# Rio Algom Mining LLC

June 21, 2019

Mr. Scott T. Anderson
Utah Division of Environmental Quality
Division of Waste Management and Radiation Control
PO Box 144880
195 North, 1950 West
Salt Lake City, Utah
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**RE: Work Plan for the Lisbon Facility Hydrogeological Supplemental Site Assessment, Phase 4; Radioactive Material License Number UT 1900481; Rio Algom Mining, LLC, San Juan County, Utah, USA**

Dear Mr. Anderson:

Rio Algom Mining LLC (RAML) is pleased to submit the enclosed *Work Plan for the Lisbon Facility Hydrogeological Supplemental Site Assessment, Phase 4* (Work Plan) consistent with the requests specified in your April 17, 2019 *Request for Additional Information* (RAI) letter to RAML. The attached Work Plan provides the technical approach to address the DWMRC RAIs and data gaps identified in the *HSSA, August 30, 2019*:

- Re-evaluate tailings water balance to determine long-term seepage rates (RAI-1, RAI-2f);
- Evaluation of surface water/groundwater interactions to the north-northwest of the Site (RAI-2c);
- Assess fault influence on groundwater flow (RAI-2a);
- Determine if natural mineralization has caused impacts to water quality at MW-124 (RAI-2b, RAI-2e);
- Evaluate stock well pumping effects on groundwater flow (RAI-2d);
- Evaluate groundwater treatment options for the northern plume (RAI-3);
- Determine appropriate background levels and update the COC list (RAI-2e, RAI-2f, RAI-5, RAI-6);
- Install additional wells to monitor plume migration and aquifer characterization (RAI-2g, RAI-4);
- Update the CSM and groundwater flow and transport model (RAI-2g); and
- Develop calculation of revised ACLs and TALs.

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Three technical reports will be prepared to document the work performed: 1) The HSSA Phase 4 Report, 2) an updated Tailing Impoundments Water Balance Modeling Report, and 3) a Background Evaluation Report. As requested, a proposed schedule to complete the technical work and associated reporting is discussed in Section 3 of the Work Plan with a high level summary schedule provided in Appendix E. The field work components are estimated to be completed in 2020. Data analysis and reporting are estimated to be completed in 2021.

Please do not hesitate to call at (916) 947-7637 if you have any questions.

Sincerely,
**Rio Algom Mining Company LLC**

Sandra L Ross

Sandra L. Ross, P.G.
Site Manager

cc: Phil Goble

# Final Work Plan for the Hydrogeological Supplemental Site Assessment, Phase 4, Lisbon Facility

## Radioactive Material License Number UT 1900481
## San Juan County, Utah

***Prepared for:***

**Rio Algom Mining LLC**
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June 21, 2019

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACL | Alternate Concentration Limit |
| BCA | Burro Canyon Aquifer |
| bgs | below ground surface |
| BLM | Bureau of Land Management |
| CAP | Corrective Action Program |
| CMB | chloride mass balance |
| COC | constituent of concern |
| CSM | Conceptual Site Model |
| DGA | Data Gap Assessment |
| DOE | Department of Energy |
| DQO | Data Quality Objectives |
| DWMRC | Utah Division of Waste Management and Radiation Control |
| EC | Electrical Conductivity |
| ERM | Electrical Resistivity Mapping |
| ET | Evapotranspiration |
| ft | foot *or* feet |
| HELP | Hydrologic Evaluation of Landfill Performance |
| HSA | hollow-stem auger |
| HSSA | Hydrogeological Supplemental Site Assessment |
| HSSA4 | Hydrogeological Supplemental Site Assessment, Phase 4 |
| INTERA | INTERA Incorporated |
| IDW | Investigation Derived Waste |
| K | hydraulic conductivity |
| Kd | sorption coefficient |
| License | Radioactive Material License Number UT 1900481 |
| LVF | Lisbon Valley Fault |
| LTI | Lower Tailing Impoundment |
| LTSM | long-term surveillance and maintenance |
| mg/L | milligrams per liter |
| mol/kg | mole per kilogram |
| mol/L | mole per liter |
| MSW | municipal solid waste |

| | |
|---|---|
| ND | non-detect |
| NR | natural recharge |
| NRC | Nuclear Regulatory Commission |
| PCA | Principal Components Analysis |
| POC | Point of Compliance |
| POE | Point of Exposure |
| RAML | Rio Algom Mining LLC |
| RAI | Request for Additional Information |
| SEM | scanning electron microscopy |
| Site | Lisbon Facility |
| TAL | Target Action Level |
| USEPA | United States Environmental Protection Agency |
| UTI | Upper Tailing Impoundment |
| XRD | x-ray diffraction |
| WCW | West Coyote Wash |
| Work Plan | Work Plan for the Lisbon Facility Hydrogeological Supplemental Site Assessment, Phase 4 |

