8/21	Thu 4/28/22	99,87,105
30		Complete Baseline Risk Assessment	100 days	Mon 1/16/23	Mon 6/5/23	93
31		**Routine Data Collection and Evaluation**	**564 days**	**Mon 7/20/20**	**Fri 10/7/22**	
32		**Monthly Fluid Level Gauging (Wells, Leachate, Surface Water)**	**489 days**	**Tue 11/3/20**	**Fri 10/7/22**	
33		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 1	5 days	Tue 11/3/20	Mon 11/9/20	19,22FS+10 eday

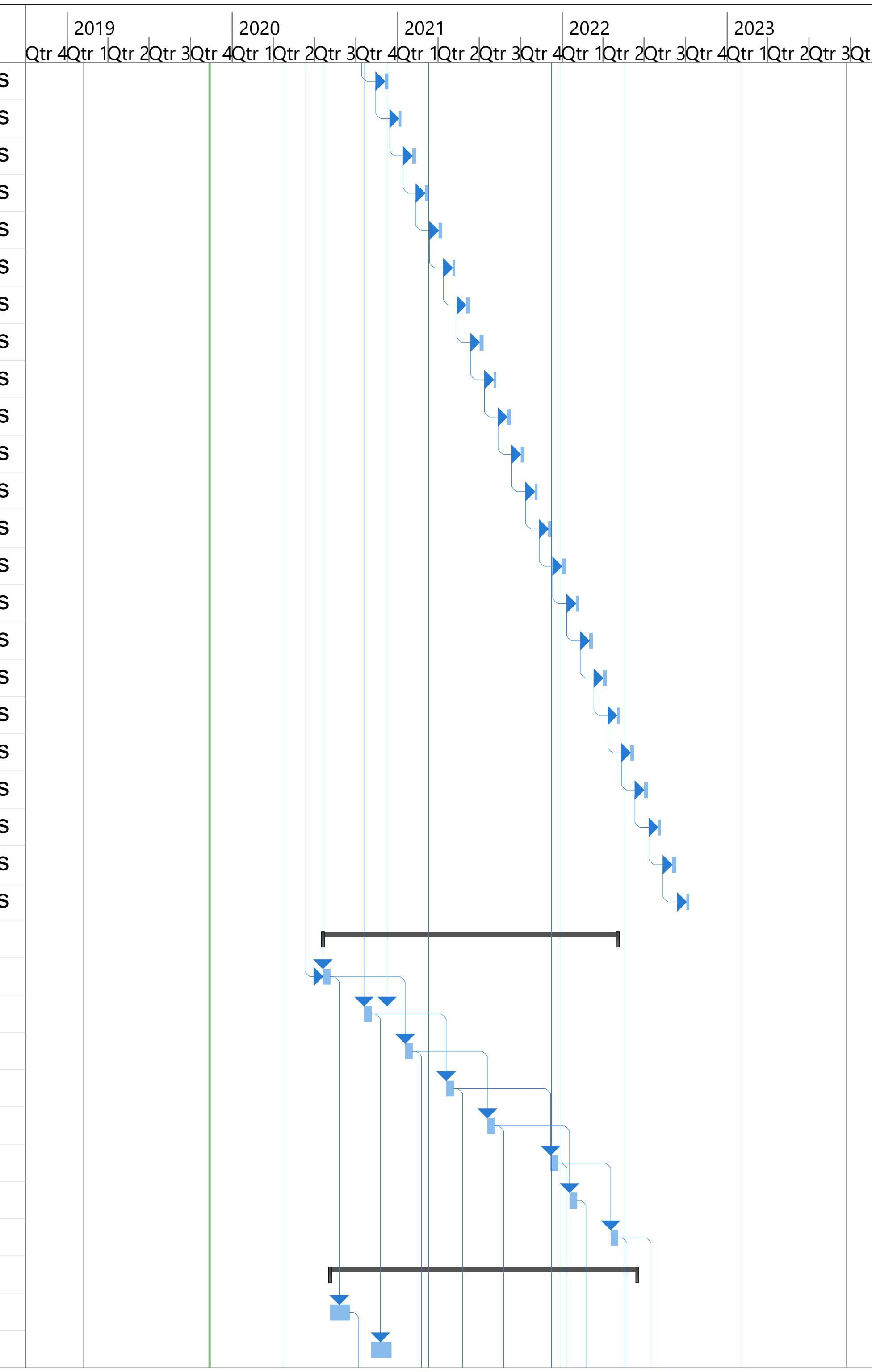


Project: Simple Project Plan
Date: Tue 11/12/19
Red font indicates ASAOC deadline
Schedule dependent on agency review times

