United States Environmental Protection Agency

Optimization Review Report
Long-Term Monitoring Optimization Study

Bunker Hill Mining and Metallurgical Complex, Operable Unit 03
East Mission Flats and Big Creek Repositories
Kootenai County and Shoshone County, Idaho
EPA Region 10

OPTIMIZATION REVIEW

BUNKER HILL MINING AND METALLURGICAL COMPLEX, OU-3
EAST MISSION FLATS AND BIG CREEK REPOSITORIES
COEUR D'ALENE BASIN, IDAHO
EPA REGION 10

FINAL REPORT
October 2016

EXECUTIVE SUMMARY

NATIONAL OPTIMIZATION STRATEGY BACKGROUND

The U.S. Environmental Protection Agency's (EPA's) definition of optimization is as follows:

> "*Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation, which may facilitate progress towards site completion. To identify these opportunities, Regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply some other approaches to identify opportunities for greater efficiency and effectiveness.*"[1]

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, state, and municipal governments. Consistent with this interest, green remediation, and environmental footprint reduction are now routinely considered during optimization reviews, when applicable.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day and compiling a report that includes recommendations intended to improve the following:

- Remedy effectiveness
- Cost reduction
- Technical improvement
- Progress to Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent review and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also, note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPPs).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA Office of Superfund Remediation and Technology Innovation (OSRTI).

[1] EPA, 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

SITE-SPECIFIC BACKGROUND

The Bunker Hill Mining and Metallurgical Complex Site (BHSS or Site) is located in the Coeur d'Alene (CdA) Basin, Shoshone and Kootenay Counties, Idaho, EPA Region 10 (R10). The BHSS includes mining-affected surface water, soils, sediments, tailings piles and groundwater along 166 river miles in the CdA Basin. BHSS was added to the National Priorities List (NPL) in 1983. The Site is managed as three operable units (OUs) by EPA R10 in cooperation with the Idaho Department of Environmental Quality (IDEQ), tribal stakeholders, and the Successor Coeur d'Alene Custodial and Work Trust (CdA Trust).

As part of remedial efforts across the BHSS, contaminated soils and sediments have been removed from areas of potential human or ecological exposure and deposited in repositories designed for long-term, safe storage of contaminated solids. The goal of the following review is to support development of effective long-term monitoring at two large-scale, low-level, soil-waste repositories in OU3 of the Bunker Hill Site.

The goal of surface and groundwater monitoring in the vicinity of the repositories is to demonstrate that the repository design, engineering and maintenance are effective at preventing repository waste from adversely impacting groundwater and surface water quality.

The Big Creek Repository (BCR) is located south of Interstate 90 and the South Fork Coeur d'Alene River (SFCDR) east of Kellogg, Idaho. The repository is located adjacent to Big Creek, a perennial stream, near its confluence with the SFCDR. From 1968 to 1979, the BCR property was part of the Sunshine Mine tailings ponds used for disposal of material generated from milling silver (Ag), lead (Pb), and zinc (Zn) ore. Historically, Big Creek was diverted around tailings ponds so that the stream bed now runs both south and west of the repository, discharging to SFCDR north of the repository. The BCR has been accepting soil waste since 2004.

The EMFR is located 1,500 feet north of the Coeur d'Alene River, immediately north of Interstate 90 (I-90), and about two miles west of the town of Cataldo, Idaho. The EMFR is located on a 23-acre parcel that was historically impacted by fluvial deposition of mining-waste contaminated sediments. The Old Mission State Park is across I-90 about ¼ mile southwest of the repository. The EMFR has been accepting contaminated soils since 2009.

Waste streams stored at the repositories are generated by multiple contractors under the Basin Property Remediation Program (BPRP), Institutional Controls Program (ICP), and other BHHS programs. These programs remove waste soil and sediment from populated areas or areas with potentially complete exposure pathways for transport and deposition at the BCR, EMFR and other repositories. The current operation of each repository is seasonal, with active waste placement taking place from about April through October each year. Maintenance and waste receipt preparations take place in the spring with waste placement and compaction occurring in the summer and fall.

SUMMARY OF CONCEPTUAL SITE MODEL AND KEY FINDINGS

BCR

The BCR was constructed on top of the capped former tailings pond east and north of Big Creek. Constituents of concern (COCs) relevant to human health exposure pathways for the site are antimony (Sb) originating in the historical tailings, arsenic (As), cadmium (Cd), Pb, and Zn in groundwater and As, Cd, Pb, manganese (Mn) and mercury (Hg) in surface water. At BCR, variability in groundwater concentrations of As and Sb are likely related to varying redox conditions within the tailings.

Constituents of environmental concern (COECs) in surface water monitored for ecological health are Cd, copper (Cu), Pb, and Zn in surface water. Site groundwater is not used as a drinking water supply, so the only current potentially complete exposure pathway is discharge of contaminated groundwater to surface water and subsequent ecological or human exposures.

Tailings from historical milling activities consist of fine sand to silt-size particles that are underlain by a thin soil horizon and native alluvium consisting primarily of gravel and cobbles with sand. Native material underlying the BCR and Big Creek is alluvial sediment over fractured bedrock. Groundwater occurs in both the alluvium and bedrock aquifers and in the tailings. Groundwater in the alluvium is unconfined and in contact with Big Creek. Within the pond tailings, there are upper perched and lower water table saturated zones

Repository monitoring is currently performed on a quarterly basis. The quarterly monitoring frequency addresses the objective of assessing hydrogeologic conditions and metals concentrations in response to seasonal hydrologic fluctuations and is consistent with state and federal guidance on monitoring waste disposal facilities. The monitoring network includes:

- Five groundwater monitoring wells screened in the alluvial aquifer;
- Five surface water sampling locations (four in Big Creek and one in SFCDR), and
- At least one piezometer installed in the tailings zone.

The following uncertainties and data gaps in the CSM were identified for the BCR:

- Accurate estimates of background (pre-repository) COC concentrations of metals in groundwater and surface water have not been developed due to a limited spatial and temporal dataset;
- Background concentrations of COCs in tailings have not been estimated. Background values can be compared with concentrations in waste to accurately assess probable sources in the event of exceedances in surface or groundwater.
- Chemical form (complexation) of metals in waste material placed in the repository were not included in materials reviewed for this evaluation.
- The solid-phase association and complexation of metals is a source of uncertainty in predicting the leachability, reactivity and mobility of metals in both waste and tailings;
- Criteria protective of surface water for groundwater discharging to Big Creek have not been established;
- Site conditions or concentrations of COCs that would trigger contingent remedial response are not identified.

EMFR

The EMFR is located in the 100-year floodplain of the CdA River in an area that has experienced frequent inundation. Mine waste-impacted sediments transported by the CdA River were deposited in the area, historically, and a dredge-spoil disposal site is located west of the repository footprint. The CdA River flows east to west around the East Mission Flats area and is present to the east, south and west of the EMFR. Flooding of the area has a 50% chance of occurring each year. The site is bordered on two sides by low-lying ground and permanent wetlands. Locally, groundwater levels can rise to ground surface in response to high river stage and inundation events and flood waters can remain ponded adjacent to the repository for extended periods (days to weeks), potentially infiltrating into the waste repository.

Shallow deposits at the site are composed of fine-grained silts and sands, thought to be derived from fluvial deposits, including mine tailings over the past 100 years. An upper alluvial sand and gravel unconfined aquifer is present from 15 to 105 feet below ground surface (ft bgs), and a sand and clay aquifer is found to the west/northwest of the repository site at the same depth. A clay/silt confining unit is below the alluvial aquifer. A lower aquifer is present below about 116 ft bgs, underlain by bedrock.

The primary goal of the monitoring program is to evaluate groundwater quality in the upper alluvial aquifer. The monitoring network consists of the following locations:

- Two piezometers screened in the repository waste (PZ-A and PZ-B);
- Seven groundwater monitoring wells, five screened in the upper alluvial sand and gravel aquifer with one in the deeper zone of the alluvial aquifer; One well (MW-E) is located in the sand and clay zone to the west of the repository.
- One CdA surface water elevation location;
- Two floodwater locations are gauged for measuring floodwater elevation and duration, with floodwater quality sampled opportunistically prior to 2015.

The following uncertainties and data gaps in the CSM were identified for the EMFR:

- The solid-phase association and complexation of metals in waste and sediments under the EMFR is a source of uncertainty in predicting the leachability, reactivity and mobility of metals in both waste and sediments;
- Accuracy of background (pre-repository) concentration estimates of metals in groundwater is uncertain due to limited spatial and temporal dataset;
- Uncertainty about the direction and magnitude of groundwater flow and its influence on geochemistry, with greater uncertainty about groundwater quality and flow directions west of the EMFR;
- Details of surface and groundwater interactions and how they may influence mobility of metals;
- The transient and long-term effects of variable geochemistry on metals mobility;
- Site conditions or concentrations of COCs that would trigger site-specific contingent remedial response are not identified.

RECOMMENDATIONS

Global recommendations for surface and groundwater monitoring applicable to both the BCR and EMFR are:

- Collect unfiltered groundwater samples once every five years to confirm that filtered samples adequately represent potential transport of particle-associated COCs.
- Collect and analyze geochemical parameters in groundwater. Results of major ion data should be used to identify the geochemical characteristics of the groundwater (e.g. calcium-carbonate, sodium-chloride). After an initial evaluation of water type, the geochemical data can be analyzed on an as-needed basis or included in geochemical modeling if sampling data indicate significant exceedances of predicted concentrations.
- Reporting formats, data analyses and background assessments for annual monitoring reports should be as consistent as possible between repositories to streamline both report writing and review. Reports should list COCs and COECs, regulatory limits and PLs, along with how PLs are calculated.
- Statistical analyses including trend analysis and summary statistics for surface and groundwater should be included in FYRs.
- Little regulatory guidance is available for detection monitoring programs with a sampling frequency less than annual. For this reason, periodic trend and statistical analysis of monitoring data will provide lines of evidence when negotiating reduced sampling frequency.

Recommendations specific to BCR are:

- Site-specific background threshold values (BTVs) should be developed for groundwater and surface water. The PL method conducted for EMFR is suitable for BCR.

- Background levels of metals in tailings below the repository should be estimated based on historical sampling data. Background in the tailings can be compared with estimates of concentrations of COCs in the waste material from the BPRP program to distinguish likely potential source areas for contamination migrating to groundwater.
- A semi-annual monitoring frequency is recommended for BCR for the near term.
- An annual monitoring frequency is recommended for BCR during the initial post-closure period (five years post-closure). In the future, a reduced monitoring frequency (e.g. every five years) may be appropriate for post-closure monitoring.
- No additional sampling locations are recommended for BCR during the post-closure period. One upgradient sampling location (either 01-SR-MW-06 or 01-SR-MW-07) is sufficient for post-closure monitoring of both groundwater elevation and water quality.

Recommendations specific to EMFR are:

- Two additional groundwater monitoring locations are recommended to characterize spatial variability and flow regimes in the area of the EMFR. The wells should be screened in the upper aquifer. One additional well is recommended north of MW-C near the transition from the sand and gravel to the sand and clay zones. The second location is recommended south of I-90, west of the repository and northwest of well MW-F to assess the flow path toward the river.

- Sampling at EMFR should continue on a semi-annual basis. Decision logic for transitioning to annual sampling may include collection of sufficient data at new wells to develop PLs; stable or no trend concentrations for all priority COCs and stable condition of the physical structure of the repository.

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NOTICE AND DISCLAIMER

Work described herein, including preparation of this report, was performed by HydroGeoLogic, Inc. (HGL) for the U.S. Environmental Protection Agency (EPA) under Task Order 0066 of EPA contract EP-S7-05-05 with HGL. The report was approved for release as an EPA document, following the Agency's administrative and expert review process.

This optimization review is an independent study funded by EPA that focuses on evaluation of existing data, discussion of the conceptual site model (CSM), and analysis of remedy performance with the overall goal of providing suggestions for improving protectiveness, and reducing operation and management costs at the Bunker Hill Mining and Metallurgical Complex Superfund Site (BHSS). Detailed consideration of EPA policy was not part of the scope of work for this review. This report does not impose legally binding requirements, confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Recommendations are based on an independent evaluation of existing Site information, represent the technical views of the optimization review team, and are intended to help the Site team identify opportunities for improvements in the current Site remediation strategy and operation and maintenance plan. These recommendations do not constitute requirements for future action; rather, they are provided for consideration by the EPA Region and other Site stakeholders.

While certain recommendations may provide specific details to consider during implementation, these are not meant to supersede other, more comprehensive planning documents such as work plans, sampling plans and Quality Assurance Project Plans (QAPPS), nor are they intended to override Applicable or Relevant and Appropriate Requirements (ARARs). Further analysis of recommendations, including review of EPA policy, may be needed before implementation.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization practices from site assessment to site completion implemented by the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI)[1]. The project contacts are as follows:

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[1] EPA, 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
Al	aluminum
Ag	silver
amsl	above mean sea level
AOC	Area of Contamination
ARAR	Applicable or Relevant and Appropriate Requirement
As	arsenic
AWQC	EPA Ambient Water Quality Criteria
BCR	Big Creek Repository
BCRA	Big Creek Repository Annex
bgs	below ground surface
BHSS	Bunker Hill Mining and Metallurgical Complex Superfund Site
BPRP	Basin Property Remediation Program
BTV	background threshold value
ccy	compact cubic yards
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CdA	Coeur d'Alene
Cd	cadmium
COC	contaminant of concern
COEC	contamination of ecological concern
CRQL	contract required quantitation limit
CSM	conceptual site model
Cu	copper
CV	coefficient of variation
cy	cubic yards
DO	dissolved oxygen
DQR	Double Quantitation Rule
EMFR	East Mission Flats Repository
EMP	Enhanced Monitoring Plan
EPA	U.S. Environmental Protection Agency
ERT	EPA Emergency Response Team
Fe	iron
ft	feet
ft/d	feet per day
ft/yr	feet per year
FYR	Five-Year Review
H	horizontal
Hg	mercury
HGL	HydroGeoLogic, Inc.
HQ	EPA Headquarters
I-90	Interstate 90
IC	institutional control

ICP	Institutional Controls Program
IDEQ	Idaho Department of Environmental Quality
IROD	Interim Record of Decision
K	hydraulic conductivity
LCL	lower confidence limit
LTMO	long-term monitoring optimization
MCL	Maximum Contaminant Level
MDL	method detection limit
Mn	manganese
NPL	National Priorities List
OIG	EPA Office of Inspector General
OLEM	Office of Land and Emergency Management
O&M	operation and maintenance
ORD	EPA Office of Research and Development
ORP	oxidation-reduction potential
OU	operable unit
Pb	lead
PL	prediction limit
QAPP	Quality Assurance Project Plan
R10	EPA Region 10
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
Sb	antimony
SC	specific conductance
SFCDR	South Fork Coeur d'Alene River
SPLP	synthetic precipitation leaching procedure
SWFP	site-wide false positive
SWPP	storm water pollution prevention
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
V	vertical
WAC	Waste Acceptance Criteria
Zn	zinc

1.0 OBJECTIVES OF THE OPTIMIZATION REVIEW

1.1 OPTIMIZATION BACKGROUND

For more than a decade, the Office of Superfund Remediation and Technology Innovation (OSRTI) has provided technical support to the U.S. Environmental Protection Agency (EPA) regional offices by using independent (third party) optimization reviews at Superfund sites. The Bunker Hill Mining and Metallurgical Complex Site (BHSS) (CERCLIS identification number IDD048340921) is located in the Coeur d'Alene (CdA) Basin, Shoshone and Kootenay County, Idaho, EPA Region 10 (R10). Two long-term, low-level, waste repositories within the Site were nominated for an optimization review by EPA R10 Remedial Project Managers (RPMs) in January 2016.

The BHSS includes mining-affected surface water, soils, sediments, tailings piles and groundwater along 166 river miles in the CdA Basin. BHSS was added to the National Priorities List (NPL) in 1983. The Site is managed as three operable units (OUs). OU1 includes populated areas of what is called the 'Bunker Hill Box', a 7 by 3-mile area where large-scale, historical ore-processing and smelting operations were located. OU2 includes the non-populated areas of the Bunker Hill Box. OU3 includes the broader area outside of the Bunker Hill Box along the Coeur d'Alene River (CdA River) and South Fork Coeur d'Alene River (SFCDR), Coeur d'Alene Lake and associated tributaries and flood plains.

As part of remedial efforts across the BHSS, contaminated soils and sediments have been removed from areas of potential human or ecological exposure and deposited in repositories designed for long-term, safe storage of contaminated solids. The goal of the following review is to support development of effective long-term monitoring at two large-scale, low-level, soil-waste repositories in OU3 of the Bunker Hill Site.

1.2 REGULATORY BACKGROUND ON REPOSITORIES

The Bunker Hill Site remediation is managed by EPA R10 in cooperation with the Idaho Department of Environmental Quality (IDEQ), tribal stakeholders, and the Successor Coeur d'Alene Custodial and Work Trust (CdA Trust).

The 2002 Record of Decision (ROD) for OU3 as well as the 2012 Interim ROD (IROD) selected construction of repositories as a remedial component to address low-level, metals-affected soils and sediments in areas of potential human contact. Repositories were selected to contain "*soils, house dust, debris, alluvial and fluvial soils and sediment contaminated by mining extraction and beneficiation waste released from historic mining facilities in the CdA Basin*" (USEPA 2002). The repositories are not intended to contain principal threat wastes such as metal concentrates without further treatment. Waste sources and quantities to be added to the repositories have been forecast based on the interim OU3 ROD requirements and the Basin Institutional Controls Program (ICP).

Based on the 2002 ROD, the remedial objectives of the repositories are to:

- Prevent adverse human health or ecological impacts and result in improvements wherever possible;
- Prevent additional groundwater and/or surface water impacts;
- Integrate with past or nearby cleanup efforts;
- Comply with all ARARs;
- Be appropriate for the characteristics of the waste that will be disposed of there;
- Be cost-effective;

- Minimize long-term operation and maintenance (O&M) costs.