# 1.0 INTRODUCTION

The Rio Algom Mining, LLC (RAML), Lisbon Facility (Site) in San Juan County, Utah, has undergone three phases of hydrogeological site assessment in the last decade. Phases 1 and 2 were conducted and reported on behalf of RAML by Montgomery & Associates (2013 and 2014, respectively). On August 30, 2018, RAML submitted two reports prepared by INTERA Incorporated (INTERA), which represent a third phase of site assessment. These reports are titled *Hydrogeological Supplemental Site Assessment* (HSSA) (INTERA, 2018a) and *Tailing Impoundments Water Balance Modeling* (INTERA, 2018b). The Utah Division of Waste Management and Radiation Control (DWMRC) reviewed these two reports and responded with a Request for Additional Information (RAI) on April 17, 2019 (DWMRC, 2019). As requested, RAML has prepared this *Work Plan for the Hydrogeological Supplemental Site Assessment, Phase 4, Lisbon Facility* (Work Plan). The DWMRC's comments and RAIs indicated an agreement with RAML's findings that additional characterization to fill data gaps, as described in the HSSA (INTERA, 2018b), is a necessary next phase for developing revised Alternate Concentration Limits (ACLs) and ultimate termination of RAML's Radioactive Material License Number UT 1900481 (License).

The site investigation activities described in this Work Plan (Phase 4 investigation) will improve the understanding of the site geology, hydrogeology, geochemistry, as well as the nature and extent of chemicals of concern, transport and attenuation mechanisms, and migration and exposure pathways to support refinement of the Conceptual Site Model (CSM). The improved CSM will provide a solid foundation for (1) addressing the DWMRC's RAIs, (2) updating the flow and transport model and developing revised ACLs, (3) terminating RAML's License, and (4) ultimately transferring the Site to the Department of Energy (DOE) Legacy Management Office. If changes to the investigation activities or approach described herein are warranted based on preliminary field results, the proposed changes will be discussed with DWMRC prior to implementation.

Each of DWMRC's RAIs (DWMRC, 2019) has been assigned a specific request number as detailed in **Appendix A**. Each specific request is addressed within one or more of the Work Plan elements described below. Additionally, Data Quality Objectives (DQOs) have been developed for specific Work Plan elements and are provided in **Appendix B**. DWMRC's RAIs, the Work Plan elements, and relevant DQOs are cross-referenced in **Table 1**.

The Work Plan elements are organized by purpose. Some elements describe new monitoring wells, cores, and other types of characterization that are proposed for the Site (**Figures 1** and **2**). Justification for new monitoring wells and cores is provided in **Table 2**. Context for new monitoring wells and cores is given in the section(s) in which they address a specific work element.

Details about drilling, coring, geophysical logging, monitoring well installation, and aquifer testing are provided in Section 2.9.

**Table 1. Work Plan Elements Related to DWMRC's RAI (Appendix A).**

| Work Plan Section | Element | Relevant DQO | DWMRC Specific Request |
|---|---|---|---|
| 2.1 | Re-evaluate tailings water balance to determine long-term seepage rates | 1 | RAI-1, RAI-2f |
| 2.2 | Additional evaluation of surface water/groundwater interactions to the north-northwest of the Site | 2 | RAI-2c |
| 2.3 | Fault influence on groundwater flow | 3 | RAI-2a |
| 2.4 | Determine if natural mineralization has caused impacts to water quality at MW-124 | 4 | RAI-2b, RAI-2e |
| 2.5 | Evaluate stock well pumping effects on groundwater flow | 5 | RAI-2d |
| 2.6 | Evaluate groundwater treatment options for the northern plume | 6 | RAI-3 |
| 2.7 | Determine appropriate background levels and update the COC list | 7 | RAI-2e, RAI-2f, RAI-5, RAI-6 |
| 2.8 | Additional wells to monitor plume migration and aquifer boundaries | 8 | RAI-2g, RAI-4 |
| 2.9 | Details of coring, monitoring well installation, aquifer testing | 2, 3, 4, 5, 8 | RAI-2a through 2e and 2g, RAI-4 |
| 2.10 | Update the CSM and groundwater flow and transport model | 8 | RAI-2g |
| 2.11 | Calculation of revised ACLs and TALs | | |
| 2.12 | Reporting | | |