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
34		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 2	5 days	Fri 12/4/20	Thu 12/10/20	33SS+31 edays
35		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 3	5 days	Mon 1/4/21	Fri 1/8/21	34SS+30 edays
36		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 4	5 days	Wed 2/3/21	Tue 2/9/21	35SS+30 edays
37		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 5	5 days	Wed 3/3/21	Tue 3/9/21	36SS+28 edays
38		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 6	5 days	Fri 4/2/21	Thu 4/8/21	37SS+30 edays
39		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 7	5 days	Mon 5/3/21	Fri 5/7/21	38SS+30 edays
40		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 8	5 days	Wed 6/2/21	Tue 6/8/21	39SS+30 edays
41		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 9	5 days	Fri 7/2/21	Fri 7/9/21	40SS+30 edays
42		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 10	5 days	Mon 8/2/21	Fri 8/6/21	41SS+30 edays
43		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 11	5 days	Wed 9/1/21	Wed 9/8/21	42SS+30 edays
44		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 12	5 days	Fri 10/1/21	Thu 10/7/21	43SS+30 edays
45		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 13	5 days	Mon 11/1/21	Fri 11/5/21	44SS+30 edays
46		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 14	5 days	Wed 12/1/21	Tue 12/7/21	45SS+30 edays
47		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 15	5 days	Fri 12/31/21	Fri 1/7/22	46SS+30 edays
48		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 16	5 days	Mon 1/31/22	Fri 2/4/22	47SS+30 edays
49		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 17	5 days	Wed 3/2/22	Tue 3/8/22	48SS+30 edays
50		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 18	5 days	Fri 4/1/22	Thu 4/7/22	49SS+30 edays
51		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 19	5 days	Mon 5/2/22	Fri 5/6/22	50SS+30 edays
52		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 20	5 days	Wed 6/1/22	Tue 6/7/22	51SS+30 edays
53		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 21	5 days	Fri 7/1/22	Fri 7/8/22	52SS+30 edays
54		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 22	5 days	Mon 8/1/22	Fri 8/5/22	53SS+30 edays
55		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 23	5 days	Thu 9/1/22	Thu 9/8/22	54SS+31 edays
56		Monthly Fluid Level Gauging (Wells, Leachate, Surface Water) 24	5 days	Mon 10/3/22	Fri 10/7/22	55SS+30 edays
57		**Complete Quarterly Groundwater Monitoring**	**454 days**	**Mon 7/20/20**	**Tue 5/3/22**	
58		Q1	12 days	Mon 7/20/20	Tue 8/4/20	21,24
59		Q2	12 days	Mon 10/19/20	Tue 11/3/20	21,24
60		Q3	12 days	Mon 1/18/21	Tue 2/2/21	58
61		Q4	12 days	Mon 4/19/21	Tue 5/4/21	59
62		Q5	12 days	Mon 7/19/21	Tue 8/3/21	60
63		Q6	12 days	Mon 12/6/21	Tue 12/21/21	61
64		Q7	12 days	Mon 1/17/22	Tue 2/1/22	62
65		Q8	12 days	Mon 4/18/22	Tue 5/3/22	63
66		**Laboratory Analysis and Data Validation**	**472 days**	**Wed 8/5/20**	**Wed 6/15/22**	
67		Q1	30 days	Wed 8/5/20	Wed 9/16/20	58
68		Q2	30 days	Wed 11/4/20	Thu 12/17/20	59