The Big Creek Repository (BCR) and the East Mission Flats Repository (EMFR), as well as other repositories, were designed to address the ROD requirements and are located within OU3 according to guidance provided in the ROD. Both the BCR and EMFR are actively accepting waste material; however, the BCR is close to capacity and will require a monitoring strategy for long-term, post-closure care. An additional repository, the Big Creek Repository Annex (BCRA) is being constructed across Big Creek from the existing BCR.

The ROD specifies that all repositories will be subject to monitoring (if necessary) to ensure the integrity of the remedy. In addition, the ROD identifies federal and state requirements that are applicable or relevant and appropriate to repository design and operation. The Idaho Solid Waste Management Rules (IDAPA 58.01.05) explicitly do not apply to "waste dumps . . . tailings and other materials uniquely associated with mineral extraction, beneficiation or processing operation" and thus are not applicable. However, the ROD specifies that the Tier II non-municipal solid waste landfill requirements are relevant and appropriate to the design, operation, and closure of the repositories necessary for implementation of the selected remedy. Tier II facilities are not required to install groundwater monitoring wells.

The ROD goes on to specify that sections of the Tier III non-municipal, solid waste landfill requirements that are relevant and appropriate for discrete remedial actions may be identified through the remedial design process. During design, the Tier III non-municipal solid waste landfill requirement to install and maintain groundwater monitoring wells at the point of compliance was determined to be relevant and appropriate. The Tier III requirement specifies quarterly monitoring unless otherwise directed by the state and continued groundwater monitoring for five years following the repository closure.

The BCR and EMFR were constructed on top of previously contaminated sediments. Because the repositories are located on contaminated property and because they contain, but do not treat waste material, they are both a remedy under the OU3 ROD and potential sources of metals leaching to surface and groundwater. For this reason, repository monitoring and data analysis must address multiple objectives. Monitoring data collected in the vicinity of the repositories may be used to evaluate remedy performance and protectiveness as well as support evaluations of BHSS-wide progress toward OU3 remedial goals for affected media. Future management of the repositories will include closure and long-term, post-closure monitoring of groundwater and surface water as well as maintenance of the structures, and monitoring institutional controls (ICs).

1.3 Scope and Objectives of the Optimization Review

The scope of the optimization study is to assess existing conditions at the repositories, and recommend cost-effective, long-term, monitoring strategies. While an evaluation of the structural integrity of the repositories is not a specific objective of this optimization effort, consideration has been given to data collection efforts that may support determinations of the mechanical safety of the repositories.

Specific objectives of this review are to evaluate conditions and operations at the BCR and the EMFR and to:

- Develop monitoring and data analysis and visualization strategies for assessing and communicating repository remedy performance, given potentially high levels of background metals contamination;
- Review the statistical approach to interpreting monitoring data;
- Identify additional analyses, tests or evaluation methods to assess surface and groundwater contamination, and identify analyses that may not be necessary;
- Recommend an optimized spatial and temporal monitoring strategy;
- Develop recommendations for post-closure monitoring at BCR.

This optimization review used existing environmental data to interpret the CSM, identify potential data gaps, and recommend improvements to monitoring the remedy. The optimization review team evaluated the quality of the existing data before using the data for these purposes. The evaluation for data quality included a review of how the data were collected, the Sampling and Analysis Plans (SAP) and the Site Quality Assurance Project Plans (QAPPs).

The following report is structured to provide background on the CSM, structure, operations, current monitoring strategy and key findings for each repository in Section 3 (BCR) and Section 4 (EMFR). Recommendations for both repositories are provided in Section 5, along with specific recommendations for each repository.

2.0 OPTIMIZATION REVIEW TEAM

The optimization review team consisted of the independent, third-party participants listed below. The optimization review team collaborated with representatives of EPA Headquarters (HQ), EPA Office of Research and Development (ORD) and EPA Region 10.

TABLE 1. Optimization Review Team

NAME	ORGANIZATION	TELEPHONE	EMAIL
Mindy Vanderford[1,2]	HydroGeoLogic, Inc.	713-838-7778	mvanderford@hgl.com

[1] *Participated in the phone conference of March 4, 2016*
[2] *Participated in phone conference of May 2, 2016*

The following individuals contributed to the optimization review process, including participation in conference calls with R10:

TABLE 2. Other Optimization Review Contributors

NAME	ORGANIZATION	TITLE/ROLE
Craig Cameron[1,2]	EPA R10	EPA R10 RPM
Kira Lynch[1,2]	EPA ORD	EPA ORD
Kirby Biggs[1,2]	EPA HQ	EPA HQ Optimization Lead
Gary Newhart[1]	EPA ERT	EPA Geotechnical/Geochemist
Rick Wilkin[2]	EPA ORD	EPA Geochemist
Don Carpenter[1,2]	IDEQ	IDEQ RPM

Notes:
[1] *Participated in the phone conference of March 4, 2016*
[2] *Participated in the phone conference of May 2, 2016*
R10 = EPA Region 10
RPM = Remedial Project Manager
HQ = EPA Headquarters
ORD = Office of Research and Development
ERT = Emergency Response Team
IDEQ = Idaho Department of Environmental Quality

Documents included in the optimization review effort are listed in Appendix A.

3.0 BIG CREEK REPOSITORY FINDINGS

3.1 WORKING CONCEPTUAL SITE MODEL

The BCR is located south of Interstate 90 and the SFCDR east of Kellogg, Idaho. The repository is located adjacent to Big Creek, a perennial stream, near its confluence with the SFCDR. From 1968 to 1979, the BCR site was part of the Sunshine Mine tailings ponds used for disposal of material generated from milling silver (Ag), lead (Pb), and zinc (Zn) ore. BCR is located north of the remaining Sunshine Mine tailings pond. Historically, Big Creek was diverted around tailings ponds so that the stream bed now runs both south and west of the repository, discharging to SFCDR north of the repository. A soil cover was placed over the mill tailings pond in 1979 and the location was used by Shoshone County through 2001 for disposal of small quantities rock, dirt and tree waste The BCR site is shown on Figure 1.

The former Sunshine tailings pond was selected as a location for a waste repository due to its availability, accessibility, lack of adjacent residential properties and community acceptance. Benefits of locating the repository on the former Sunshine pond site included flat terrain and a history of contamination. The presence of previously contaminated material under the repository, however, presents challenges in assessing potential future impacts of waste disposed of in the repository. As an Area of Contamination (AOC) within Bunker Hill OU3, the repository area is subject to remedial objectives described in OU3 RODs.

Table 3 lists a chronology of relevant BCR events.

TABLE 3. Big Creek Repository Site Chronology

Date	Action
1968 - 1979	Sunshine Mill Tailings Pond, Big Creek diverted around ponds
1979	Sunshine Mill Tailings Pond at Big Creek closed and covered with soil
1979 - 2001	BCR site used for disposal of small amounts of soil and vegetation
2001	USACE BCR Phase I Field Investigation -- Installation of groundwater wells and groundwater, soil and surface water sampling program and geotechnical investigations begin
2002	ROD for OU3
2002 - 2003	BCR receives waste soil from Basin Yards Program
2004	BCR site purchased by IDEQ, Repository final design and initiation of operation as a selected remedy
2005	Revised tailings stability analyses
2007	Design work to raise height of repository
2011	Footprint of BCR expanded north; BCR monitoring and quality assurance plan
2012	IROD for OU3
2014	BCR Fate and Transport Model Report

3.1.1 BCR Design, Construction and Operation

Between 2001 and 2004, groundwater and surface water samples were collected at the former Sunshine pond site by the U.S. Army Corps of Engineers (USACE) as part of a Phase I and II field investigations supporting BCR design (USACE 2004b). The final stability analysis, design and implementation of the repository was completed in 2004. Investigations included trenching, chemical sampling of soil, subsurface soil, surface water and groundwater, geotechnical testing of soils, topographic surveying, and debris inventory. The USACE Phase II (2004) report found that the shear strength of former pond materials was not high, but that creation of the repository was possible if waste materials were added using a slow and staged filling process. Slow loading was anticipated to consolidate lower material resulting long-term stability. Later stability assessments determined that the underlying tailings were more stable than originally estimated (Golder 2005, WGI 2007), but a protocol for careful, sequential application of waste materials was continued.

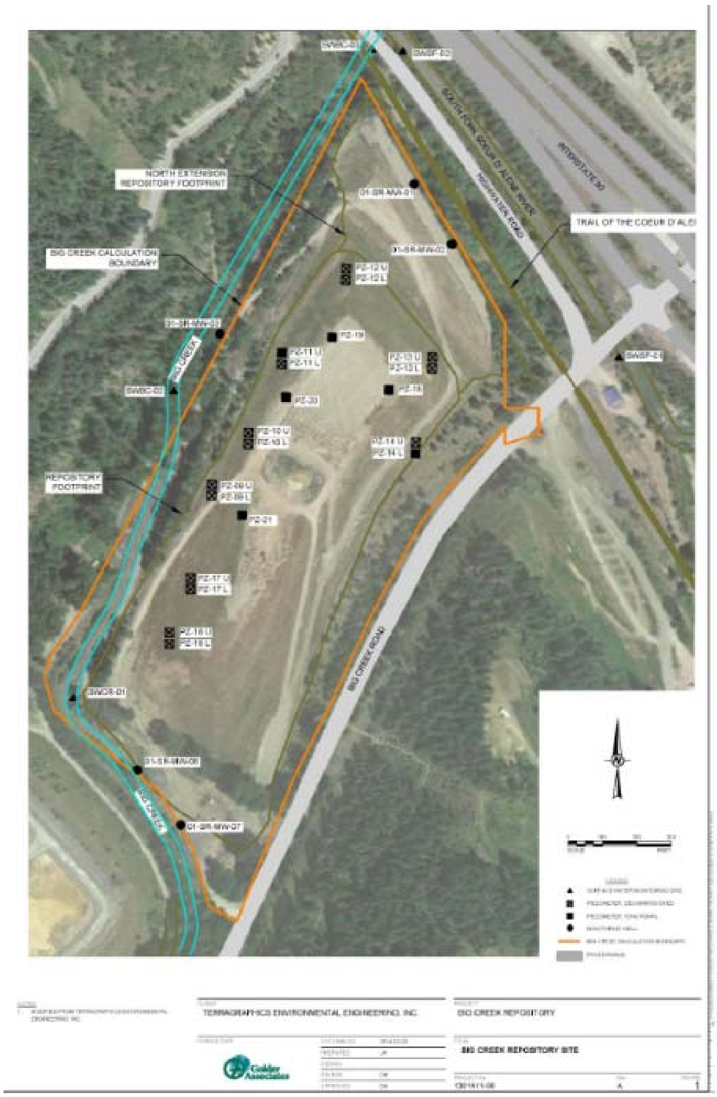

Figure 1: BCR Site Map and Monitoring Locations [Excerpted from Figure 1 (TerraGraphics 2014a). All figures reproduced full-scale in Appendix B]

The BCR was constructed on top of the capped former tailings pond east and north of Big Creek. A cross section of the BCR showing relative positions of the tailings, embankments, repository waste and existing monitoring wells is shown in Figure 2. The original design of the BCR estimated waste capacity of the repository of 250,000 cubic yards (cy) with an anticipated operating life of 10 years (USACE 2004a). During the initial design phase, the height of the repository was limited to 30 feet (ft) by overhead electrical transmission lines. Power lines limiting height were moved, and the capacity of the repository was increased by 40,0000 to 50,000 cy of waste and the maximum height was raised by 30 ft.

In 2011, the BCR was expanded to the north by 5.3 acres to increase capacity. The expansion added 126,000 cy waste capacity to the BCR. The final expansion design includes a sediment detention basin in the center of the repository, an evapotranspiration cover system and structures to limit erosion, an infiltration gallery and an updated storm water management system to prevent contaminated runoff.

The exterior slopes of the repository were originally designed to a ratio of 3 horizontal (H) to 1 vertical (V) unit and to contain 6 inches of clean soil to prevent contaminated runoff. The original design and modifications in the intervening years have taken measures to reduce surface water runoff from the repository.

The current operation of the repository is seasonal, with active waste placement taking place from about April through October each year. Maintenance and waste receipt preparations take place in the spring with waste placement and compaction occurring in the summer and fall. Waste soils delivered to the BCR are consolidated, segregated and blended, if necessary, at a staging point and then delivered to the top of the repository. Soils are placed in thin lifts using a dozer and compacted using a vibratory roller. Methods of dust suppression are employed at all stages of waste handling. During the 2015 field season, a calculated 21,644 compact cubic yards (ccy) of waste was added to the BCR.

Waste streams are generated by multiple contractors under the Basin Property Remediation Program (BPRP), ICP, Paved Roads program, and Remedy Protection program. These programs remove waste soil and sediment from populated areas or areas with potentially complete exposure pathways. Repository operators confirm that waste deliveries are compliant with Waste Acceptance Criteria (WAC) for composition, moisture and size, among other criteria (NorthWind 2015a). WAC include restrictions on the amount of moisture in the waste, size of rock or waste material, vegetative content, presence of scrap metal, wood or debris more suitable for a sanitary landfill. Waste liquids meeting disposal criteria are disposed directly to the storm water retention basin (NorthWind 2015a).

Since BCR has been in operation and receiving waste, more than 20,000 residential soil samples were analyzed through the BPRP. The BPRP data for sample locations requiring remediation should be representative of waste contained at BCR as this is the primary waste disposed of in the repository. Table 4 presents detailed BPRP lead and arsenic results.

The results of the historical BPRP sampling are consistent with the results of a 2015 study (MFA, 2015) that measured lead concentrations in the upper two feet of the BCR. Lead concentrations in six composite samples from 0 to 12 inches below the repository surface ranged from 1410 mg/kg to 2600 mg/kg. The lead concentration in four composite samples from 12 to 24 inches below the repository surface ranged from 1390 mg/kg to 2330 mg/kg.

TABLE 4. BPRP Arsenic and Lead Concentration Summary

Metal	**Number of Samples[a]**	**Min (mg/kg)**	**Max (mg/kg)**	**Arithmetic[b] Mean (mg/kg)**	**Standard Deviation (mg/kg)**	**Median (mg/kg)**
Arsenic	20,622	0.69	7,000	67	151	30.5
Lead	20,623	2	90,800	2,575	4,117	1,440

Notes:

Summary statistics based on data from the BPRP collected 2004 through 2011 from locations in the program requiring remediation

mg/kg = milligram per kilogram

Max = Maximum

Min = Minimum

[a]Number of samples collected from sample locations requiring remediation used to create summary statistics: 0–1, 1–6 and 6–12 inch samples were included but the 12–18 inch horizon were excluded for non-garden sample locations; 0–1, 1–6, 6–12, 12–18, 18–24 inch samples were included for garden sample locations. The higher of original/duplicate, original/split and original/resample pairs was used for calculations.

[b]Based on data from properties that were initially sampled between 2004 and 2011. Assumes: (1) all sample locations sampled 2004–2011 that require remediation have been remediated and the remediated material was sent to a repository; (2) all sample locations requiring remediation (except gardens) were remediated to 12 inches (some actually may have been remediated to 6 inches, meaning 6 to12 inches of material included in this analysis may not have actually gone to the repository); and (3) garden sample locations requiring remediation were remediated to 24 inches.

The original tailings pond underlying BCR was constructed in 1968 and had a footprint of approximately 22 acres with about 14 acres of interior pond space. The depth of tailings at the time of the Phase II investigation (2004) was 48 ft at the center of the pond to the contact between the tailings and native soil (approximately 2410 ft amsl). The pond was excavated about 14 ft below the level of the bottom of Big Creek (approximately 2424 ft amsl). Tailings dam embankments were constructed between 10 to 40 ft with the slope ratio 1.4 H to 1 V. Embankments were composed of gravel, cobbles and sand, and appear to rest on a foundation of silt and organic material with native soil beneath the pond. Historical boreholes suggest the embankment contains pockets of black sludge that may be antimony (Sb) waste.

The tailings pond dam was raised 10 ft in 1973 using angular mine waste. Seepage was observed at the tailings dam and bentonite was placed in the pond in an unsuccessful effort to prevent leakage. The pond was removed from service in 1979 and covered with embankment material and native alluvial soils. In 1997, the west embankment was damaged during flooding and, subsequently, repaired. It was observed that the embankment is composed of loose, fine, gravel with sand and silt and may be a structural weak point. Two decant lines mentioned in historical documents were investigated during the Phase II program. One line was found grouted and abandoned. The second line was never found. It is assumed both of these lines were grouted.

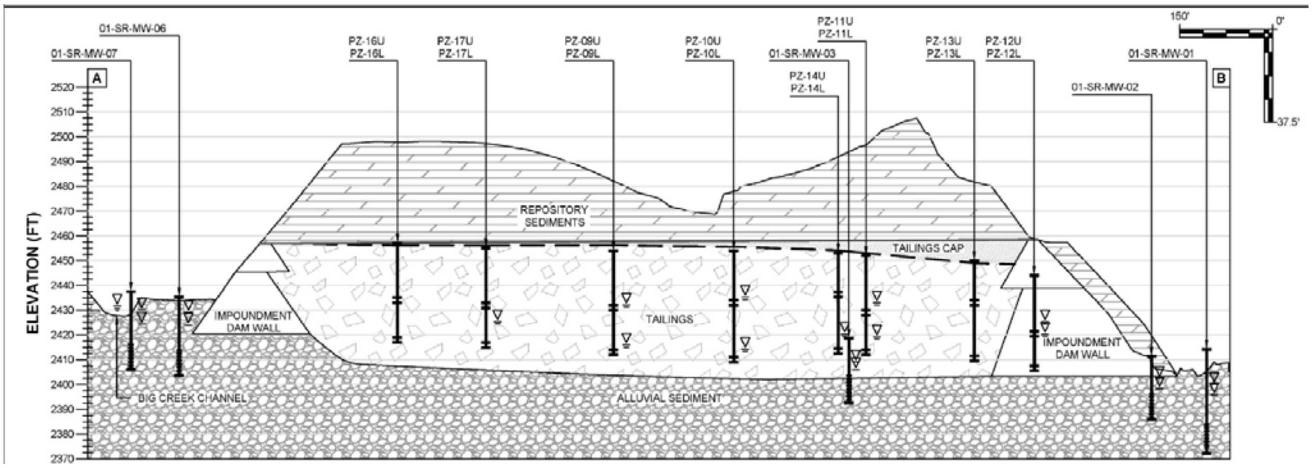

Figure 2: Big Creek Repository Cross-Section [Excerpted from Figure 2 (IDEQ 2015a). All figures reproduced full-scale in Appendix B]

3.1.2 Constituents of Concern

Constituents of concern (COCs) relevant to human health exposure pathways for the site are Sb, arsenic (As), cadmium (Cd), Pb, and Zn in groundwater and As, Cd, Pb, manganese (Mn), and mercury (Hg) in surface water. Constituents of environmental concern (COECs) in surface water monitored for ecological health are Cd, copper (Cu), Pb, and Zn in surface water. Site groundwater is not used as a drinking water supply, so the only current potentially complete exposure pathway is discharge of contaminated groundwater to surface water and subsequent ecological or human exposures.