**Notes:**

ACL=Alternate Concentration Limit

COC= constituent of concern

MW = monitoring well

TAL= Target Action Level

## Table 2. Objectives for Proposed Wells and Cores at the Lisbon Site.

| Proposed Well | Location | Objective |
|---|---|---|
| MW/C-130 | NE of subsidiary fault (footwall?) | Characterize aquifer properties near spring (CWS-1) (groundwater flow direction and water quality), collect core for rock chemistry and attenuation evaluation, perform aquifer test near spring and subsidiary fault for model input parameters |
| MW-131 | Near SW-1 | Evaluate water quality near potential exposure pathway; determine depth of alluvium, characterize hydraulic parameters, and monitor groundwater effects from pumping in SW-1. |
| MW-132S | SW of LVF in alluvium | Characterize alluvial aquifer properties near LVF |
| MW/C-132D | SW of LVF in BCA (footwall of LVF) | Characterize Navajo Sandstone aquifer properties near LVF, collect core for rock chemistry and attenuation evaluation, perform aquifer test near LVF |
| MW-133S | NE of LVF in alluvium | Characterize alluvial aquifer properties near LVF |
| MW/C-133D | NE of LVF in BCA (hanging wall of LVF) | Characterize BCA aquifer properties near LVF, collect core for rock chemistry and attenuation evaluation, perform aquifer test near LVF |
| MW-134 | North of WCW | Determine groundwater levels for use in calculating flow directions and hydraulic gradients near the WCW |
| MW/C-135 | SW of subsidiary fault (hanging wall?) | Characterize aquifer properties near spring (CWS-1) (groundwater flow direction, hydraulic gradients, and water quality), collect core for rock chemistry and attenuation evaluation, perform aquifer test near spring (CWS-1) and subsidiary fault |
| MW/C-136 | South of MW-129 in southern aquifer | Improve spatial coverage for monitoring groundwater quality in the southern plume. Provide inputs to the groundwater flow and transport modeling, collect core for rock chemistry and attenuation factor evaluation |
| MW/C-137 | NW corner of LTI toe | Establish groundwater quality near the LTI, collect core for rock chemistry and attenuation factor evaluation |
| MW/C-138 | NW of MW-124 | Establish groundwater quality and type north of the LTSM boundary, collect core for rock chemistry and attenuation evaluation |
| C-124-Alt | Near MW-124 | Collect core adjacent to well MW-124 to provide visual evaluation of fracturing and mineralization and to provide additional rock samples for rock chemistry analysis. |

**Notes:**

Aquifer tests will be conducted on all wells as part of aquifer characterization to inform the flow model.

All bore holes will be geo-physically logged.

NE = northeast

NW = northwest

SW = southwest

LVF = Lisbon Valley fault

BCA = Burro Canyon Aquifer

LTI = Lower Tailing Impoundment

LTSM = Long-term surveillance and maintenance

C = core

MW = stands for monitoring well

# 2.0 WORK PLAN ELEMENTS

Since submission of the HSSA (INTERA, 2018a), additional work to address data gaps has been performed during a noninvasive Data Gap Assessment (DGA) field program that took place from Fall 2018 through Spring 2019. The approach to the DGA, combined with the additional proposed work discussed below, represent the Work Plan tasks necessary to further characterize the Site, update the CSM, inform the flow and transport model, and ultimately lead to calculation of revised ACLs and Target Action Levels (TALs) for the Site. Details and results from the DGA work will be combined with the results obtained from the implementation of this Work Plan and documented in a Hydrogeological Supplemental Site Assessment, Phase 4 (HSSA4) report. Additional reports stemming from this Work Plan will include a revised Site Water Balance Report and a Background Evaluation Report.

## 2.1 Tailings Water Balance

In order to address DWMRC's RAI-1 and RAI-2f and to better characterize long-term percolation values, site-specific data will be collected to determine natural recharge rates. These data will also provide inputs for evaluating potential improvements (updated design) to the Lisbon Facility's tailing impoundment covers.

The goal of this task is to provide site-specific data that will improve the calibration of the initial water balance simulations from the Hydrologic Evaluation of Landfill Performance (HELP) model (INTERA, 2018b). The preliminary estimated moisture flux rates through the Upper Tailing Impoundment (UTI) and the Lower Tailing Impoundment (LTI) under current cover conditions will be refined and then applied to the calibrated model. The model would then be used to evaluate possible future cover configurations that could minimize long-term percolation of moisture through the tailings profile. To accomplish this, RAML proposes the following:

- Collect data to estimate the natural recharge rate to groundwater at selected locations in the vicinity of the Site [natural recharge (NR) locations shown on **Figure 1**]. The chloride mass balance (CMB) method (described further below) will be used to estimate natural recharge.
- Develop HELP model profile(s) simulating the surrounding natural conditions and calibrate the HELP model to the estimated natural recharge.
- Collect data to better understand the evaporative zone depth of the current covers over the UTI and LTI.
- Simulate moisture flux through the current UTI and LTI covers using the calibrated HELP model and refined evaporative zone depth data in order to update long-term estimated flux values for the existing impoundment covers (as appropriate).

- Apply the calibrated HELP model to simulation of long-term flux rates through the UTI and LTI for hypothetical future cover configurations and source input to the groundwater flow and transport model.

The following section provides additional detail for the proposed work.