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Date: Tue 11/12/19
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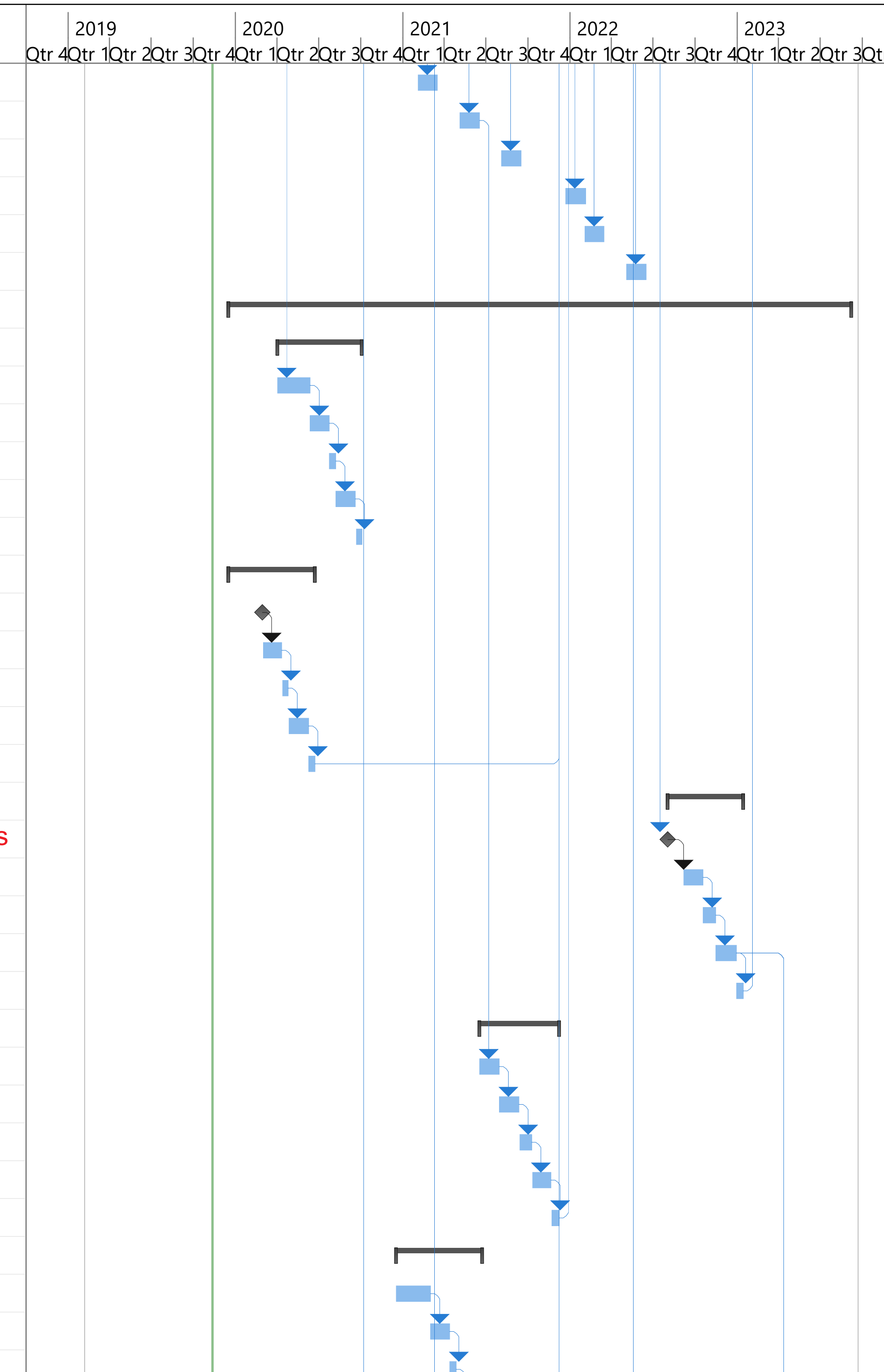
Task; Split; Milestone; Summary; Project Summary; Inactive Task; Inactive Milestone; Inactive Summary; Manual Task; Duration-only; Manual Summary Rollup; Manual Summary; Start-only; Finish-only; External Tasks; External Milestone; Deadline; Progress; Manual Progress