During the Phase I investigation (USACE 2002), tailings, soils, groundwater and surface water were analyzed for metal COCs. Concentrations of Sb have exceeded screening levels historically in Big Creek and in the SFCDR downstream from the confluence of Big Creek and SFCDR. Data indicated that Pb levels in tailings were below screening levels, but As was high in most samples. Synthetic precipitation leaching procedure (SPLP) of tailings indicated low mobility of most metals with the exception of Mn in some samples. Surface soil samples indicated some exceedances for both As and Pb. Groundwater sampling during the Phase I investigation showed ARAR exceedances for As, Cd, Sb, iron (Fe), Pb and Mn.

Regulatory thresholds for groundwater have been identified as the National Primary Drinking Water Maximum Contaminant Levels (MCLs) for As, Cd, Pb, and Sb and the Secondary MCL for Zn. Regulatory thresholds for surface water are the Idaho Ambient Water Quality Criteria (AWQC) for As, Cd, Cu, Pb, Sb and Zn. AWQC for Cd, Cu, Pb and Zn are calculated based on water hardness. No AWQC are established for Hg and Mn, so thresholds are set at the EPA MCLs for drinking water.

Total dissolved metals concentrations from the BCR monitoring program are compared against the regulatory thresholds. Specific, risk-based, groundwater quality standards for protection of ecological receptors exposed through groundwater discharge to surface water are not identified in the SAP.

3.1.3 Hydrology, Hydrogeology and Geology

The BCR is located south of the mouth of Big Creek where it discharges to SFCDR. The Big Creek valley has a flat bottom and is filled with moderately rounded coarse to fine-grained gravel alluvium, which contains cobbles, sand and silt. The valley walls are steep and rise several hundred feet in elevation above the valley bottom. Total precipitation in the area is estimated to be about 32 inches per year (both rain and snow). Big Creek drains an area of approximately 30 square miles including areas of historical mining activities. The stream channel of Big Creek was modified significantly during historical mining and pond operations.

The designated beneficial uses of Big Creek include cold water aquatic life, salmonid spawning, secondary contact recreation, agricultural, industrial water supply, wildlife habitat, and aesthetics. Big Creek is a losing stream (discharging to groundwater) at the southern end of the BCR and gaining along the western edge of the site before it discharges to SFCDR.

Tailings from historical milling activities consist of fine sand to silt-size particles that are underlain by a thin soil horizon and native alluvium consisting primarily of gravel and cobbles with sand. Grain size in the tailings pond area decreases from south to north (consistent with the former pond inflow point to the south). At the time of decommissioning, the former tailings pond was capped with native alluvium excavated to form the adjacent, new, Sunshine tailings pond (USACE 2004b). The south and west tailings pond embankment is within the Big Creek 100-year flood plain.

Native material underlying the BCR as well as Big Creek is alluvial sediment over fractured bedrock. Groundwater occurs in both the alluvium and bedrock aquifers and in the tailings. Groundwater in the alluvium is unconfined and in contact with Big Creek. Within the pond tailings sediments there are upper perched and lower water table saturated zones. During the USACE investigations, groundwater was found to be mounded and perched on lenses of fine sediments within the tailings in the west and north sections of the repository with depth to groundwater 16 ft below the base of the repository material in the tailings.

The more extensive lower groundwater unit in the tailings is present across the entire repository and is found at 35 ft below the base at the south end and approximately 15 ft above the alluvial aquifer at the northwest end of the BCR. Because of the depth of the original tailings pond excavation, this unit is below the channel of Big Creek and is in contact with the alluvial aquifer. Groundwater elevations are 2,430 feet above mean sea level (ft amsl) upgradient in the south repository area to 2,400 ft amsl in the north. Groundwater gradients are to the north, toward the SFCDR. Groundwater seeps were not observed at the BCR during recent investigations, but were observed historically, during operation of the tailings pond.

3.1.4 Geochemistry

The mobility of metals at BCR is controlled, in large part, by elemental chemical characteristics and metal complexation resulting from the local geochemical environment. For the purpose of evaluating mobility, metals can be grouped according to basic chemical characteristics, with Cd, Zn, Cu and Pb in one group and As and Sb in another. The complexity of Hg reactions places it in a unique category. As a general rule, Cd, Zn and Cu will be more mobile in the dissolved phase while Pb and Hg tend to be particle or colloid-associated.

Metal mobility is largely determined by complexation reactions that include 1) metals associated with iron (hydr)oxides and 2) metals associated with sulfides, or 3) other complexes and organic/inorganic interactions. The complexation state of the metals with iron hydroxides and sulfides can affect the solubility, leachability and solid partitioning tendencies of the metals. Given this framework, the main factors affecting metals mobility are pH, oxidation/reduction (redox) conditions, concentration of potential complexing agents, and methylation/demethylation reactions. Therefore, prediction of metals mobility requires data on the pH, oxidation/reduction potential (ORP) and major ion groups in water and how they vary with time.

BCR is somewhat unusual in that Sb is a COC. In general, the solution chemistry of Sb is not well understood, but should be similar to As. Sb belongs to Group 15 of the periodic table of the elements along with nitrogen, phosphorous, As, and bismuth. In groundwater, Sb exists in two oxidation states (+3 and +5), similar to arsenic. As and Sb can become significantly more mobile under anaerobic conditions. The mobility of Sb is generally considered to be limited by secondary mineral precipitation and partitioning to clay minerals and metal (hydr)oxides of aluminum (Al), Fe, and Mn (Filella, Belzile et al. 2002). Solubility constraints of Sb-oxides and adsorption to solids limit the potential mobility of Sb in most groundwater environments; however, there are uncertainties about the behavior of this element in anoxic environments which could trigger mobilization. In ore deposits, Sb typically exists as a sulfide mineral such as stibnite (Sb_2S_3) or as a sulfosalt like tetrahedrite ($Cu_{12}Sb_4S_{13}$).

At BCR, variability in groundwater concentrations of As and Sb are likely related to varying redox conditions within the tailings.

Based on the documents reviewed, the specific range of chemical associations of the metal COCs at BCR, including complexation and sorption characteristics, are not thoroughly understood.

3.1.5 Potential Contaminant Fate and Transport

The USACE Design Analysis Report (USACE 2004a) identified two critical fate and transport issues for the BCR:

- The potential for repository waste to increase existing contaminant concentrations in groundwater, and
- The potential for groundwater impacted by the repository waste to discharge to Big Creek.

In terms of BCR remedy performance, the primary contaminant fate pathways of concern at the BCR are leaching of metals to groundwater by infiltration or precipitation through waste placed on top of the tailings and runoff or potential erosion of repository materials to surface water.

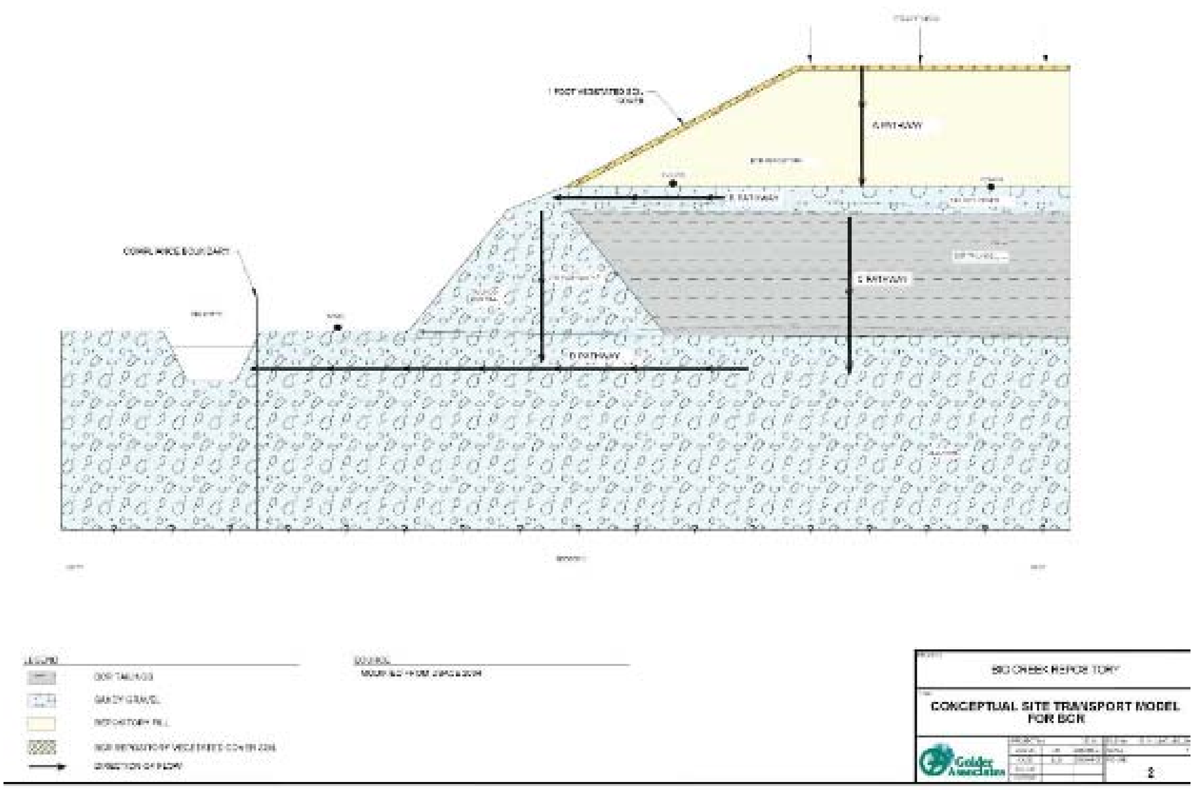

Figure 3: BCR Fate and Transport Model [Excerpted from Figure 2 (TerraGraphics 2014a). All figures reproduced full-scale in Appendix B]

A fate and transport model was created for the BCR (TerraGraphics 2014a) simulating likely transport pathways for contaminants after closure of the repository with the addition of a one-foot vegetative cover. The model was run with conservative (ten times maximum measured waste leachate concentrations) as well as less conservative (maximum measured waste leachate concentrations) input values to account for uncertainties associated with current and future geochemical conditions. The modeling did not include geochemical modeling to predict metals mobility.

The primary pathway modeled was precipitation water migrating through the repository waste material mobilizing COCs with flow vertically through the tailings layer to the alluvial aquifer (pathway A-C-D in Figure 3). Accumulation of meteoric water on top of the tailings layer and horizontal flow through the repository wall and downward into the alluvial aquifer (A-B-B2-D) was determined to be a less likely fate pathway. The model was used to predict leaching rates and potential increases in concentrations above existing contamination in groundwater and Big Creek at a presumed western compliance boundary (the top 20 ft of the alluvial aquifer approximately 300 ft north and west of the repository).

Results of the modeling effort indicate that none of the metals modeled will leach into groundwater at concentrations in excess of remedial goals any time within the next several hundred years, given the most conservative input parameters. For surface water, only arsenic may be mobilized to Big Creek in slight excess of the remedial goal based on the most conservative input parameters. For less conservative input parameters (e.g. measured maxima), there were no scenarios that produced an exceedance. Overall, modeling results predict that leaching from waste material or the underlying tailings will not significantly impact surface or groundwater.

The model results have not been confirmed (or refuted) by site data in the intervening years. The BCR-specific fate and transport of metals under the highly variable hydrologic and geochemical conditions is a potential data gap in the CSM. Geochemical modeling may reduce uncertainty in interpretation of the results of the fate and transport model.

3.2 BCR MONITORING PROGRAM

3.2.1 Goals and Objectives of Monitoring Program

The goal of surface and groundwater monitoring in the vicinity of the BCR is to demonstrate that the repository design, engineering and maintenance are effective at preventing repository waste from adversely impacting groundwater and surface water quality. The BCR monitoring program is described in the *Sampling and Analysis Plan /Quality Assurance Project Plan for Groundwater and Surface Water Monitoring at the Big Creek Repository Revision No. 5* (TerraGraphics 2011).

The SAP identifies the following specific objectives for surface and groundwater monitoring: 1) evaluate the groundwater hydraulic gradient and flow direction, 2) monitor water levels within the BCR repository waste and 3) evaluate and manage potential effects of the repository on groundwater and nearby surface water quality.

It is unclear if groundwater elevation or water quality measurements are also used to assess the stability and mechanical integrity of the engineered repository or if they are used in repository management decisions. Monitoring to evaluate the mechanical stability of the repository structure is not described in the SAP, nor is it fully described in Annual Operations Reports (NorthWind 2015a). Additional descriptions of how groundwater elevations relate to overall repository maintenance may be described in the site Storm Water Pollution Prevention plan (SWPP), which was not reviewed.

Potential additional monitoring objectives for the BCR may include providing data for assessing Basin-Wide progress toward surface and groundwater cleanup goals. BCR data may be used to evaluate cumulative impacts of both the historical contamination as well as repository maintenance on surface and groundwater relative to Site-wide ARARs.

3.2.2 Monitoring Locations and Frequency

Repository monitoring is currently performed on a quarterly basis, with target sampling months February, May, August and November. The quarterly monitoring frequency addresses the objective of assessing hydrogeologic conditions and metals concentrations in response to seasonal hydrologic fluctuations and is consistent with state and federal guidance on monitoring waste disposal facilities. The monitoring network includes:

- Five groundwater monitoring wells screened in the alluvial aquifer;
- Five surface water sampling locations, and
- At least one piezometer installed in the tailings zone (Note: Seven piezometers installed in the tailings with continuous automated water-level data loggers are described in the SAP. Most appear to have been decommissioned as repository waste was added to the surface).

The five groundwater wells screened in the alluvium outside of the known tailings are gauged for groundwater elevation and sampled for dissolved metals and water quality parameters. Analytes measured in groundwater are As, Cd, Pb, Sb, and Zn along with physical parameters pH, temperature, specific conductance (SC), dissolved oxygen (DO) and ORP.

Two of the alluvial zone monitoring wells are located upgradient (south) of the repository, while one is located cross-gradient to the west near Big Creek. Two other wells are located downgradient of the repository (north) closer to the SFCDR.

Surface water samples are collected from three locations along Big Creek and two locations in the SFCDR. Surface water analytes are As, Cd, Cu, Hg, Mn, Pb, Sb, and Zn as well as physical parameters (e.g. temperature, pH) and hardness/alkalinity constituents to support calculation of site-specific AWQC. The three sampling locations in Big Creek are upgradient and cross-gradient of the repository and near the point of discharge to SFCDR. The SFCDR is sampled upgradient and downgradient of the Big Creek discharge point.

3.2.3 Data Analysis

Groundwater elevations are used to construct potentiometric surface maps to confirm flow direction and gradients. Elevation data are compared with previous sampling events to quantify variability in flow characteristics in the vicinity of the repository.

Analytical data from individual sampling locations are compared against regulatory thresholds identified for surface or groundwater (see Section 3.1.2) as well as historical maximum concentrations. The detection frequency and number of detections above thresholds are tabulated for each location. Based on reports reviewed, there are no identified concentration results which would trigger contingent actions Time-series data are analyzed for overall trends using non-parametric statistical methods as well as for potential seasonal trends. Both increasing and decreasing trends in metals are identified. Potential contingent actions resulting from trend results are not identified in supporting documentation.

Field parameters are evaluated for quality control purposes, but are not integrated into a formal geochemical evaluation.

3.2.4 Dataset for Determination of Background

During the ACOE investigations, surface and groundwater were analyzed for COCs/COECs. Groundwater data were collected from six monitoring wells, one piezometer and three surface water locations in Big Creek between 2001 and 2004, before repository activities were initiated. The BCR dataset includes six to seven sample results taken prior to construction of the repository.

The SAP and other documents reviewed do not include estimates of background concentrations of metals at the BCR. Background concentrations developed from data 2001 to 2004 would represent both natural and anthropogenic sources of metals present prior to addition of repository waste. Comparisons of sampling results to a representative background threshold value (BTV) would indicate potential contributions of metals from repository waste or management activities. To date, background concentrations have not been developed or used in the BCR monitoring program.

3.3 UNCERTAINTIES AND DATA GAPS

The following uncertainties and data gaps in the CSM were identified for the BCR:

- Accurate estimates of background (pre-repository) COC concentrations of metals in tailings, groundwater and surface water have not been developed due to a limited spatial and temporal dataset;
- Statistical estimates of background concentrations of COCs in tailings have not been developed. Statistical background values can be compared with concentrations in waste to accurately assess probable sources in the event of exceedances in surface or groundwater.
- Chemical form (complexation) of metals in waste material placed in the repository were not included in materials reviewed for this evaluation.