### 2.1.1 Natural Recharge Field and Laboratory Evaluation

This field investigation is designed to estimate the natural recharge of precipitation (deep percolation to groundwater) in undisturbed area(s) in the vicinity of the UTI and LTI, and to investigate evaporative zone conditions in natural, undisturbed areas. Areas selected for natural recharge investigation will be limited to a surface slope of 1 to 3% in order to reflect the top slopes of the current UTI and LTI impoundments and possible future enhancements to the UTI and LTI covers.

Stephens and Coons (1994) describe the methodology for using the CMB method of estimating natural recharge to corroborate percolation rates calculated through a municipal solid waste (MSW) landfill using the HELP model. The CMB method has been widely applied in semi-arid climates (Stone, 1984; Phillips et al., 1987; Dettinger, 1988; Scanlon and Richter, 1990). The CMB method recognizes that the principle source of chloride ions in the soil-water profile is chloride in precipitation. As precipitation infiltrates, chloride accumulates in the soil and is concentrated by evapotranspiration (ET) within the root zone. At equilibrium, the mass rate of chloride input to the soil from precipitation will equal the mass rate of chloride output to the water percolating below the root zone. In the HELP model, precipitation rate, chloride in the precipitation, and ET rates are assumed to represent long-term averages. As such, the flow and transport are in steady state. Application of the CMB method assumes that water percolating below the root zone eventually becomes recharge to groundwater. Under ideal conditions, chloride would be expected to increase in concentration with increasing depth and reach a constant value below the depth where neither evaporation nor ET are significant.

The details of this task are summarized as follows:

- **Figure 1** shows the locations of six shallow borings and associated shallow test pits ("NR" designations – bright green circles). Using a portable hollow-stem auger (HSA) drill rig (or similar), each boring will be drilled through unconsolidated alluvium to bedrock refusal, or up to approximately 30 feet (ft) below grade to collect representative samples of the alluvial profile to total depth.
- A split-spoon sampler will be driven at selected depth intervals in each boring to total depth. In addition to collecting samples for laboratory determination of soil index properties (geotechnical properties), samples will be collected for determination of chloride

concentration. Selected samples will be sent to the laboratory for determination of saturated hydraulic conductivity and unsaturated hydraulic conductivity characteristics.

- Samples in the field will be logged and identified by a qualified geologist or engineer, and boring logs will be constructed from the field and laboratory characterization of the soil samples.
- Adjacent to (within 5 to 15 ft) each boring location, a rubber-tired backhoe will be used to excavate a short, shallow trench (approximately 4 ft in depth and 8 to 10 ft in length). In each trench the soil and rooting profile will be characterized, and trench logs will be developed for each location.
- Both the boring and trench at each location will be backfilled with native materials.

### 2.1.2 Impoundment Covers Field Evaluation

This task is a field investigation to better understand and document the evaporative zone conditions within the existing UTI and LTI covers. The details of this task are summarized as follows:

- At four to six locations (to be determined by the Site Engineer) on each of the UTI and LTI, a rubber-tired backhoe will be used to excavate a short, shallow trench (approximately 3 to 4 ft in depth and approximately 8 to 10 ft in length). In each trench the soil and rooting profile will be characterized, and trench logs will be developed for each location. Soil moisture sensors may be installed in at least two trenches, one on the LTI and one on the UTI, to aid in the tailings water balance modeling. The soil moisture sensors installed in a series along a depth profile will assist in quantifying runoff, storage, and infiltration into the tailings cover system.
- Prior to excavation, the rock cover with be removed and stockpiled for replacement after the trench is backfilled. Any cover materials with distinguishing characteristics (i.e., clay versus sand, etc.) excavated from the trench will be segregated into distinct spoil piles so that the cover profile at each location can be recreated to the extent practicable when backfilling takes place.
- The trench at each location will be backfilled with native materials as described above. Compaction of the replaced cover materials will be accomplished with the bucket of the backhoe in no greater than 8-inch lifts. Stockpiled rock will be placed on top of the re-compacted cover materials.

### 2.1.3 Calculation of Natural Recharge Rate and HELP Modeling of Natural Soil Profile

In this task the rate of natural recharge to groundwater in the vicinity of the Site will be determined through the CMB method (see Section 2.1.1), and the HELP model will be calibrated to this site-specific recharge rate. The details of this task are summarized as follows:

- Rate(s) of natural recharge will be calculated from the field and laboratory data measured in nearby native undisturbed soils (Section 2.1.1).
- HELP model profiles of natural conditions will be developed from the boring and trench logs (Section 2.1.1).
- Water balance modeling will be conducted to calibrate the HELP model to natural, undisturbed recharge rates.

### 2.1.4 Refined HELP Modeling of Existing UTI and LTI Covers

This task includes refinement of the HELP model for the UTI and LTI existing covers based upon calibrated natural conditions as well as supplemental information about the evaporative zone conditions within the existing covers collected during the field work described in Section 2.1.2.