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
69		Q3	30 days	Wed 2/3/21	Tue 3/16/21	60
70		Q4	30 days	Wed 5/5/21	Wed 6/16/21	61
71		Q5	30 days	Wed 8/4/21	Wed 9/15/21	62
72		Q6	30 days	Wed 12/22/21	Thu 2/3/22	63
73		Q7	30 days	Wed 2/2/22	Tue 3/15/22	64
74		Q8	30 days	Wed 5/4/22	Wed 6/15/22	65
75		**Prepare Submittals**	**944 days**	**Tue 12/17/19**	**Wed 9/6/23**	
76		**Prepare Well Inventory Summary Report**	**130 days**	**Thu 4/2/20**	**Fri 10/2/20**	
77		Draft Report	50 days	Thu 4/2/20	Thu 6/11/20	16
78		USEPA Comments	30 days	Fri 6/12/20	Thu 7/23/20	77
79		Draft Final Report	10 days	Fri 7/24/20	Thu 8/6/20	78
80		USEPA Approval	30 days	Fri 8/7/20	Fri 9/18/20	79
81		Final Report	10 days	Mon 9/21/20	Fri 10/2/20	80
82		**Prepare 2019 Hydrogeological/Groundwater Characterization Report**	**130 days**	**Tue 12/17/19**	**Mon 6/22/20**	
83		Draft Report	50 days	Tue 12/17/19	Fri 2/28/20	
84		USEPA Comments	30 days	Mon 3/2/20	Fri 4/10/20	83
85		Draft Final Report	10 days	Mon 4/13/20	Fri 4/24/20	84
86		USEPA Approval	30 days	Mon 4/27/20	Mon 6/8/20	85
87		Final Report	10 days	Tue 6/9/20	Mon 6/22/20	86
88		**Prepare Baseline Risk Assessment Work Plan**	**114 days**	**Mon 8/1/22**	**Fri 1/13/23**	
89		Draft Report	0 days	Mon 8/1/22	Mon 8/1/22	65FS+90 edays
90		USEPA Comments	30 days	Tue 9/6/22	Mon 10/17/22	89
91		Draft Final Report	20 days	Tue 10/18/22	Mon 11/14/22	90
92		USEPA Approval	30 days	Tue 11/15/22	Thu 12/29/22	91
93		Final Report	10 days	Fri 12/30/22	Fri 1/13/23	92
94		**Prepare Groundwater Modeling Work Plan**	**120 days**	**Thu 6/17/21**	**Tue 12/7/21**	
95		Draft Report	30 days	Thu 6/17/21	Thu 7/29/21	70
96		USEPA Comments	30 days	Fri 7/30/21	Fri 9/10/21	95
97		Draft Final Report	20 days	Mon 9/13/21	Fri 10/8/21	96
98		USEPA Approval	30 days	Mon 10/11/21	Fri 11/19/21	97
99		Final Report	10 days	Mon 11/22/21	Tue 12/7/21	98
100		**Prepare 2020 Hydrogeological/Groundwater Characterization Report**	**130 days**	**Thu 12/17/20**	**Tue 6/22/21**	
101		Draft Report	50 days	Thu 12/17/20	Mon 3/1/21	
102		USEPA Comments	30 days	Tue 3/2/21	Mon 4/12/21	101
103		Draft Final Report	10 days	Tue 4/13/21	Mon 4/26/21	102



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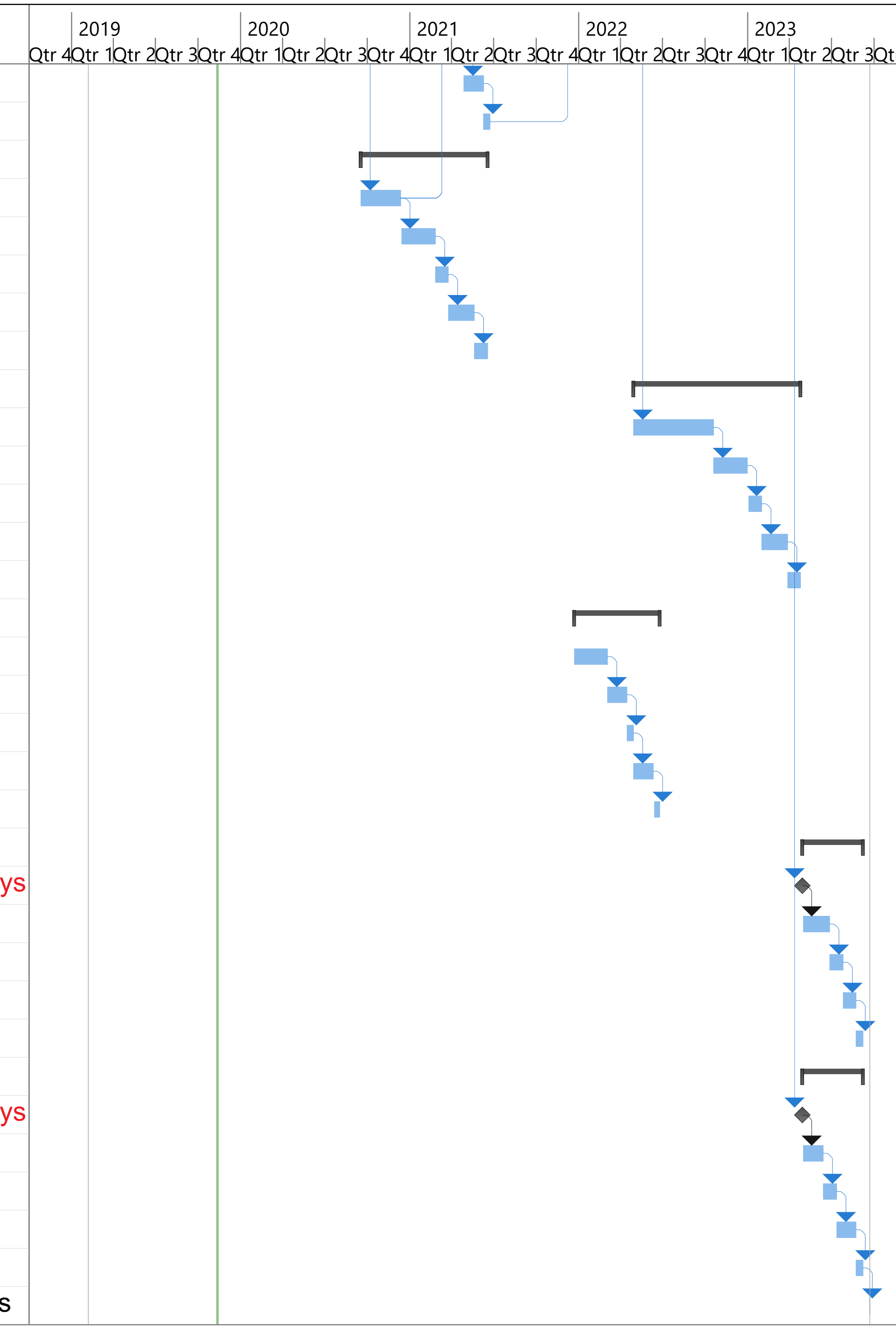
Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