- The solid-phase association and complexation of metals is a source of uncertainty in predicting the leachability, reactivity and mobility of metals in both waste and tailings;
- Criteria protective of surface water for groundwater discharging to Big Creek have not been established;
- Site conditions (e.g. mechanical stability) or concentrations of COCs that would trigger contingent remedial response are not identified.

4.0 EAST MISSION FLATS REPOSITORY FINDINGS

4.1 WORKING CONCEPTUAL SITE MODEL

Like the BCR, the EMFR was designed and constructed to address the remedies selected in the 2002 ROD and 2012 IROD for OU3. The EMFR is located 1,500 feet north of the CdA River, immediately north of Interstate 90 (I-90), and about two miles west of the town of Cataldo, Idaho. The EMFR is located on a 23-acre parcel that was historically impacted by fluvial deposition of mining-waste contaminated sediments. As such, it is located within the OU3 AOC and is included in long-term efforts to remediate historical metals releases. Private property is located to the north and northwest of the repository. The Old Mission State Park is across I-90 about ¼ mile southwest of the repository.

The EMFR was developed to support the ICP and has been accepting wastes from the Lower CdA Basin since 2009. The specific location was selected, in part, due to accessibility, levelness of the terrain and the presence of existing contamination. As with the BCR, the presence of contamination in the vicinity of the repository creates challenges in monitoring the impact of the repository itself on surface and groundwater. The design of the repository included technical approaches anticipated to be protective of groundwater quality beneath the site.

About 200,000 cy of contaminated soil has been placed in the EMFR since August 2009. An estimated 416,000 cy of waste material is anticipated to be disposed of at the site. Table 5 lists a chronology of relevant EMFR events. The site area of the EMFR is illustrated on Figure 4.

TABLE 5. East Mission Flats Repository Site Chronology

Date	Action
2002	ROD for OU3
2006	IDEQ buys property that will be site of EMFR
2007	EMFR monitoring and design work begins
2009	EMFR EPA Office of Inspector General (OIG) Report, EMFR 90% Design Report; Enhanced Monitoring Plan (EMP); Waste disposal begins at EMFR
2012	Interim ROD for OU3
2014	SAP/QAPP for EMFR monitoring program; EMFR Fate and Transport Model
2015	Prediction limits (PL) developed for EMFR groundwater constituents

4.1.1 EMFR Design, Construction and Operation

The EMFR is situated in the CdA River floodplain at the base of bedrock outcrops in a flat area prone to seasonal flooding. Mine waste-impacted sediments transported by the CdA River were deposited in the area, historically, and a dredge-spoil disposal site is located west of the repository footprint. There is no history of disposal of dredge spoils directly on the repository property. However, metals concentrations in the shallow (0- 4 ft bgs) fluvial sediments predating the repository were 114 mg/Kg As, 20 mg/Kg Cd, 8,700 mg/Kg Pb, and 2800 mg/Kg Zn (Golder 2014), indicating contaminated conditions. Deposition of contaminated sediments on repository property are likely a result of periodic flooding and transport of affected sediments from the CdA River. Native soil below 4 ft bgs does not indicate mining waste impacts. The potential mobility of metals in the fluvial sediments deposited before construction of the repository is a source of uncertainty in the CSM.

The EMFR repository footprint was originally estimated to cover about 14 acres in a roughly triangular shape (TerraGraphics 2009a). The design volume of the repository is 445,000 cy of waste including a proposed clean cover of 30,000 cy. Due to public concerns for aesthetics, the height of the repository will not exceed 2,165 ft amsl to reduce visual impact.

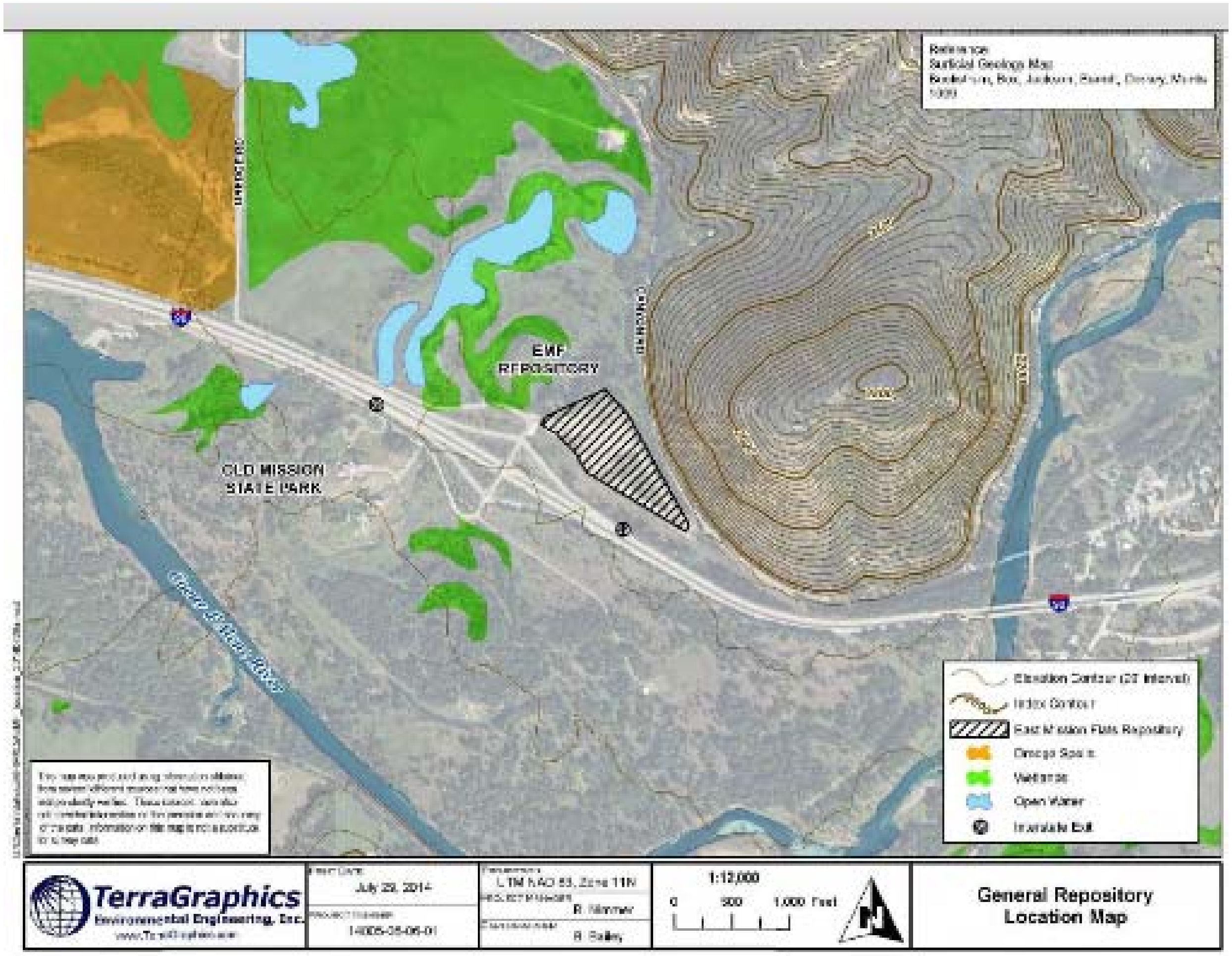

Figure 4: EMFR Site Area [Excerpted from Figure 1(IDEQ 2015b). All figures reproduced full-scale in Appendix B]

Perimeter slopes are composed of waste material at a 3H:1V ratio to reduce the amount of time precipitation runoff is in contact with perimeter material. A protective layer is installed over the perimeter waste material with a minimum of 21 inches of clean material placed prior to seasonal closure each year. Design of the EMFR required accommodations for flooding conditions, notably flood-induced erosion and transport of waste materials and potential infiltration of floodwater. The original base elevation of the site is 2,135 ft amsl while the 100-year flood elevation is 2,148.5 ft amsl, a 14 ft difference. Seasonal upward groundwater gradients have been observed in the area.

Storm water retention basins are constructed within the perimeter of the repository to prevent discharge of affected runoff. Because of the potential for flooding, an elevated area has been constructed to receive and process wastes to prevent inundation during wet seasons.

The current operation of the EMFR is similar to that described for BCR (see Section 3.1.1). Wastes consistent with the WAC are received from the BPRP and other ICP programs during the summer and fall and are placed, compacted and graded on top of the repository. Efforts are made to minimize wind transport of affected material. During the 2014 waste placement season, 20,310 ccy of waste was added to the repository (NorthWind 2015b). As is the case at BCR, waste material is not routinely sampled at the time of or after placement.

4.1.2 Constituents of Concern

COCs considered indicative of wastes in the EMFR are As, Cd, Pb, and Zn with Cu and Hg of secondary interest. Sb is not considered a COC at EMFR. Regulatory thresholds for metals in groundwater are MCLs for most metals with the Secondary MCL for Zn. COECs and ecologically protective concentrations have not been identified for the EMFR.

Sampling and monitoring activities began in 2007 in the EMFR area. These data established a baseline for groundwater flow and water quality as well as background concentrations before placement of repository waste.

4.1.3 Hydrology, Hydrogeology and Geology

The EMFR is located in the 100-year floodplain of the CdA River in an area that has experienced frequent inundation. The CdA River flows east to west around the East Mission Flats area and is present to the east, south and west of the EMFR. Flooding of the area has a 50% chance of occurring each year. The site is bordered on two sides by low-lying ground and permanent wetlands (see Figure 4). Wetlands to the northwest of the repository have been affected by redeposition of sediment. An estimated 6.6 million cy of metals-affected dredge spoil have been disposed of over the 130-acre Mine Owners Association site to the west of the repository (TerraGraphics 2009a). The EMFR is bordered to the east by a bedrock outcrop.

Locally, groundwater levels can rise to ground surface in response to high river stage and inundation events and flood waters can remain ponded adjacent to the repository for extended periods (days to weeks), potentially infiltrating into the waste repository. Groundwater levels are typically highest in the spring and lowest in the fall and closely track fluctuations in the CdA River stage. Site groundwater-surface water interactions are complex and their influence on geochemistry and metals mobility is an area of uncertainty in the CSM.

Hydraulic modeling to estimate flood elevations, extent of inundation, flow velocities and shear stresses was performed prior to construction of the repository (TerraGraphics 2009a). The design for the repository construction included elements to improve resilience to flooding as well as calculations confirming that the repository would not increase flood levels on adjacent properties.

A cross-section of the EMFR is shown on Figure 5. Hydrogeologic investigations indicate that there are several layers of unconsolidated deposits under the EMFR site:

- Shallow low-permeability silt and clay from ground surface (base of the repository) to about 15 to 20 ft bgs; the upper 4 ft depth contains contaminated fluvial deposits;
- An upper alluvial sand and gravel unconfined aquifer from 15 to 105 ft bgs; A sand and clay aquifer is found to the west/northwest of the repository site at the same depth;
- A clay/silt confining unit from 105 to 116 ft bgs, separating upper and lower coarse-grained units;
- A lower alluvial sand and gravel confined aquifer below 116 ft bgs.
- The alluvial sediments overly a sedimentary bedrock that outcrops in the area, notably to the east of the repository.

Shallow deposits (0- 4 ft bgs) at the site are composed of fine-grained silts and sands, thought to be derived from fluvial deposits, including mine tailings over the past 100 years. The thickness of the affected fluvial deposits and the magnitude of metals concentrations likely varies across the site. The upper silt/clay unit has low permeability and is thought to limit migration of repository leachate into the alluvial aquifer. Waste piled on the shallow deposits is anticipated to compact and depress the soil, further reducing hydraulic conductivity (K) of the material below the footprint of the repository.

Monitoring wells on site are screened in the upper alluvial unit, outside of the repository footprint, approximately 17 to 27 ft bgs in the more transmissive gravel and sand zones. Groundwater is encountered at 12 to 15 ft bgs. Groundwater in the upper sand and gravel aquifer is confined and typically has a downward vertical gradient. Horizontal gradients are typically shallow and are influenced by the stage of the river. The horizontal gradient varies seasonally from approximately 0.001 to 0.0006 ft/ft across the site (TerraGraphics 2009a).

Horizontal flow is, typically, across the site to the southwest, toward the CdA River. Monitoring data indicate that the horizontal gradient shifts to the west-northwest during flood events and vertical gradients can shift upward for short periods of time. Changes in river stage cause a rapid response in groundwater elevations at sand and gravel aquifer wells. This suggests that the sand and gravel aquifer likely extends to the CdA River which in turn likely contributes to aquifer recharge. Recharge to the aquifer is also thought to occur from the tributaries and wetlands to the north. Groundwater is thought to discharge to the CdA River, but variability in groundwater and surface water interactions may result in alternating gaining and loosing conditions. Details of surface and groundwater interactions and how they may influence mobility of metals in the area is a data gap in the CSM.

Flow within the sand and clay zone to the west of the repository site is not well characterized because only one monitoring well is completed in this unit. Water surface elevations are typically three to seven feet higher in the sand and clay aquifer when compared to the sand and gravel aquifer below the repository (Figure 6). The influence of the sand and clay aquifer on the geochemistry and flow direction in the sand and gravel aquifer is a source uncertainty in the EMFR CSM.

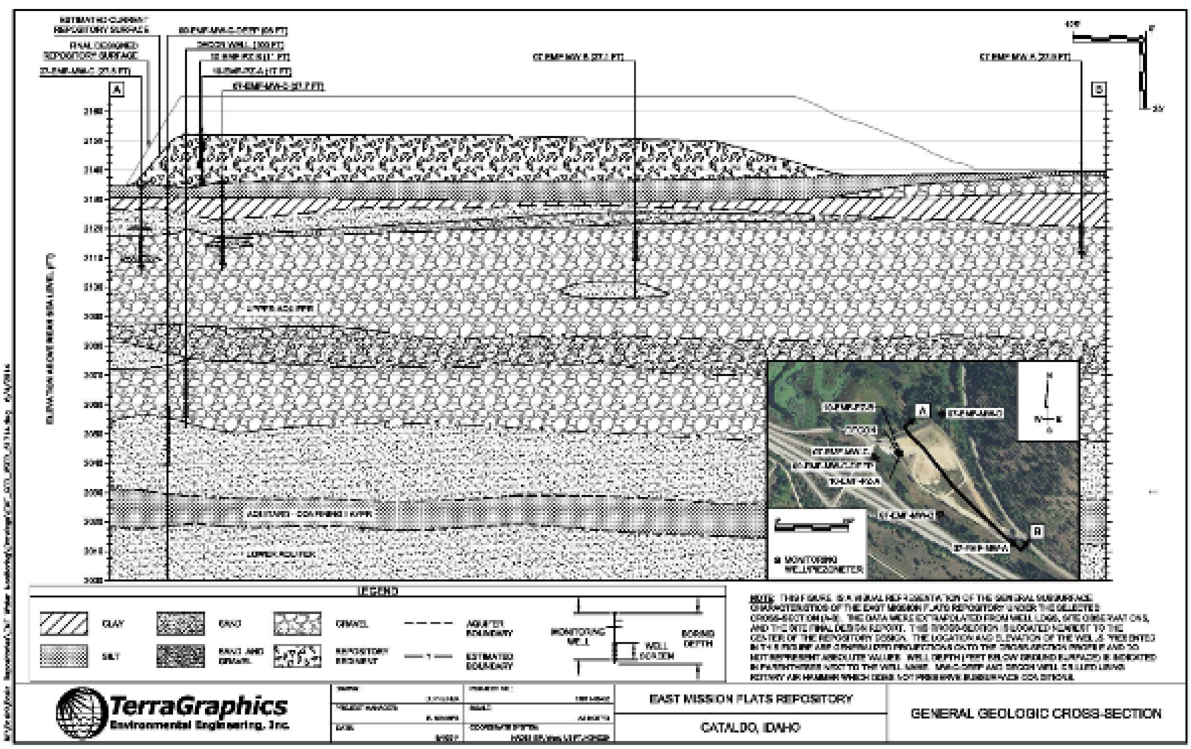

Figure 5: EMFR Cross section [Excerpted from Figure 2 (IDEQ 2015b). All figures reproduced full-scale in Appendix B]

4.1.4 Geochemistry

The general framework for metal chemistry and complexation discussed for BCR under Section 3.1.4 also applies to EMFR. However, groundwater geochemistry in the area of EMFR appears more complex.

Results for pH, SC and groundwater elevations indicate that the sand and clay zone to the west of the repository is distinct from the sand and gravel aquifer immediately below the repository. Field parameters indicate that the sand and clay unit has low DO and ORP, with higher concentrations of As likely resulting from reducing conditions. The sand and clay zone is closer to the dredge-spoil disposal site, and therefore, may be impacted by metals leaching from that area. The sand and gravel aquifer below the repository is more aerobic with lower concentrations of As. Historically, metal concentrations measured within the sand and gravel aquifer are below ARARs. It is unclear whether groundwater from the west intermittently mixes with groundwater below the EMFR, potentially causing changes in both geochemistry and metals concentrations.

Groundwater quality below the EMFR may be altered by a variety of site processes. Infiltration of meteoric water may increase dissolved oxygen, while stagnant water conditions or influx of natural organic matter may induce anaerobic conditions. Rising groundwater may change basic geochemistry within the waste. Waste materials (including organic matter) on top of the affected fluvial sediments may influence the mobility of metals within the sediments below the repository.

Spatial and temporal heterogeneity in geochemical conditions can complicate estimation of background levels of metals in underlying sediments and, ultimately, complicate assessment of the source (either repository wastes or underlying soils) of COCs in groundwater. Variable geochemical conditions combined with complex hydrogeology may contribute to potentially high variability in groundwater sampling results. The transient and long-term effects of geochemistry on the variability of metals concentrations is a source of uncertainty in the CSM.