The details of this task are summarized as follows:

- Model input data based on 2016 borings will be updated with new evaporative zone depth information from the impoundment cover trench logs (Section 2.1.2).
- Simulations will be run on the newly calibrated model to refine the long-term estimated flux values through the existing impoundment covers.

### 2.1.5 Refined HELP Modeling of Design (Hypothetical) UTI and LTI Covers

This task includes water balance modeling of hypothetical vegetated covers for the UTI and LTI. The hypothetical covers may include layer analogues to surrounding natural conditions (slopes of 1 to 3%) and other potential covers designed to minimize deep percolation through the tailing profiles by enhancing soil water storage and encouraging ET. Advances in the science of cover performance and lessons learned from monitoring conventional covers has led to development of alternative options for renovating or transforming conventional covers into more sustainable ET covers (Waugh et al., 2009). A comprehensive and detailed performance review of new methods will be conducted with full consideration of the structural longevity requirements.

The details of this task are summarized as follows:

- Alternate cover configurations will be designed and evaluated using the calibrated UTI and LTI HELP models as a foundation control.
- Layers from the calibrated natural recharge HELP model profile will be conceptually applied as a cover to the UTI and LTI model profiles to mimic natural soil water balance conditions.
- Simulated long-term flux rates through the UTI and LTI for various cover designs will then be analyzed to determine the optimal performance configurations for a new cover and/or the most beneficial enhancements to the current cover.

- Climate change will be acknowledged within long-term evaluation modeling to better understand the potential impacts of changing temperatures and precipitation distribution on site operations from a design and operation standpoint. Multiple climate change scenarios will be simulated with consideration of the future climate projections for Lisbon.
- Evaluate potential changes to the source term inputs for the groundwater flow and transport model.

### 2.1.6 Natural Recharge and Water Balance Modeling Report

This task includes development of a revised Site Water Balance Report documenting the field investigations, analyses, modeling, and conclusions regarding the water balance performance of the existing UTI and LTI (and hypothetical) cover(s) to minimize deep percolation to groundwater to the degree practicably achievable.

The proposed report will focus on the water balance performance of the existing impoundment covers and hypothetical cover(s). The report will provide a basis for evaluating if enhancements to the existing covers or hypothetical new covers will meet performance criteria. Hypothetical new covers or cover enhancements impact other aspects of the Tailings Facility's performance and as-built conditions (e.g., dam safety, surface water management, groundwater quality, and construction completion reporting), which must be investigated and documented. As such, the proposed plan is, and resulting report will be, limited to evaluations of cover performance and conceptual-level design of hypothetical covers. Any decision to pursue enhanced or new covers for the impoundments will require additional follow-on studies, detailed analyses, and design to support the changed conditions and demonstrate the long-term maintenance issues referenced in Utah Administrative Code R313-24.

## 2.2 Surface Water-Groundwater Interactions

West Coyote Wash (WCW) is located north of the preliminary long-term surveillance and maintenance (LTSM) boundary. Determining the hydraulic relationship between surface water and groundwater in this area is critical for understanding how WCW could be potentially impacted by groundwater in the Burro Canyon Aquifer (BCA). Better understanding of surface water and groundwater interactions in this area is critical to flow and transport modeling and ACL development.

To address RAI-2c, INTERA installed hand-augered piezometers and stream gages along WCW during the DGA field program. During this field program, INTERA also measured stream discharge along WCW as it flows over the Lisbon Valley Fault (LVF) to determine whether the stream gains or loses groundwater near the fault. Note that recent work has revealed a distinction between the original LVF fault trace presented by Doelling (2004; referred to as "Doelling LVF" in figures) and a feature identified as the actual LVF in Electrical Resistivity Mapping (ERM) surveys (**Figure 1**; lines 1, 7, 8, and 9). The actual LVF in the northern area is referred to as "ERM LVF" in figures. Future work to address RAI-2c includes the installation of wells to the north and northwest of the preliminary LTSM boundary.

### 2.2.1 Piezometer and Stream Gage Installation

To better understand the possible connection between surface water and groundwater in WCW, shallow piezometers (PZ-10 through PZ-19) and stream gages (GS-2 and GS-3) were installed (**Figure 2**). The piezometers and stream gages were installed using a 3-inch hand auger. Soils encountered during augering were logged. Transducers were placed in all piezometers that intercept water and in stream gages to collect water level information. The piezometers were installed in soils near WCW and the spring (described below; **Figure 2**; CWS-1). Comparison of water levels in piezometers and stream gages will be used to calculate vertical and horizontal hydraulic gradients near the stream and, in conjunction with the soil types and estimated hydraulic parameters related to those soil types, provide an estimate of flow between the stream and groundwater. Additional piezometers and stream gages may be added as the need arises.