FIGURE 10-2. PROJECT SCHEDULE
REMEDIAL INVESTIGATION / FEASIBILITY STUDY
WEST LAKE LANDFILL OU-3

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
104		USEPA Approval	30 days	Tue 4/27/21	Tue 6/8/21	103
105		Final Report	10 days	Wed 6/9/21	Tue 6/22/21	104
106		**Prepare OU-3 Work Plan Addendum**	**190 days**	**Thu 9/17/20**	**Thu 6/17/21**	
107		Draft Report	60 days	Thu 9/17/20	Fri 12/11/20	67
108		USEPA Comments	50 days	Mon 12/14/20	Wed 2/24/21	107
109		Draft Final Report	20 days	Thu 2/25/21	Wed 3/24/21	108
110		USEPA Approval	40 days	Thu 3/25/21	Wed 5/19/21	109
111		Final Report	20 days	Thu 5/20/21	Thu 6/17/21	110
112		**Prepare Groundwater Modeling Report**	**250 days**	**Fri 4/29/22**	**Mon 4/24/23**	
113		Run Model Simulations and Prepare Draft Report	120 days	Fri 4/29/22	Tue 10/18/22	29
114		USEPA Comments	50 days	Wed 10/19/22	Fri 12/30/22	113
115		Draft Final Report	20 days	Tue 1/3/23	Mon 1/30/23	114
116		USEPA Approval	40 days	Tue 1/31/23	Mon 3/27/23	115
117		Final Report	20 days	Tue 3/28/23	Mon 4/24/23	116
118		**Prepare 2021 Hydrogeological/Groundwater Characterization Report**	**130 days**	**Wed 12/22/21**	**Fri 6/24/22**	
119		Draft Report	50 days	Wed 12/22/21	Thu 3/3/22	
120		USEPA Comments	30 days	Fri 3/4/22	Thu 4/14/22	119
121		Draft Final Report	10 days	Fri 4/15/22	Thu 4/28/22	120
122		USEPA Approval	30 days	Fri 4/29/22	Fri 6/10/22	121
123		Final Report	10 days	Mon 6/13/22	Fri 6/24/22	122
124		**Prepare Baseline Risk Assessment Report**	**90 days**	**Fri 4/28/23**	**Wed 9/6/23**	
125		Submit Draft Report	0 days	Fri 4/28/23	Fri 4/28/23	92FS+120 edays
126		USEPA Comments	40 days	Mon 5/1/23	Mon 6/26/23	125
127		Draft Final Report	20 days	Tue 6/27/23	Tue 7/25/23	126
128		USEPA Approval	20 days	Wed 7/26/23	Tue 8/22/23	127
129		Final Report	10 days	Wed 8/23/23	Wed 9/6/23	128
130		**Prepare OU-3 RI Report**	**90 days**	**Fri 4/28/23**	**Wed 9/6/23**	
131		Submit Draft Report	0 days	Fri 4/28/23	Fri 4/28/23	92FS+120 edays
132		USEPA Comments	30 days	Mon 5/1/23	Mon 6/12/23	131
133		Draft Final Report	20 days	Tue 6/13/23	Tue 7/11/23	132
134		USEPA Approval	30 days	Wed 7/12/23	Tue 8/22/23	133
135		Final Report	10 days	Wed 8/23/23	Wed 9/6/23	134
136		**Attend Meeting with USEPA**	1 day	Thu 9/21/23	Thu 9/21/23	135FS+10 days



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Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			