4.1.5 Potential Contaminant Fate and Transport

The primary fate and transport mechanisms considered in the design of the EMFR were:

- Rainwater and snowmelt percolating through the emplaced waste and, potentially, leaching metals to surface and groundwater.
- Lateral infiltration and migration into the repository from ponded surface water and erosion due to floodwater;
- Upwelling of groundwater into repository waste due to seasonal fluctuations.

These pathways were evaluated in the 90% Design Report (TerraGraphics 2009a) Appendix Q).

The early design work evaluated the potential for lateral infiltration of ponded surface water and upwelling of groundwater into the repository waste. Results indicated that waste saturation due to these conditions would not be significant based on the low hydraulic conductivity of the compacted waste and the compacted silts and clays underlying the repository. With only minimal saturation of the repository materials, it was concluded that any residual water in the base of the repository would not pose a significant threat to groundwater quality. Erosion during flooding was also evaluated during the design. The potential for erosion from floodwater was mitigated during the design by armoring the repository side slopes to an elevation equivalent to the 100-year flood.

The potential for the repository waste to leach metals to groundwater and surface water was also evaluated during the initial design. Column test data indicated that leaching of metals from repository soil by precipitation and snowmelt percolating through the repository would not release any As, Cd, or Pb, and only very low concentrations of Sb and Zn. The repository soils pose minimal risk to groundwater quality. The column test data for the contaminated soils underlying the repository waste showed a greater potential for leaching metals to groundwater but not at levels that posed a risk to human health.

In addition to early design work, a fate and transport model has been developed for the EMFR to estimate risk from metals leaching (Golder 2014). The purpose of the modeling effort was to understand if repository contaminants could migrate to a designated compliance boundary at unacceptable concentrations after placement of a one-foot soil cover on EMFR after closure. The model considered transport by percolation of meteoric water through the waste and the shallow subsurface silts and clays to the alluvial sand and gravel aquifer. Conservative (ten times maximum measured waste leachate concentrations) as well as less conservative (maximum measured waste leachate concentrations) input values were used during the modeling to account for uncertainties in current and future geochemical conditions. Results of the modeling effort indicate that there would be no exceedances of ARARs at the model calculation boundary over the next several hundred years given the most conservative input parameters.

The model results have not been confirmed (or refuted) by site data in the intervening years. The EMFR-specific fate and transport of metals under the highly variable hydrologic and geochemical conditions is a potential data gap in the CSM. As with the BCR, geochemical modeling may reduce uncertainty in interpreting the results of the fate and transport model.

4.2 EMFR MONITORING PROGRAM

4.2.1 Goals and Objectives of Monitoring Program

The primary goal of the sampling and monitoring activities at the EMFR site is to demonstrate that waste disposal is not adversely impacting groundwater quality underneath the EMFR. The monitoring program for EMFR is described in the 2009 *Enhanced Monitoring Plan* (EMP) (TerraGraphics 2009b) and the 2014 *Sampling and Analysis Plan /Quality Assurance Project Plan for Water Monitoring at the East Mission Flats Repository Revision No. 2* (TerraGraphics 2014b). Prediction limits (PLs) for groundwater samples were developed in a 2015 white paper (TerraGraphics 2015a). Monitoring results are presented in annual reports summarizing data collection and interpretation efforts.

The development of an EMP (TerraGraphics 2009b) for the site was stimulated, in part, by an investigation by the OIG in response to community complaints about siting of the repository. The EMP is intended to address community concerns about discharge of metals from the repository to surface and groundwater. OIG recommendations included monitoring for saturation and pore water quality in the waste materials, evaluating vertical gradients between the shallow and deep water-bearing zones as well as interactions between the CdA River water and groundwater. The OIG also recommended evaluating statistical trends in groundwater quality parameters.

Monitoring objectives summarized in the annual reports (IDEQ 2015b), derived from the SAP and EMP are:

- Evaluate water levels and water quality parameters of porewater within the waste repository;
- Evaluate surface water influence on groundwater levels and flow direction at the site;
- Evaluate the quality of floodwater entering and leaving the site (Note: floodwater monitoring was discontinued in September 2014);
- Evaluate hydraulic gradients and groundwater flow direction over time, both vertically and horizontally, at the EMFR site;
- Evaluate the potential effects of the repository on groundwater.

The OIG monitoring recommendations were intended to reduce uncertainty in the potential mobility of contaminants caused by variable geochemistry and the addition of waste material. The goal of groundwater monitoring is to specifically identify any changes to groundwater quality caused by construction or operation of the repository.

Sampling and data interpretation described in the EMP are based on guidance provided in *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* (Unified Guidance) (USEPA 2009). The EMP and subsequent white paper applies the steps outlined in the Unified Guidance to develop non-parametric PLs for the COCs As, Cd, Pb and Zn based on the dataset acquired before repository operation.

In addition to identified COCs, groundwater is analyzed for physical and chemical parameters including temperature, pH, SC, DO, ORP and common ions including alkalinity, sulfate, chloride, sodium, calcium, magnesium, and potassium (TerraGraphics 2014b and IDEQ 2015b). Under the water quality monitoring objectives, groundwater data are evaluated to identify statistically significant changes or trends in water quality.

4.2.2 Monitoring Locations and Frequency

Repository monitoring was performed on a quarterly basis between 2007 and January 2015 with sampling events occurring in months January, April, July and October. After January 2015, the monitoring program was changed to a semi-annual sampling frequency with a 1 in 3 retesting/ Double Quantification Rule (DQR) strategy with concentration PLs estimated for each well/COC combination. Semi-annual sampling is scheduled around April and October of each year to capture variability introduced by high and low water seasons. The retesting/DQR strategy was developed based the EPA Unified Guidance (USEPA 2009) and analyses performed by the Optimal Rank Values Calculator software (EPA Region 8).

The groundwater monitoring network is shown on Figure 7 and consists of the following locations:

- Two piezometers screened in the repository waste (PZ-A and PZ-B);
- Seven groundwater monitoring wells, five screened in the upper alluvial sand and gravel aquifer with one in the deeper zone of the alluvial aquifer; One well (MW-E) is located in the sand and clay zone to the west of the repository.
- The CdA River elevation is monitored at the USGS gaging station (12413500) near Cataldo;
- Two floodwater locations are gauged for measuring floodwater elevation and duration, with floodwater quality sampled opportunistically prior to September 2014.

Groundwater monitoring wells located in the 23-acre parcel of the EMFR are MW-A to the east, MW-B south, MW-C west and MW-D north of the repository. Depending on seasonal flow direction either MW-A or MW-D are upgradient sampling locations. Water levels are closest to ground surface at well MW-C and recent results have indicated exceedances of PLs at this location. MW-F is screened in the shallow alluvial sand and gravel aquifer located approximately 600 ft south of the site on the south side of I-90 in a downgradient/cross gradient flow direction. Recent sampling results have also indicated exceedances of PLs at MW-F.

MW-C-deep is screened in the lower alluvial aquifer near MW-C. Well MW-E is located approximately 1,700 feet west of the site. MW-E is screened in the sand and clay aquifer, and boring logs and sampling data indicate that the zone is stratigraphically and geochemically distinct from locations MW-A through MW-D. MW-E tends to have higher pH, SC, and As concentrations than wells screened in the sand and gravel aquifer. MW-E groundwater elevations are correlated with river stage, but with a smoother, slower response than the MW-A through MW-D locations. The MW-E water table elevation is typically three to seven feet higher than the MW-A through MW-D locations (Figure 6). The difference in water table elevations between the two units provides the potential for groundwater in the sand and clay aquifer to contribute to and mix with groundwater in the sand and gravel aquifer. There are no groundwater sampling locations between MW-E and MW-C/MW-D to monitor the transition area between the sand

and clay and sand and gravel aquifers. Uncertainty about groundwater quality and flow directions west of the EMFR is a data gap in the CSM.

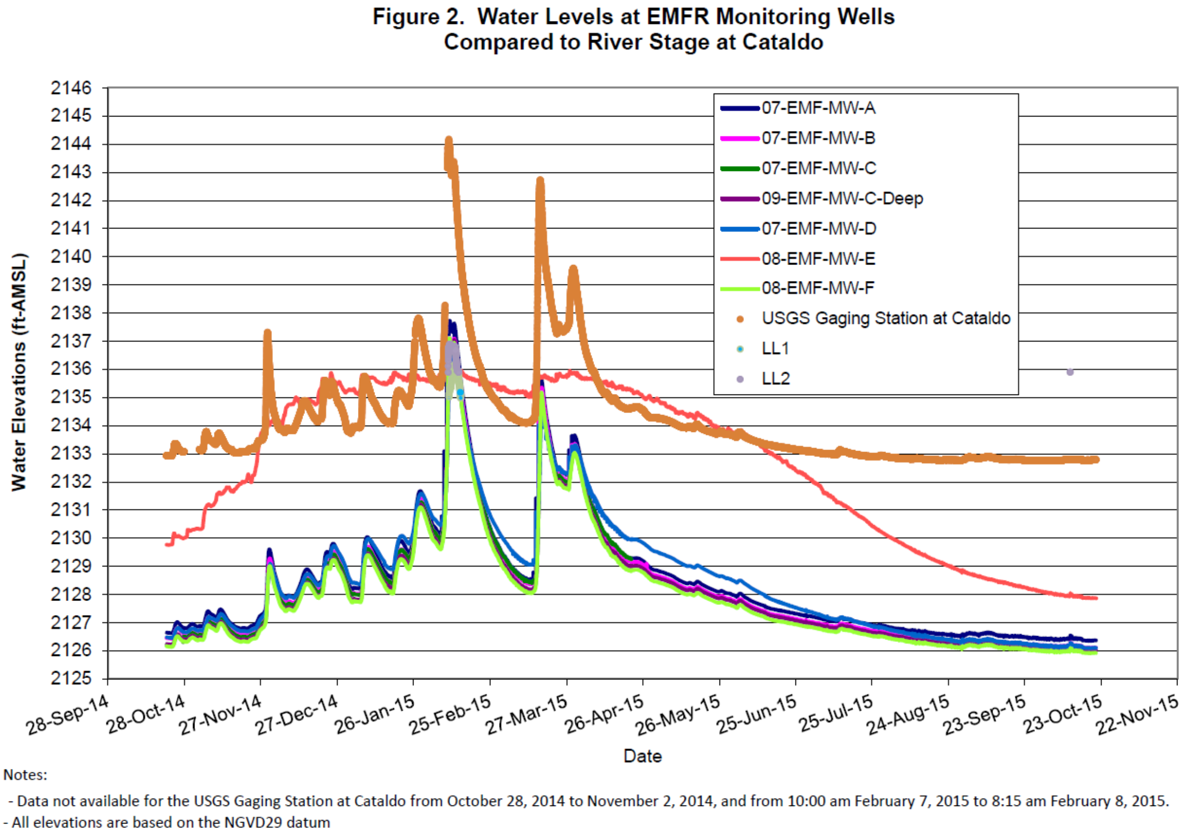

Figure 6: EMFR Water Level Data [Excerpted from Figure 2 (TerraGraphics 2016). All figures reproduced full-scale in Appendix B]

4.2.3 Data Analysis

Saturation of the waste material is monitored by measuring water levels in two piezometers. If water is present in the waste, physical and chemical characteristics of the waste porewater are measured. Monitoring saturation and geochemistry of water ponded in the waste was an OIG recommendation.

Groundwater monitoring wells and surface water locations are gauged for water levels and are compared with CdA River stage data to improve the hydrogeologic CSM. River levels and groundwater potentiometric surfaces are compared to historical measurements to identify any anomalies or changes in the flow regime.

The depth and persistence of floodwater is measured by automatic data-loggers and used to refine the hydrologic CSM. Historically, floodwater has been analyzed opportunistically for metal COCs., The floodwater monitoring was discontinued because the results are difficult to interpret due to minimal changes in metal concentrations between sample events and a lack of defensible methods to determine reasons or source of changing concentrations.

Monitoring wells are sampled for groundwater elevations, metal analytes, dissolved anions (e.g. chloride, nitrate, sulfate) and physical and geochemical parameters (pH, temperature, SC, DO, ORP). Both filtered and unfiltered samples have been collected for metals analyses (TerraGraphics 2009a), but only dissolved metals analyses have been performed after 2014.

Sampling results for wells in the upper sand and gravel aquifer are compared against regulatory thresholds and estimated non-parametric PLs calculated from the data collected between 2007 and 2013 (for 2014 sampling events). The PLs were calculated based on a background dataset including results of eight sampling events between December 2007 and August 2009 for wells MW-A, MW-B, MW-C (shallow), MW-D and MW-F. Wells MW-E and MW-C (deep) are determined to be outside of the shallow sand and gravel unit directly below the repository, and do not have PLs. Groundwater analytical results for dissolved metals are compared against contract required quantitation limits (CRQL) and method detection limits (MDLs) for COCs that have not been detected in groundwater.

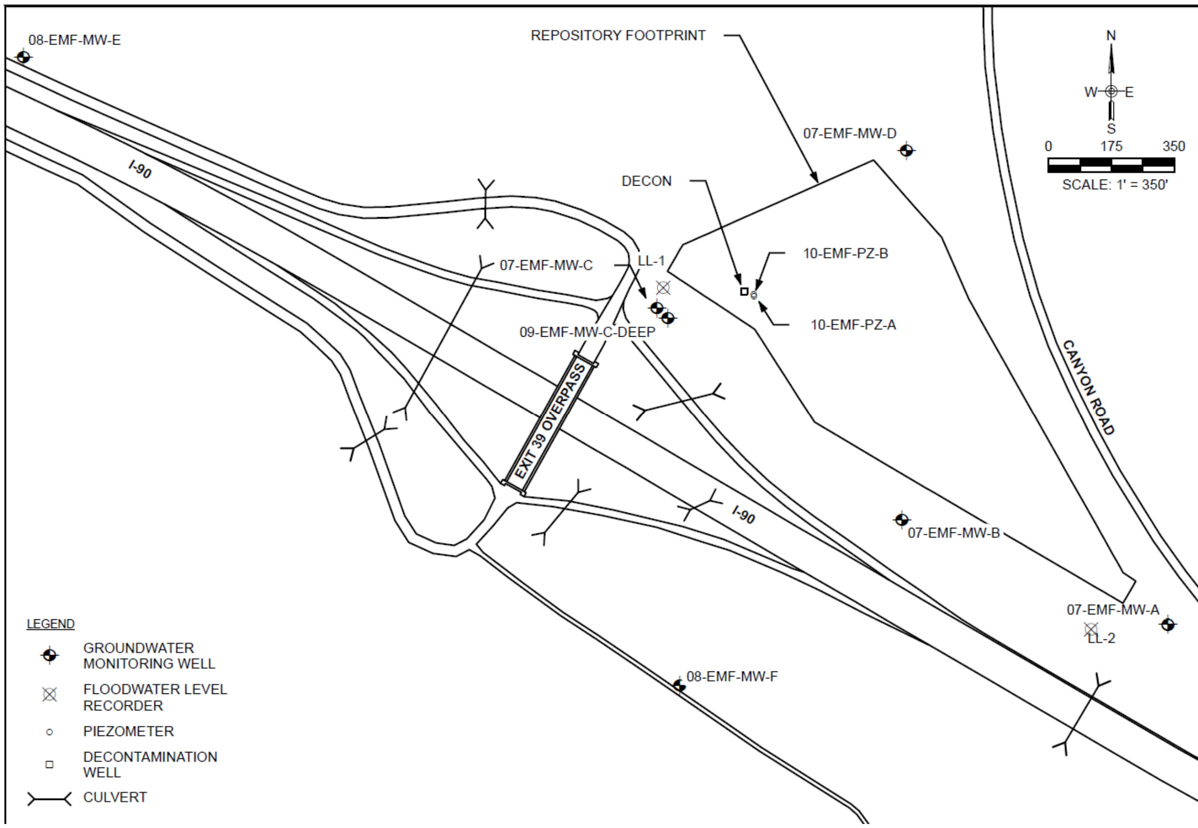

Figure 7: EMFR Monitoring Network and Site Plan [Excerpted from Summary of the April 2015 Semi-Annual and Resampling Water Monitoring Events at the East Mission Flats Repository (IDEQ 2015b, TerraGraphics 2015b)

When PLs are exceeded, the well or wells are resampled (TerraGraphics 2016), and the exceedance is documented in the water quality monitoring report. The applicable procedures outlined in 40 CFR Part 258, Criteria for Municipal Solid Waste Landfills, Subpart E, Groundwater Monitoring and Corrective Action, guide response actions for exceedances of PLs or ARARs or for increasing concentration trends. Other applicable regulations include 40 CFR 264 and 40 CFR part 257.

40 CFR 264.51 states:

> *Each owner or operator must have a contingency plan for his facility. The contingency plan must be designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste*

constituents to air, soil, or surface water.

It is unclear if the EMFR has a site-specific contingency plan to deal with the unique consequences of structural failure or sustained exceedances of ARARs, particularly in the event of a catastrophic episode. The unique feature of the EMFR that may not be captured in the contingency actions specified in the regulations is that the surrounding area is highly contaminated. Concentration exceedances are more likely to result from influx of surrounding material than mobilization of COCs from ‘waste’ material. Structural failure may transport cleaner repository ‘waste’ over and into more highly contaminated areas. This feature of the repositories, not anticipated in the solid waste regulations, may lead to more extensive corrective actions than is warranted.

4.2.4 Dataset for Background Determination

Groundwater monitoring data were collected on a quarterly basis from seven monitoring wells between December 2007 and August 2009, when repository construction and operation began. Piezometers sampled in the Mission Flats area during 2001 to 2003 (TerraGraphics 2009a) indicated some high concentrations of Zn, but the data were not considered of adequate quality to include in the determination of background.

The 2007 to 2009 dataset includes results from eight individual groundwater sampling events before the repository began operations. These data form the foundation of developing statistical PLs for concentrations of metals in groundwater. These data have been combined with sampling results collected through 2013 (or later) to develop current PLs, as lines of evidence support the conclusion that the repository has not had an effect on groundwater since operations began. Spatial and temporal heterogeneity (seasonality) as well as variable hydrology and geochemistry at the site result in highly variable water quality measurements. The relatively short time frame of 2007 to 2009 is likely insufficient to observe metals concentration responses to the ranges in high and low water and geochemical conditions expected over the monitoring lifetime of the repository. In general, a more extensive background dataset is required for data with high variability.