### 2.2.2 Stream Discharge Measurements

Measurements of stream discharge along WCW were collected using salt tracer slug injections following the methods outlined by Payn et al. (2009). Slug injection of a salt tracer allows for the calculation of discharge for a given measurement point along a small stream by measuring the dilution of a known mass of dissolved conservative tracer, in this case, NaCl. A slug of salty water is injected into the stream and, at a set distance below the injection, a measurement point is designated where electrical conductivity (EC) is continuously measured before, during, and after the salt slug passes. The EC measurements are then converted to chloride concentrations by calibrating to chloride concentrations measured in samples collected from the measurement point during the slug injection. A plot of chloride concentrations over time reveals the passing of the slug injection through the measurement point. The time it takes to complete one slug injection is the time between release of the slug, passing of the slug, and return of EC measurements to background values. Discharge at a measurement point is calculated by dividing the total mass of chloride injected by the integrated area under the curve on a plot of chloride concentrations versus time (also known as a breakthrough curve). During the slug injection, the maximum chloride concentrations in the stream remain below Secondary Maximum Contaminant Levels (Utah Code R309-200-6; 250 mg/L), and evidence suggests that slug injection of salt tracers does not impact macroinvertebrates, amphibians, and fish (Weikel et al., 2005).

Slug injections were conducted at various points along WCW from downstream to upstream. The net difference in discharge between two measurement points was determined by independent slug injections for each point. The presence of multiple ponds and highly vegetated sections of WCW limited the locations where slug injections could occur. In total, eight slug injections and discharge measurements were completed for six locations along WCW, downstream of a spring discovered during the DGA field program. Further discussion of this spring is provided in the next section.

### 2.2.3 Seep and Spring Geochemistry

A seep (LVS-1) was identified during the Phase 3 HSSA field work and is present along WCW where it flows over the ERM LVF (**Figure 3**). During the DGA field program, RAML and INTERA personnel discovered a spring (CWS-1) that feeds into WCW (**Figure 3**). Since discovery, each of these surface water features has been sampled at least once for field parameters and geochemistry. RAML will continue to monitor these surface water sites as part of the HSSA 4 program.

As described in the HSSA, surface water and nearby groundwater samples were collected from the area north and northwest of the preliminary LTSM boundary in April 2018 (INTERA, 2018a). The Coyote Wash spring (CWS-1) was sampled in October 2018. All samples were analyzed for various dissolved constituents, and the results are provided in **Appendix C**. In an effort to determine possible relationships between surface water and groundwater in this area, the geochemistry of surface water samples was compared to all groundwater samples across the Site, as well as a subset of nearby groundwater samples (**Figure 3**) that were determined to be unimpacted by tailings leakage and fault groundwater (INTERA, 2018a). The geochemistry of surface water and groundwater was compared using the same Principal Components Analysis (PCA) approach outlined in Section 4.2.3 of the HSSA (INTERA, 2018a). The data from samples collected in April and October 2018 (**Appendix C**) was added to the site-wide dataset tested with PCA in the HSSA (INTERA, 2018a, Table 4.2).

Preliminary PCA results show that the Lisbon Valley seep (LVS-1) is most geochemically similar to nearby groundwater sampling locations SW-1 and PZ-8, both south of the seep (**Figure 3**). Coyote Wash spring (CWS-1) is most geochemically similar to RL-5, West Well, and SW-1. Groundwater from RL-5 could be upgradient of the spring; whereas groundwater at SW-1 and the West Well are likely downgradient of the spring, but not necessarily hydraulically connected to the spring (**Figure 3**). Given the relatively low concentrations of constituents of concern (COCs) in CWS-1 and RL-5, the water issuing at the spring likely represents unimpacted, regional groundwater.

At this time, LVS-1 and CSW-1 do not appear to be impacted by either the mineralized fault or tailings seepage. These surface water features represent potential exposure pathways, however, so they will continue to be monitored. As described in the next section, new monitoring wells will also be installed near the seep and spring in order to provide data that can be incorporated into the flow and transport model.

### 2.2.4 West Coyote Wash Area Well Installation and Coring

Two sets of well pairs, MW-132S/D and MW-133S/D, are planned near WCW to characterize surface water-groundwater interactions north of the preliminary LTSM boundary near WCW. Wells MW-132S and MW-133S will also be used to evaluate the shallow alluvial aquifer underlying WCW near the LVF (**Figure 1** and **Table 2**)

Two ERM surveys (**Figure 1**, lines 10 and 11) were conducted parallel to, and on either side of the LVF to determine alluvial thickness near the ERM LVF. The ERM surveys will be provided in the HSSA4 Report. Results of these ERM surveys indicate that the alluvium may be up to 100 ft thick in this area. Seismic surveys can provide stronger contrasts between alluvium and the underlying bedrock and may be conducted parallel to and across the LVF in WCW. The results of the seismic surveys can provide a more definitive mapping of alluvium and help to establish the potential exposure pathways and model boundary conditions near WCW.