4.3 UNCERTAINTIES AND DATA GAPS

The following uncertainties and data gaps in the CSM were identified for the EMFR:

- The solid-phase association and complexation of metals in waste and sediments under the EMFR is a source of uncertainty in predicting the leachability, reactivity and mobility of metals in both waste and sediments;
- Accuracy of background (pre-repository) concentration estimates of metals in groundwater is uncertain due to limited spatial and temporal dataset;
- Uncertainty about the direction and magnitude of groundwater flow and its influence on geochemistry, with greater uncertainty about groundwater quality and flow directions west of the EMFR;
- Details of surface and groundwater interactions and how they may influence mobility of metals;
- The transient and long-term effects of variable geochemistry on metals mobility;
- General approaches applicable to the EMFR for contingent responses in the event of ARAR exceedances or structural failures are described in regulatory requirements for solid waste disposal facilities (40 CFR Parts 257, 258, and 264). How these requirements will be interpreted and implemented in the event of an exceedance or failure, given the pre-existing extent contamination in the vicinity of the repositories, is unclear.

5.0 RECOMMENDATIONS

Site-specific recommendations are provided for major areas associated with long-term monitoring optimization. Costs or savings for implementing each recommendation are not provided due to lack of site-specific cost estimation data. It is also anticipated that cost savings achieved for some recommendations such as reduced monitoring frequency may be offset by costs for other recommendations such as additional monitoring locations or analyses.

5.1 GLOBAL RECOMMENDATIONS FOR ANALYTES AND DATA COLLECTION

5.1.1 Filtered and Unfiltered Samples

Because COCs such as Pb and Hg are likely to be transported associated with particles or colloids, periodic collection of unfiltered groundwater samples should be performed to confirm results from filtered samples. The recommendation is to collect unfiltered samples once every five years at groundwater monitoring locations in both BCR and EMFR in support of analyses for the FYR. Sampling results from filtered samples can be compared with unfiltered samples in the same way that duplicate samples are compared for data quality control.

5.1.2 Physical and Geochemical Parameters

The leachability, reactivity and mobility of primary COCs is, to a large extent, controlled by the physical and geochemical environment. Primary geochemical factors affecting metals mobility include temperature, pH and ORP; however, water chemistry, including the major anions and cations, may control complexation leading to mobility or retention on solids. Collection of groundwater chemistry data is important if geochemical modeling is required at some point in repository operation.

Many of the geochemical parameters are already part of the sampling program. A list of recommended physical and geochemical parameters to be measured in groundwater is listed in Table 6.

TABLE 6. Groundwater Field and Geochemical Parameters

Temperature	Alkalinity	Magnesium
pH	Sulfate	Potassium
Specific conductivity (SC)	Chloride	Iron
Oxidation/Reduction Potential (ORP)	Sodium	Turbidity
Dissolved Oxygen (DO)	Calcium	

Field and geochemical parameters such as temperature, pH, SC, ORP, DO, turbidity and alkalinity should be collected for each monitoring event. Major ions such as sulfate, chloride, sodium and calcium may be collected once in each season prior to the next FYR (i.e. two times every five years) to characterize the basic site water chemistry. Results of major ion data should be used to identify the geochemical characteristics of the groundwater (e.g. calcium-carbonate, sodium-chloride). Data may be visualized using Stiff, Piper or Maucha, diagrams to characterize groundwater.

After an initial evaluation of water type, the geochemical data can be analyzed on an as-needed basis. Reasons to reanalyze water chemistry may include confirmed or sustained, sample results significantly outside of PLs, changes in the physical structure of the repositories, or after large-scale flooding events.

5.2 GLOBAL RECOMMENDATIONS FOR DATA REPORTING AND ANALYSES

5.2.1 Consistent Reporting Formats

Data collection and reporting for BCR, EMFR, the new BCRA as well as other repositories in OU3 have similar monitoring requirements and challenges. Existing and future repositories will have to document changes in water quality as a result of repository activities and estimate of background concentrations based on expanding databases. Annual reports are currently very similar in format, and of generally high quality, but do not have consistent data analyses and visualization elements.

Reporting formats, data analyses and background assessments for annual monitoring reports should be as consistent as possible between repositories to streamline both report writing and review. Recommended elements of the report are:

- Table of COCs and COECs for surface and groundwater with regulatory limits (e.g. MCLs) and the relevant 'background' statistics in the form of PLs and BTVs. (see Appendix C Table C.1 as an example);
- A section describing how BTVs or PLs were calculated for the repository area and the dataset used to perform the calculations (see Section 5.1.2);
- Table comparing estimated concentrations of metals in emplaced waste relative to pre-repository soils, sediments or tailings. Including an estimate of the upper range of concentrations of metals from the BPRP program (similar to Table 4) and background estimates for the original soil/tailings underlying the repository;
- Conclusions and recommendations section that references monitoring objectives described in the introduction. (Note: this is already done very well in several annual reports and should be replicated across the program).

For FYR reports, include more detailed statistical analyses of data:

- Statistical trend analysis results for each monitoring location and COC combination (see Section 5.1.3) including the confidence or significance of the trend;
- Summary statistics for geochemical and physical parameters including the historical maximum, minimum, median and 95% upper confidence limit (UCL) and 95% lower confidence limit (LCL) to identify potential changes in geochemical conditions that may affect metals mobility (this can be included as an appendix to the main report).

5.2.2 Background Threshold Values and Prediction Limits

Estimates of background concentrations in surface and groundwater, including both anthropogenic and natural sources of COCs, are important for demonstrations of repository performance and for long-term assessment of Site-wide restoration. Several methods in addition to those listed in the Unified Guidance are available in statistical literature to estimate background. However, all methods require large datasets for media with high spatial and temporal variability.

The PL estimation method used for the EMFR is consistent with EPA RCRA guidance, and provides a good point of comparison for assessing repository performance. However, other descriptors of background conditions can provide a useful set of values to compare to on-going sampling results. Important data descriptors include the maximum result for a sampling location, coefficient of variation (CV), percent detection for intermittently detected COCs, and a 95% UCL on the pre-repository dataset (for COCs detected more than 30 percent of the time). Maximum results and CV can indicate the amount of variability in the dataset. UCLs are similar to PLs, but they don't control for Site-Wide False Positive (SWFP) results. UCLs provide a single number that is an intuitive indication of historical concentrations, given that results can be above the 95% UCL 5 percent of the time without constituting an exceedance or outlier.

UCLs can be evaluated on the same dataset used to calculate PLs. Calculation of the 95% UCLs can be performed using the ProUCL software (Singh and Singh 2013) developed by EPA or other commercial software products.

5.2.3 Statistical Trend Analysis

For each monitoring location and priority COC, statistical trends should be evaluated and presented in the FYR report. For constituents that are detected greater than 50 percent of the time, a parametric or nonparametric statistical method can be used to evaluate the trend. Parametric trend analysis such as linear regression is appropriate for normally distributed datasets. Non-parametric trend analysis such as the Mann-Kendall test is appropriate for datasets with no discernable distribution.

For COCs detected less than 50% of the time, the detection frequency can be reported, and results above the PLs recorded.

Statistical trends should identify increasing and decreasing trends, but it is also important to identify the confidence or significance of the trend and what constitutes a 'stable' dataset. For Mann-Kendall tests, the value of 'S' statistic should be listed to provide an indication of the magnitude and sign of the trend. The *p*-value of the trend (significance) can also be reported; however, the value [(1-p) x 100] provides a more intuitive and easier to understand measure of the confidence in the trend. For example, for $p = 0.034$ a confidence factor would be [1-(0.034)] x 100 = 96.6%. For linear regression analyses, the slope magnitude and sign and the standard error on the slope can be used to assess the significance of the trend.

Stable trends can be defined as datasets that do not indicate increasing or decreasing trends and have low CV (e.g. below 1). Variable datasets are those with no distinct increasing or decreasing trends but exhibit high CV.

Statistical trends should be reported along with the BTVs and PLs to evaluate potential changes in groundwater and surface water quality over longer periods of time. By reviewing and comparing several metrics, including statistical trends, PLs and 95% UCLs, and *p* values there is reduced likelihood of misinterpretation of a single metric. Full statistical analyses should be performed and recorded on an every-five-year basis.

5.2.4 Reducing Sampling Frequency

One area of uncertainty for EMFR, BCR and all other long-term monitoring programs centers on the Unified Guidance recommendations for detection monitoring programs. In the Unified Guidance, control of SWFP is calculated around a minimum annual sampling frequency. There is no guidance on how to design a sampling program or control for SWFPs for a sampling frequency lower than annual, such as biennial (every two years) or once every five years. The statistical framework described in the Unified Guidance was developed for the Resource Conservation and Recovery Act (RCRA) program with a regulatory framework that specifies minimum annual sampling frequencies.

For CERCLA sites undergoing very long-term restoration under largely stable conditions, reduced sampling frequencies may be technically appropriate and cost effective. However, it is unclear how these programs should be designed within the current statistical and regulatory framework.

The sampling strategy and PLs developed for EMFR are currently based on a semi-annual sampling frequency. Sampling may be reduced to annual as the repository moves toward closure, with a new sampling strategy and calculated PLs. However, reducing sampling frequency further may require a different strategy in developing PLs. Currently, it is unclear how lower frequency sampling programs will be evaluated by regulatory agencies. Development of detection monitoring programs for reduced sampling frequencies will be an evolving area of regulatory guidance.

Based on the data reviewed, repository sampling should likely be reduced to an every-five-year or lower frequency after closure. While there is no guidance on a path to reduce sampling frequencies below annual, calculation and reporting of summary statistics and trends in FYRs should contribute to a 'lines-of-evidence' approach to negotiating reduced sampling frequencies.

5.2.5 Fate and Transport and Geochemical Models

While there are uncertainties in the fate and transport models developed for each of the repositories, there are no specific recommendations for improving fate and transport model parameters in the short term. By using a range of leachate concentrations and conservative input parameters, the modeling satisfactorily represents current conditions at the site to evaluate future repository impacts. The recommendation is to compare site data to model predictions on a five-year frequency and identify any significant variation from modeled concentrations or conditions.

If concentrations of any COC significantly exceed expected values, geochemical modeling may be a better approach to addressing uncertainty and evaluating the fate and potential transport of metals. Geochemical modeling software such as Geochemist Workbench or other similar tool may be used to identify factors contributing to metal mobility. Updating the fate and transport models with geochemical modeling may be part of contingency actions should there be confirmed exceedances of ARARs.

5.2.6 Contingency Planning for Confirmed Exceedances of ARARs

General approaches to contingent responses in the event of ARAR exceedances or structural failure are described in regulatory requirements for solid waste disposal facilities (40 CFR Parts 257, 258, and 264); however, the EMFR differs in some significant ways from standard solid waste facilities. Data indicate that the material stored within the repositories is significantly less impacted by metals than surrounding media.

While it is extremely unlikely that repository activity will cause exceedances of ARARs in groundwater and surface water, there is potential for surrounding material to migrate causing apparent exceedances. Catastrophic episodes may transport materials either from the repository or from surrounding contaminated areas potentially implicating the repository in releases of hazardous materials. Decision logic and contingency planning should be developed for each repository outlining how potential releases will be distinguished from area-wide contamination planning for appropriately-scaled corrective measures.

The contingency decision logic should include a description of sampling/resampling results that will trigger additional investigations. Additional investigation activities should be proposed that will identify the source of exceedances (e.g. mobilization of pre-repository or contamination arising from the wastes, mobilization due to changing environmental conditions). Contingency planning may include descriptions of corrective measures or potential remedies to prevent exceedances directly related to repository waste such as capping, slurry wall installation or excavation to isolate high-level or mobile waste material or groundwater extraction and treatment to contain groundwater plumes.

5.2.7 SAP for Mechanical Stability

Future SAP documents should include a section on how mechanical stability of the repositories is evaluated. A description of the type and frequency of investigations, data collection, management and communication, and contingency responses would support long-term repository management. Consider including a section on monitoring mechanical stability of the repositories in the annual reports, either in the water quality monitoring report or in the annual operations report.

5.3 BCR-SPECIFIC RECOMMENDATIONS

5.3.1 Estimation of Background Threshold Values and Sampling Frequency.

BCR site-specific estimates of BTVs should be developed for groundwater and surface water. The BTVs can be estimated using the PL method used for the EMFR.

As with the EMFR, a semi-annual sampling frequency should be considered for the BCR surface and groundwater, in the short term. PLs can be calculated based on the semi-annual sampling frequency. It is recommended that the full dataset collected since 2001 be used to estimate PLs in order to capture the variability resulting from seasonal changes in recharge and geochemical conditions.

Background values for tailings below the waste should be estimated from the historical dataset as a point of comparison against estimated concentrations in waste placed in the repository. In order to assess remedy performance, the contribution of metals to surface and groundwater from repository material needs to be distinguished from existing contamination from the historical tailings and mining activities. Assessment of progress toward broader Site-Wide remediation objectives will require quantification of metals leaching from both the historical tailings and repository materials.

Calculation of background values will provide a basis to distinguish existing contamination from suspected impacts from the waste or repository maintenance activities. The data collected before official waste placement includes six sample results, which is a fairly small dataset for evaluating background concentrations. However, the pre-repository data collected from tailings can be used to estimate a 95% UCL and a range of values representing existing contamination.

5.3.2 BCR Post-Closure Monitoring

The BCR is approaching capacity with closure anticipated in the near future. Recommendations for post-closure monitoring are similar to those already presented, including development of BTVs, PLs and trend evaluations for surface water, groundwater. However, an annual monitoring frequency is recommended for the initial post-closure period. PLs for BCR should be developed based on annual monitoring. Annual monitoring will likely be conducted for five years after closure.

In the future, a reduced monitoring frequency (e.g. every five or ten years) may be appropriate for long-term, post-closure monitoring; however, at this point, it is difficult to design a low-frequency sampling program using recommendations in the Unified Guidance. In the future, a low-frequency monitoring program should be developed by consulting regulatory agencies and stakeholders to ensure a consensus on adequacy of data collection. Decision logic for transitioning to a very low-frequency sampling schedule (e.g. less than annual) is presented in Section 5.4.2.

No additional sampling locations are recommended for BCR during the post-closure period. One upgradient sampling location (either 01-SR-MW-06 or 01-SR-MW-07) is sufficient for post-closure monitoring of both groundwater elevation and water quality. Due to the proximity of the new BCRA, datasets and BTVs developed for BCR may be useful for evaluating background conditions at BCRA, and additional data collected at BCRA may provide additional data for resolving uncertainties at the BCR.

As noted, groundwater data collected in the vicinity of the repositories may support Site-wide assessments of groundwater quality for OU3. Data needs for BHSS Site-wide assessment may determine sampling locations and frequencies after repository closure. Data from both the BCR and BCRA remedies may be used in the future to confirm that groundwater discharge to Big Creek does not cause exceedance of ecologically protective conditions in the stream.

5.4 EMFR-SPECIFIC RECOMMENDATIONS

5.4.1 *Sampling Locations*

Metals concentrations in groundwater in the EMFR area are characterized by high spatial uncertainty. The repository is located above and adjacent to two aquifer zones with different geochemistry – the sand and gravel aquifer below the repository and the sand and clay aquifer immediately to the west. Groundwater flow directions appear to be predominantly to the southwest, however, there is evidence of variable or intermittent flow directions that may result in mixing of water from the two zones, notably in the area of MW-C.

Two additional groundwater monitoring locations are recommended to characterize spatial variability and flow regimes in the area. Proposed additional monitoring locations are indicated on Figure 8. The wells should be screened in the upper aquifer. One additional well is recommended north of MW-C near the transition from the sand and gravel to the sand and clay zones. This location is recommended to clarify interactions between the sand and gravel and the sand and clay aquifers as well as groundwater flow directions and gradients.

The second location is recommended south of I-90, west of the repository and northwest of well MW-F. This location is recommended to address concentrations downgradient of the repository on the potential migration pathway to the CdA River. This sampling location is anticipated to address uncertainties in flow direction and magnitude, potential interactions between surface water and groundwater and, potentially, resolve uncertainty about COC concentration variability at MW-F.