MW-132S and MW-133S will be drilled through the alluvium on the southwest (footwall) and northeast (hanging wall) side of the ERM LVF, respectively, close to where the fault crosses beneath WCW (**Figure 1**). Lithologic logs of the alluvium and aquifer test analysis will be used to estimate hydraulic properties of the alluvium on each side of the fault. Water levels in the alluvial wells will be compared to nearby surface water levels to indicate the type of hydraulic connection between the surface water and the groundwater. Aquifer tests will further characterize the degree of hydraulic connection between shallow groundwater and surface water.

The presence of spring CWS-1 (**Figure 1**) suggests that a geologic structure may be responsible for groundwater discharging at that location. A second set of wells, MW-130 and MW-135, will be installed into the BCA south of spring CWS-1 (**Figure 1**) on either side of the suspected fault (see Section 2.3.2 for further description).

Prior to well drilling, core holes will be drilled to provide a visual indication of fracturing, and to provide additional solid material for geochemical analysis and characterization of possible COC sources and attenuation. Details of well installation, coring, and aquifer testing are provided in Section 2.9.

## 2.3 Evaluating Fault Influence on Groundwater Flow

Determining the location of the LVF and subsidiary faults is important to identify potential additional controls on localized flow conditions in the area northwest of the preliminary LTSM (RAI-2a). In 2017, geophysical data was collected using ERM to better characterize the LVF within the preliminary LTSM boundary (surveys 1 through 4, 5a, and 5b) (**Figure 1**). To build on the data collected in 2017, an additional ERM investigation was completed from November 9 through December 7, 2018 (surveys 6 through 11) (**Figure 1**). Four of the 2018 surveys (surveys

6 through 9) were oriented perpendicular or nearly perpendicular to the strike of the LVF to monitor for the LVF and subsidiary faults running parallel to the LVF. Three of these surveys were conducted in the northwest area of the Site (surveys 7 through 9), and one was conducted near the LTI (survey 6). Two surveys (10 and 11) were conducted parallel to, and on either side of, the LVF to monitor for alluvial thickness and structural features oriented perpendicular to the LVF and roughly parallel to WCW (**Figure 1**).

### 2.3.1 Groundwater Flow Near the LVF

As discussed in the HSSA (INTERA, 2018a), shallow geologic formations southwest of the LVF are dry except for local saturations following very high precipitation years. This indicates that there is either no flow or very limited flow across the LVF from the BCA. This is also supported by the fault gouge identified in trenches and core collected at four locations that crossed the LVF (INTERA, 2018a).

Aquifer testing was conducted to assess whether there was a damage zone in the hanging wall of the LVF that exhibits an enhanced hydraulic conductivity (K). Even though aquifer test results were inconclusive, the core shows higher fracturing along the edge of the fault zone that may represent a higher-K damage zone. This suggests that a pathway may exist, allowing groundwater to flow in a direction along-strike or down-dip of the LVF. Also discussed in the HSSA (INTERA, 2018a), there may be downward flow along the fault near wells MW-116 and MW-126 (**Figure 1**). From evaluation of water levels in this area and compartmentalization in Lisbon Valley from subsidiary faulting parallel or subparallel to the LVF, it was determined that there may be some groundwater flow towards the fault in the area between the LVF and the LTI, but that flow rates are very low (INTERA, 2018a). Limited hydraulic communication between fault blocks is also observed further south along the LVF near MW-125 where compartmentalization due to subsidiary faulting is assumed responsible for the large offsets in water levels between MW-125 and wells in the center of Lisbon Valley (INTERA, 2018a).

One area where groundwater may have a strong component of flow towards the LVF is near WCW, north of the preliminary LTSM boundary. ERM results parallel to the LVF (**Figure 1**, surveys 10 and 11) indicate that the fault may be eroded beneath WCW, allowing groundwater to flow across the fault to the west. Results of ERM surveys 7, 8, and 9 crossing the LVF, (**Figure 1**) suggests that the fault may still be intact along those survey lines.

The original trace of the LVF was presented by Doelling (2004; referred to as "Doelling LVF" in figures). During trenching, coring, and well installation as part of the 2017 HSSA field investigation, the physical location of the LVF was confirmed to coincide with the suspected fault feature on the ERM surveys (INTERA, 2018a). The feature identified as the actual LVF in ERM surveys 1, 7, 8, and 9 is aligned with the splay fault that branches from the main fault to the southeast near well MW-107D (**Figure 1**) and the observed fault feature near the Lisbon Valley seep (**Figure 2**; LVS-1), and is referred to as "ERM LVF" in figures. Four wells will be installed to evaluate the ERM LVF underlying WCW including: MW-132S, MW-132D, MW-133S, and MW-133D (**Figure 1** and **Table 2**). The shallow and deep wells at the MW-132 and MW-133 well clusters will be drilled into the alluvium and the underlying bedrock, respectively.