The new wells should be sampled semi-annually. At least four years of semi-annual sampling will be required before reasonable PLs can be developed. Until a significant dataset is developed for these locations, sampling results can be compared with ARARs and with 95% UCLs for other locations in the

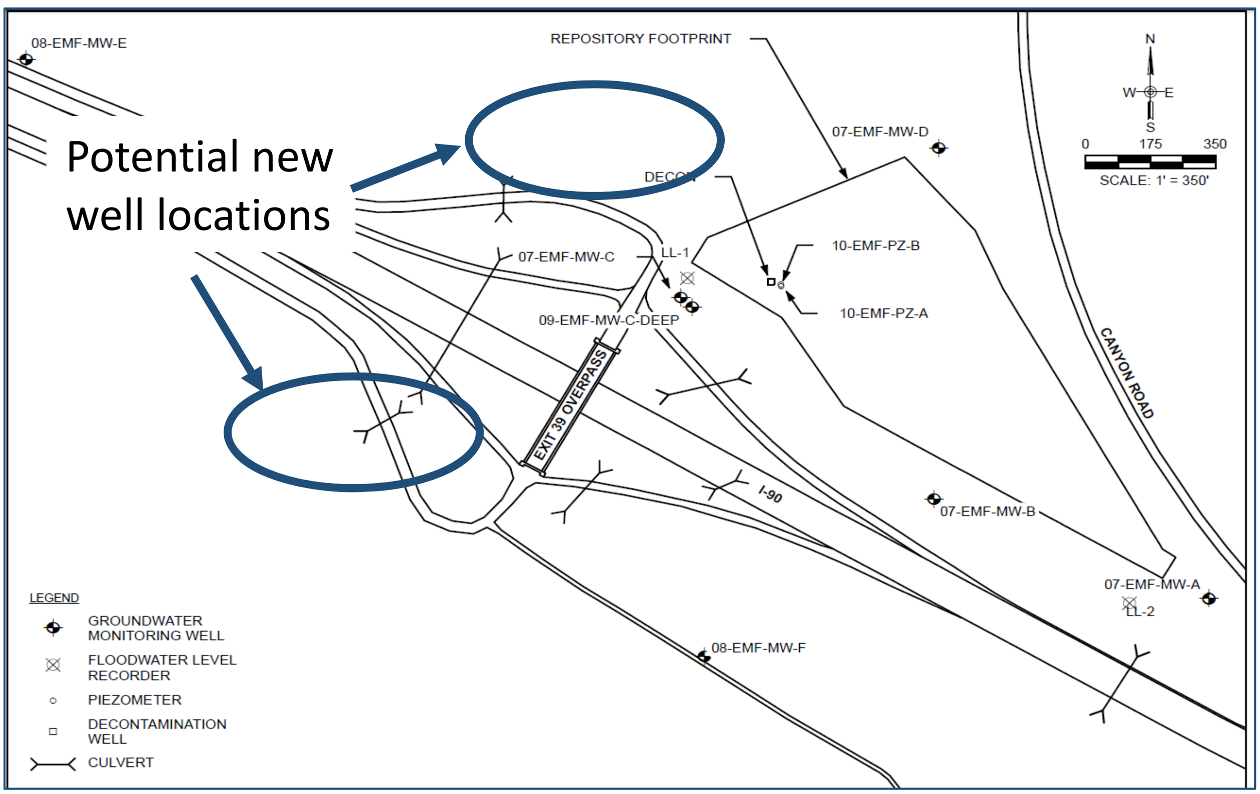

Figure 8: EMFR New Monitoring Well Recommendations [Figure based on except from (TerraGraphics 2015b), full size figure reproduced in Appendix B]

network.

No changes are recommended for the piezometers used to assess saturation within the waste material. These piezometers can be used to demonstrate unsaturated conditions, supporting a conclusion of low risk of mobilization of COCs from the waste material.

5.4.2 Sampling Frequency

Sampling at EMFR should continue on a semi-annual basis. Decision logic for transitioning to annual sampling may include:

- Collection of sufficient data at new sampling locations to develop PLs;
- 'Stable' or no trend in concentrations of all priority COCs (or no increase in detection frequency for COCs routinely below reporting limits) for a period of four years;
- No major mechanical degradation of the repository or extreme flooding (above 100-year flood levels) or other natural disaster for a period of four to five years as documented in a FYR.

As noted with the BCR monitoring recommendations, transitioning to a low-frequency sampling program should include consultation with relevant regulatory and stakeholder organizations to establish consensus on adequacy of data collection.

APPENDIX A:
REFERENCES

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APPENDIX B:
SUPPORTING FIGURES

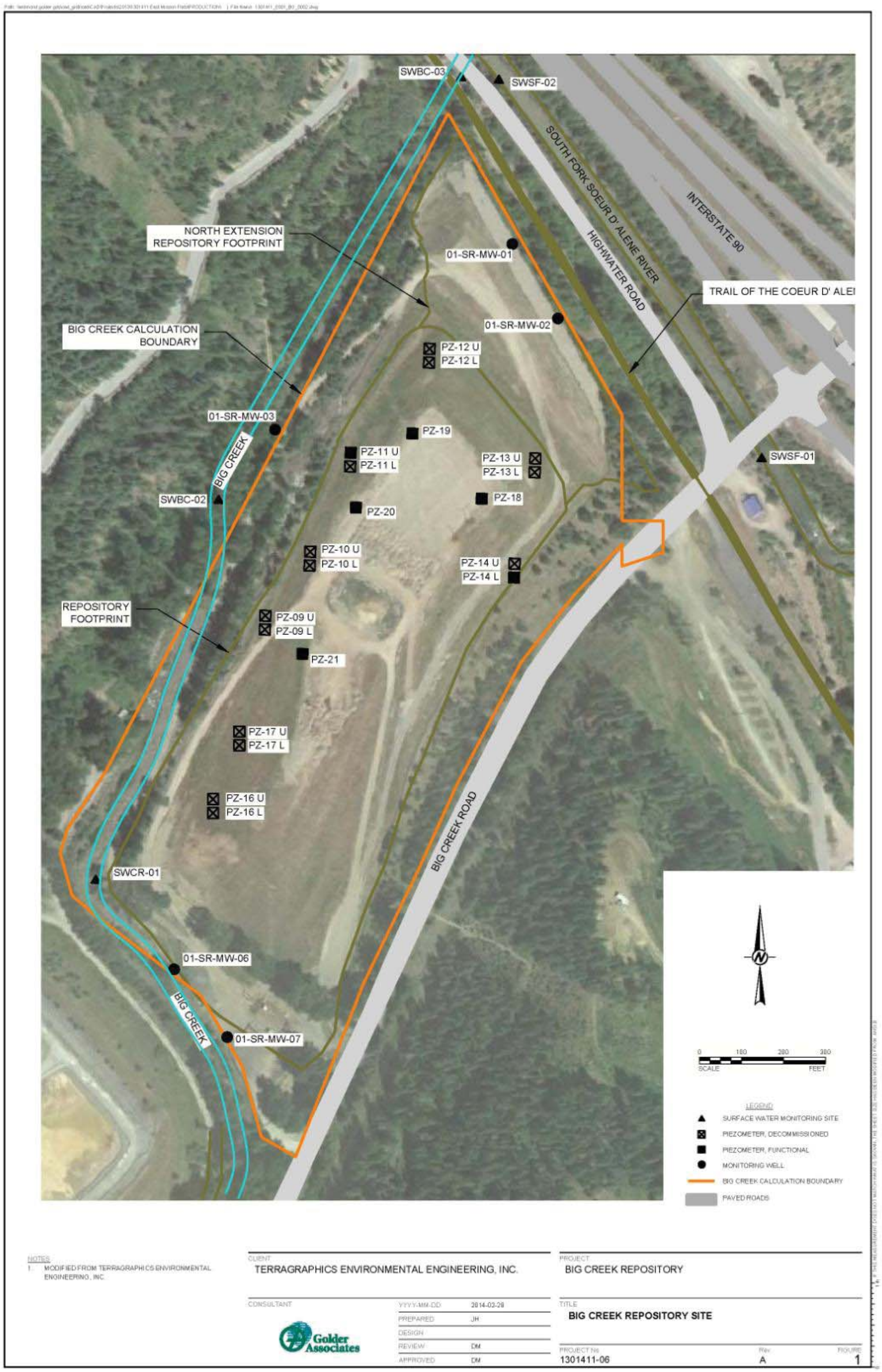


Figure 1. BCR Site Map (from Golder 2014)

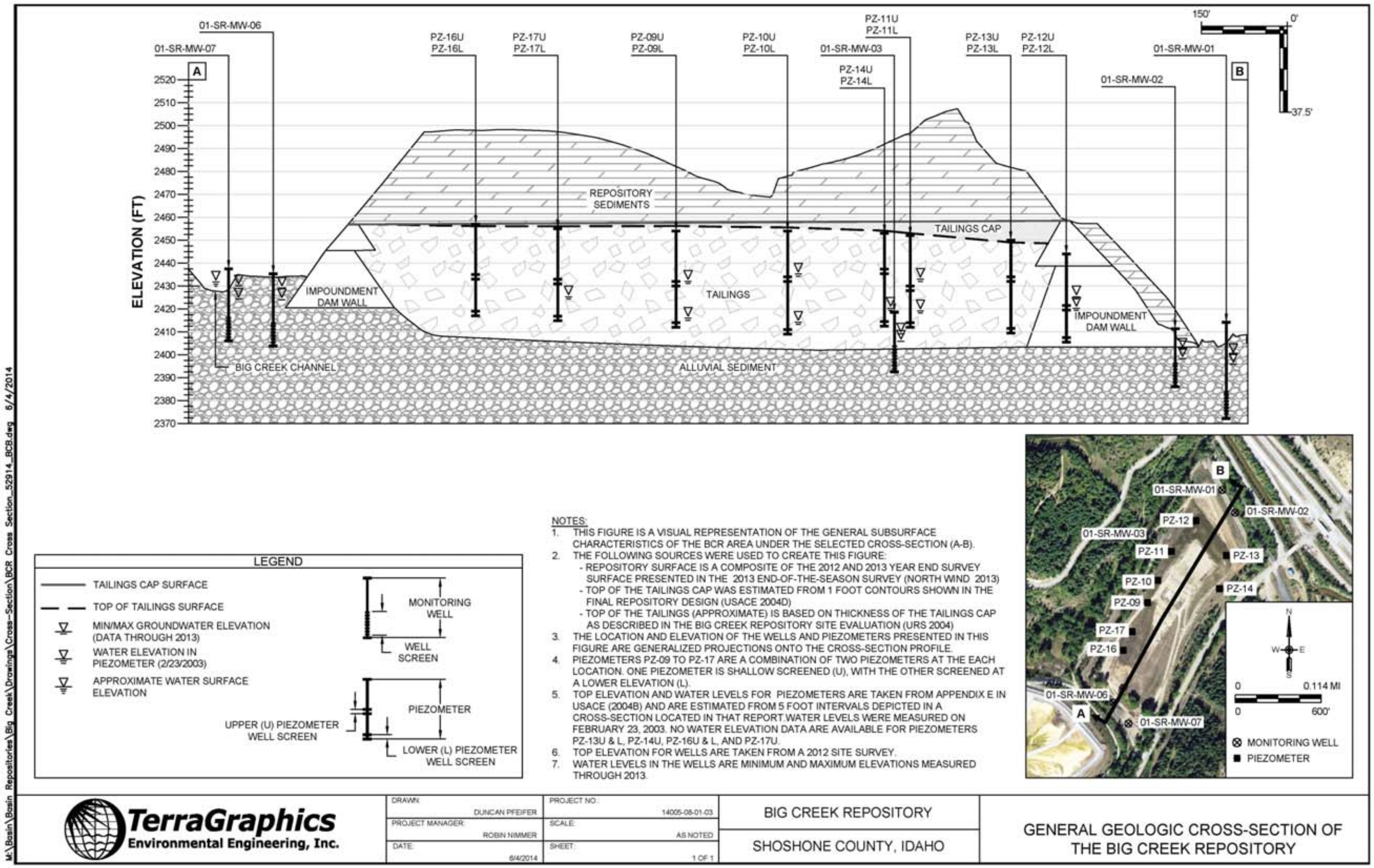


Figure 2. General geologic cross-section of the Big Creek Repository.

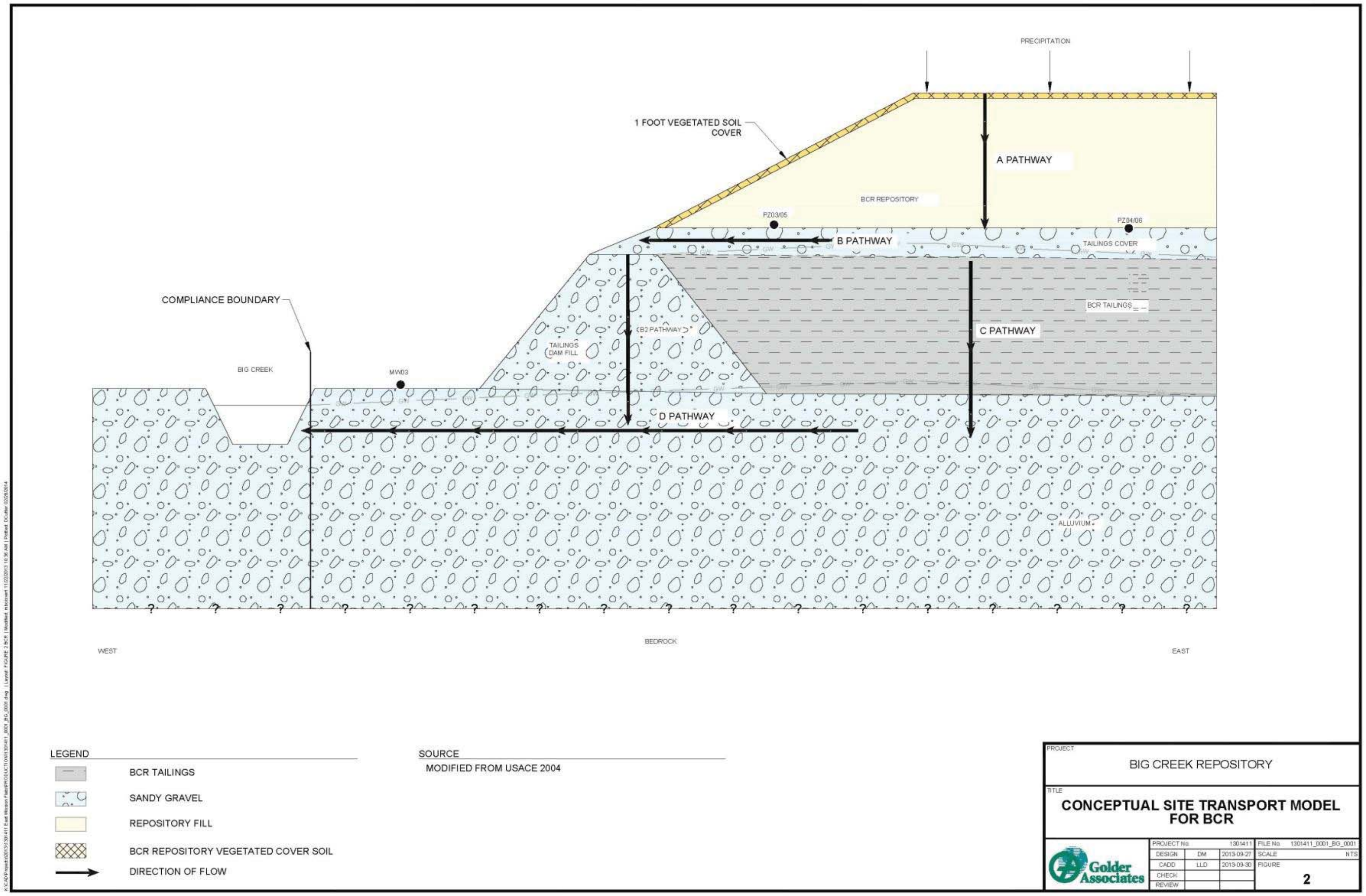


Figure 2. Conceptual Site Transport Model for BCR (from Golder 2014)

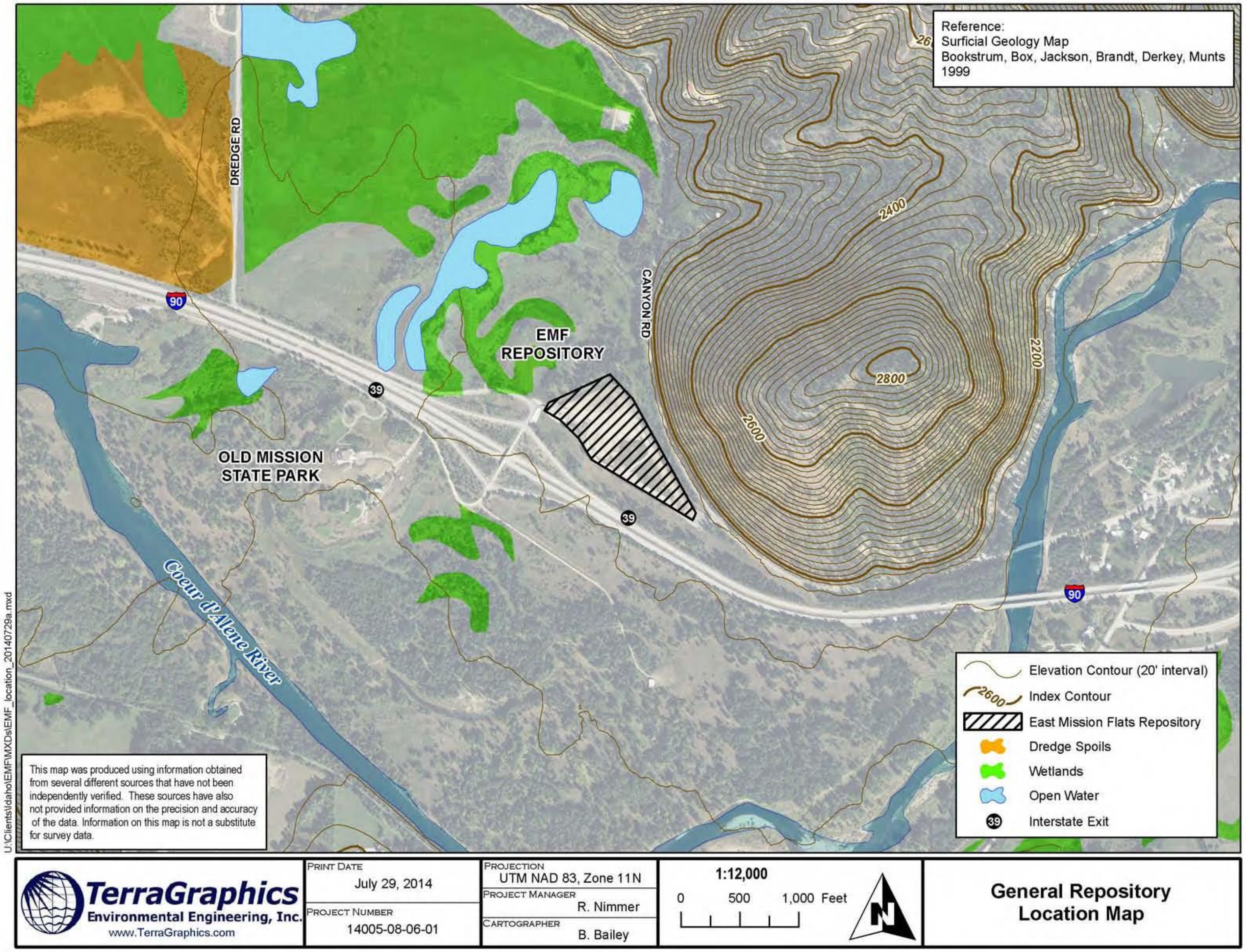


Figure 1. East Mission Flats Repository Location - Cataldo Idaho.

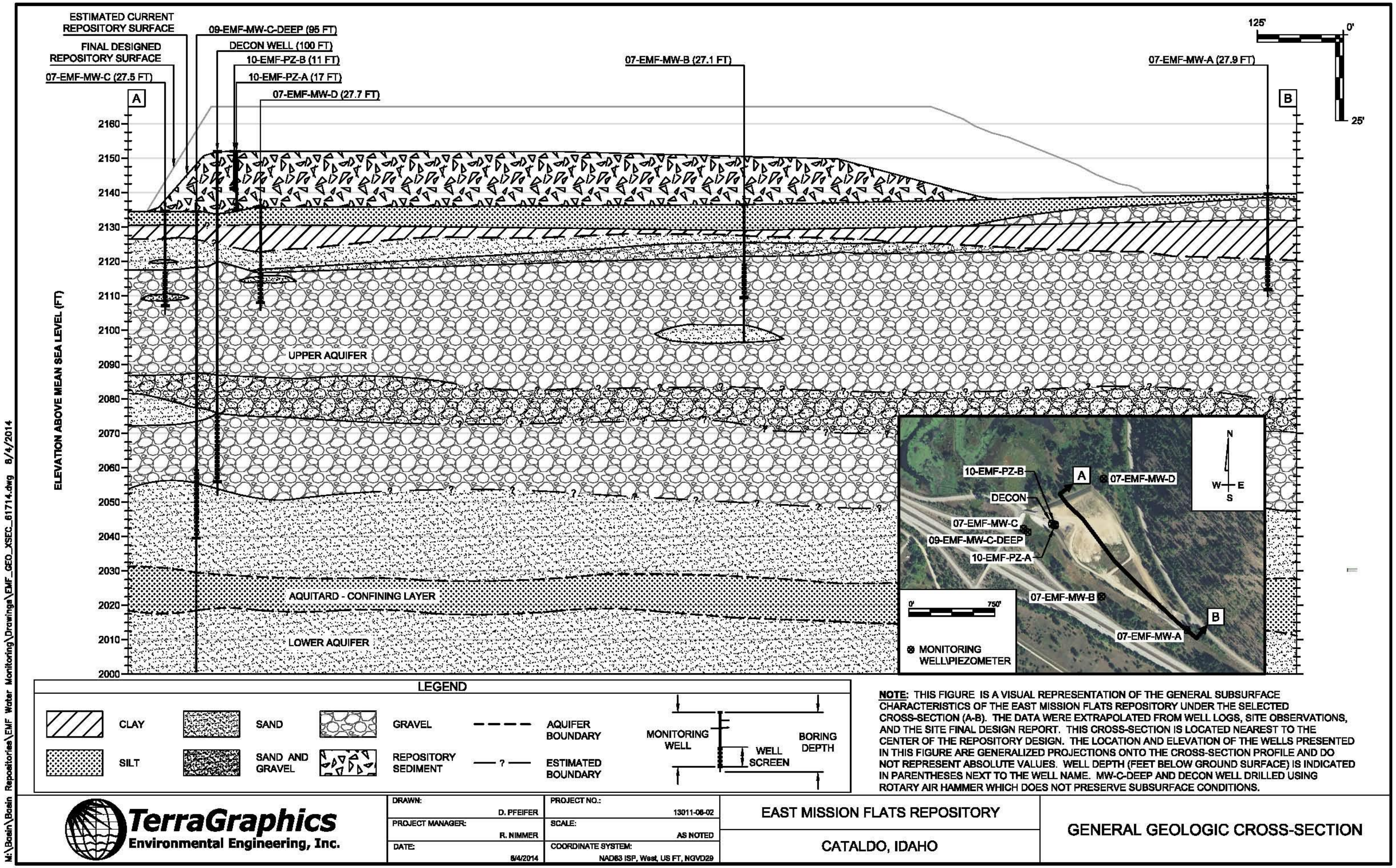
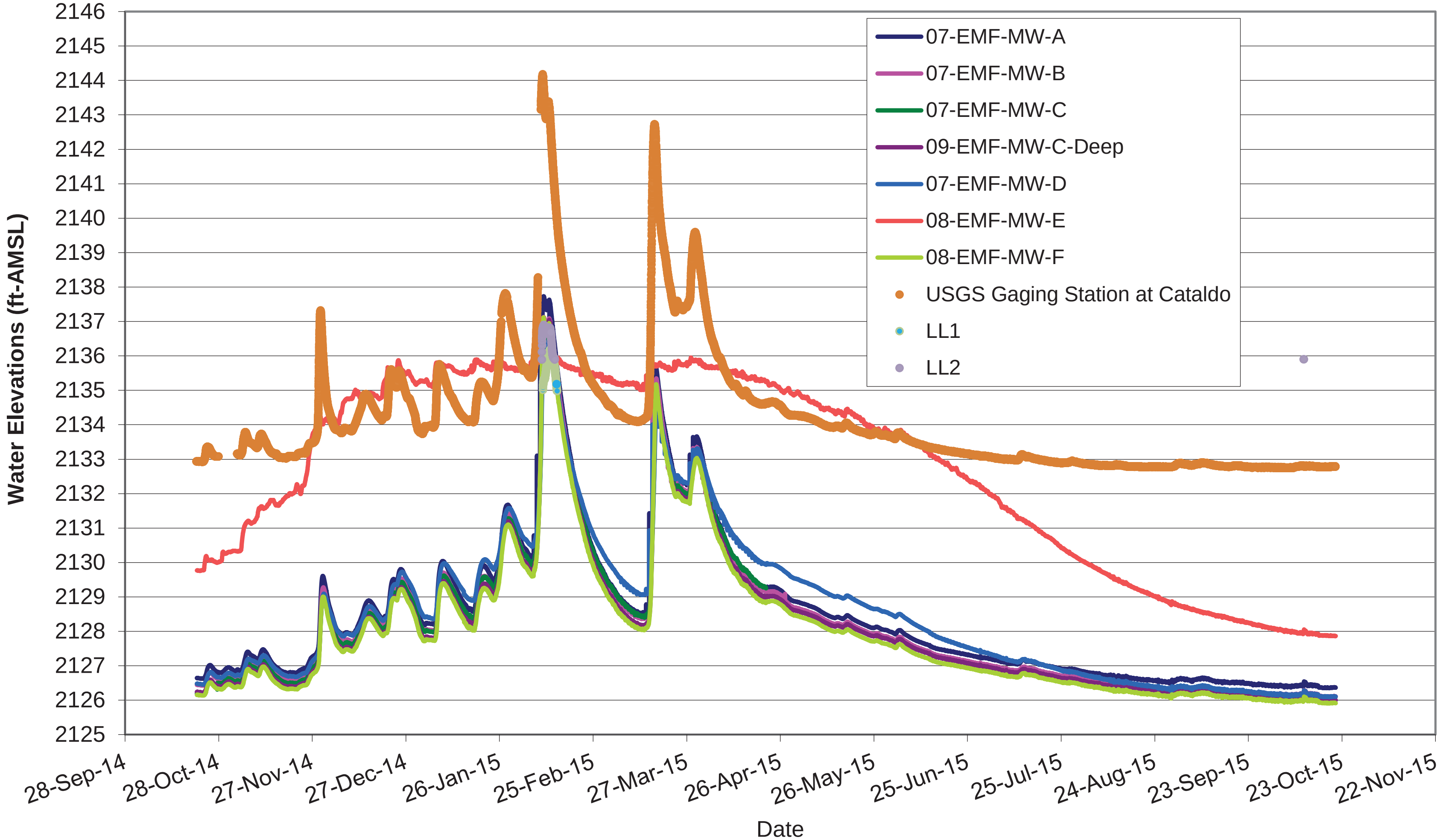


Figure 2. East Mission Flats Repository geologic cross section.

Figure 2. Water Levels at EMFR Monitoring Wells
Compared to River Stage at Cataldo



Notes:

- Data not available for the USGS Gaging Station at Cataldo from October 28, 2014 to November 2, 2014, and from 10:00 am February 7, 2015 to 8:15 am February 8, 2015.
- All elevations are based on the NGVD29 datum

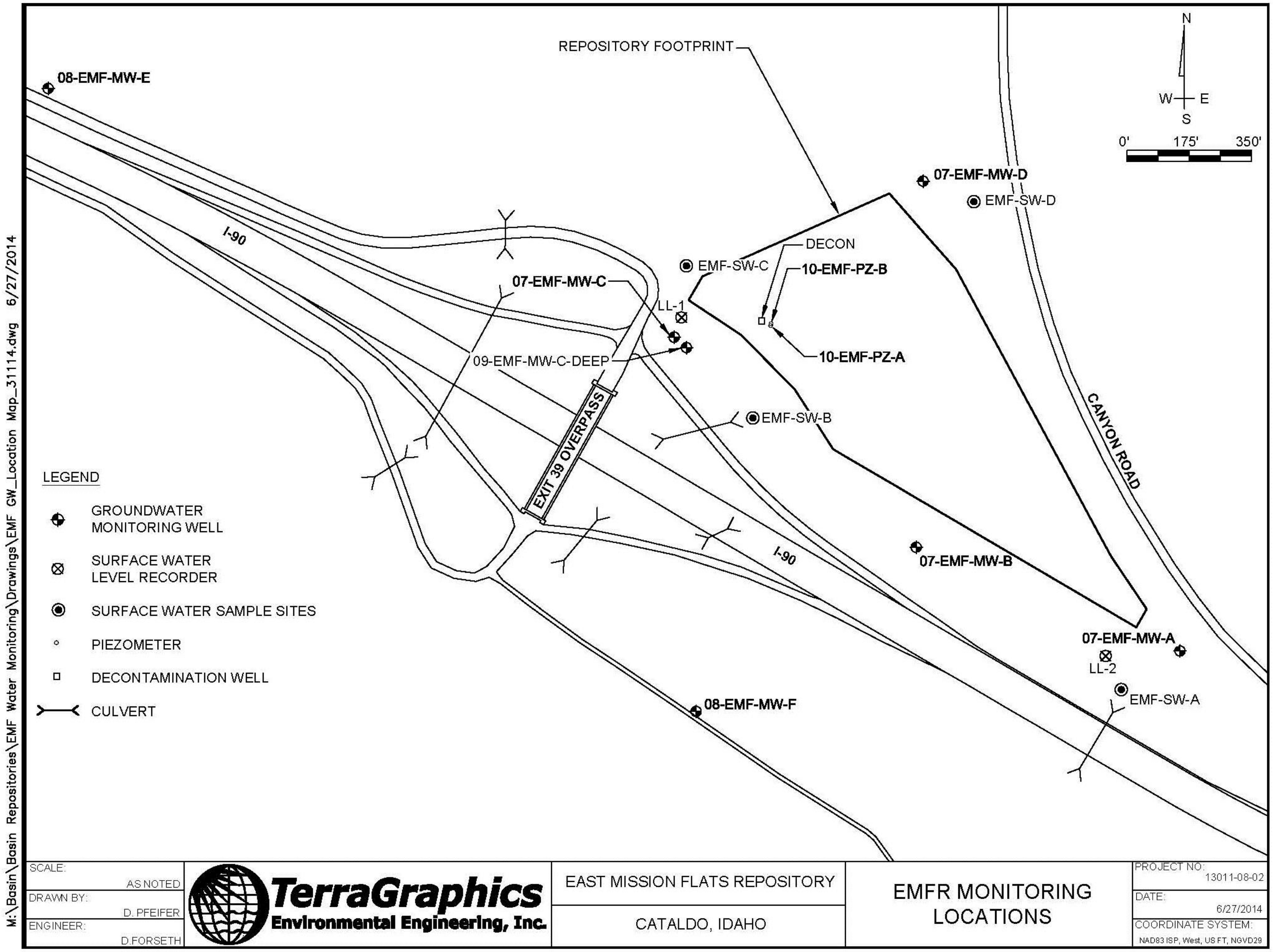


Figure 3. East Mission Flats Repository groundwater and surface water monitoring location.

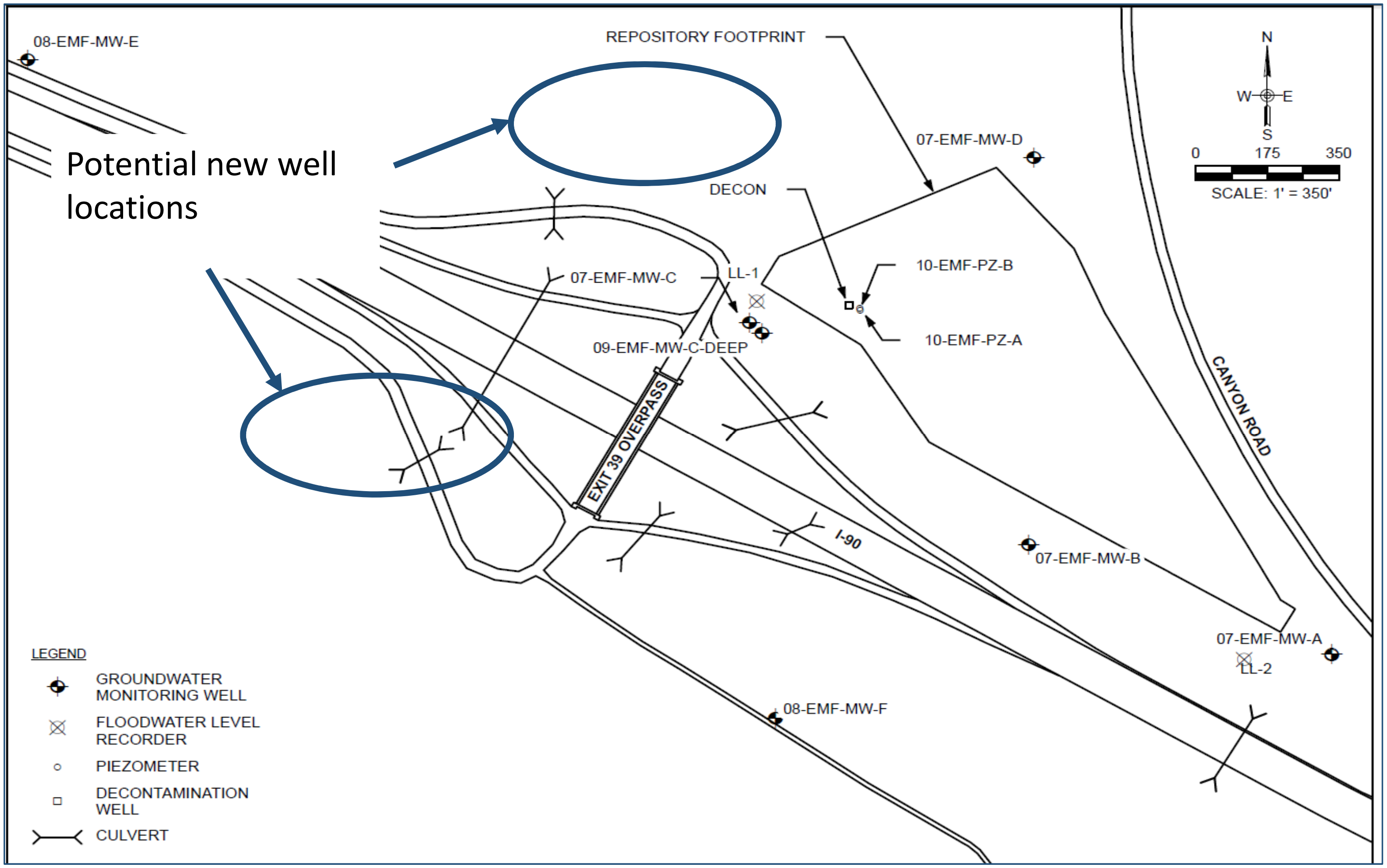


Figure 7: EMFR New Monitoring Well Recommendations [Figure based on except from (TerraGraphics 2015b)

APPENDIX C:
SUGGESTED TABLE FORMATS

TABLE C.1. Example Table for Representing Repository Groundwater Monitoring Data

East Mission Flats Repository MW-A

Constituent	Detection Frequncy [%]	Recent Result	Maximum Result	Recent Above Maximum ?	PL	Recent Above PL?	Regulatory Threshold	Recent Above Threshold?	Pre-Disposal 95% UCL
Arsenic	5	<1	1.8	No	1.4	No	10	No	<1
Cadmium	10	<.2	1.7	No	0.77	No	5	No	<.2
Lead	50	<1	2.6	No	1	No	15	No	<1
Zinc	100	616	1,750	No	1,710	No	5000	No	753

Notes:

1. Concentrations shown in ug/L. "<" = below detection limit.
2. Maximum result for time frame 12/11/2007 through 10/27/2014. Recent result is from 10/27/2014.
3. PLs based on data from MW-A collected 2007 to 2013.
4. Regulatory thresholds are primary and secondary MCLs.
5. 95% UCL calculated from data collected from MW-A prior to waste disposal.

TABLE C.2. Example Table for Representing Statistical Trend for Five Year Review

East Mission Flats Repository MW-A

Constituent	S	Confidence in Trend [%]	Coefficient of Variation	Recent Trend	Trend from Previous Monitoring
Lead	-6	19	0.01	S	NT
Zinc	25	75	1.05	NT	NT

Notes:

1. S = Mann Kendall Statistic
2. Confidence in the trend is calculated as (1-*p*) x 100%
3. Coefficient of Variation is calculated from the standard deviaion divided by the mean.
4. S = Stable, no trend low variability; NT = No Trend, high variability