Prior to well drilling, core will be collected at C-132D and C-133D to provide a visual indication of fracturing and additional solid material for geochemical analysis, and aid characterization of possible COC sources and attenuation processes. Aquifer tests in each well will characterize the hydraulic characteristics of the aquifer material and LVF. Details of well installation, coring, and aquifer testing are provided in Section 2.9.

### 2.3.2 Characterization of Subsidiary Faults

As discussed in the HSSA, subsidiary faults to the LVF most likely exist within Lisbon Valley near the Site (INTERA, 2018a). Similar subsidiary faulting has been well documented further to the south of the Site (Hahn and Thorson, 2006). The subsidiary faulting may be expressed as east-dipping faults roughly parallel to the LVF but with smaller displacement, antithetic faults northeast of the LVF dipping to the west, and splay faults that branch from the LVF. Determining the location of subsidiary faulting of the LVF is important to identifying structural controls on groundwater flow at the Site. Characterization of potential fault zones will rely on the ERM surveys described above.

To the south of Coyote Wash spring, a suspected fault is identified in ERM surveys 9 and 10 that may act as a structural control for the spring. ERM surveys 8 and 9 (**Figure 1**) provide evidence for the suspected fault. Two additional wells, MW-130 and MW-135 (**Figure 1** and **Table 2**), will be installed on either side of the suspected fault. Trenching will be used to first identify the location of the fault. Prior to well drilling and installation, core will be collected at C-130 and C-135 to provide a visual indication of fracturing, and to provide additional solid material for geochemical analysis and characterization of possible COC sources and attenuation processes. Water levels in the two wells will be compared to monitor for differences that may indicate the fault is acting as a barrier to flow. Aquifer tests will be conducted on each well while observing water levels in the well opposite the fault to provide further indication of the fault's influence on groundwater flow. Details of well installation, coring, and aquifer testing are provided in Section 2.9.

## 2.4 Water Quality in MW-124

The DWMRC's RAI-2b and RAI-2e highlight the remaining question of whether water quality in MW-124 is impacted by the northern plume, natural mineralization, or both. The HSSA describes the purpose and methods for drilling monitoring well MW-124 near the northern preliminary

LTSM boundary. MW-124 was constructed in September 2017 to help delineate the groundwater quality conditions downgradient from the northern plume. Uranium concentrations in MW-124 have ranged from 0.136 to 0.206 milligrams per liter (mg/L) since October 2017. These uranium concentrations are above the background value set for the northern BCA (MW-5 = 0.01 mg/L), and below the value set for the nearby point of exposure (POE) wells (0.32 mg/L).

The HSSA presents lines of evidence that suggest that MW-124 could be placed within or near a mineralized fault zone. These lines of evidence include (1) higher permeability based on large volumes of water produced during drilling and development and aquifer testing and (2) fine-grained layers, some of which contained sulfides that resemble those found in the mineralized sections of the LVF core samples (INTERA, 2018a). Given that the PCA presented in the HSSA indicates that uranium in groundwater near the LVF (the Doelling LVF and the ERM LVF line up in this area) in the vicinity of wells MW-126 and MW-116 appears to be naturally sourced, natural uranium mineralization near MW-124 could also account for the elevated uranium concentrations. To test this hypothesis, further evaluation will include (1) leaching of MW-124 drill cuttings and (2) coring near MW-124 (**Figure 1**, C-124 Alt, **Table 2**). Geochemical data for C-124 Alt (described below) and MW-124 groundwater samples will be compared to other core and groundwater samples collected to date to determine if the water type is representative of a mineralized zone, tailings impact, or a mixture of water types.

### 2.4.1 Leaching of MW-124 Drill Cuttings

During drilling of MW-124, cutting samples in the form of rock chips were collected and preserved every 5 or 10 ft below ground surface (bgs). Drill cutting samples were selected for a leach test based on similarities to the metal-rich layers in LVF core samples as described in the HSSA (INTERA, 2018a, Appendix 4E). The samples were located just above, within, and at the bottom of the screened interval of MW-124, covering the following depth intervals: 60 to 70 ft bgs, 70 to 80 ft bgs, 130 to 136 ft bgs, and 136 to 140 ft bgs. Drill cutting samples were sent to ACZ Laboratories, Incorporated (Steamboat Springs, CO) to be analyzed using Method 1312 (United States Environmental Protection Agency [USEPA], 1994). This method will be modified for leach testing on cuttings from MW-124 to use groundwater from upgradient well RL-4 as the leach fluid instead of the "synthetic precipitation" called for in the method. The leach fluid in Method 1312 is typically a dilute sulfuric-nitric acid solution, with a pH of 5.0 or 4.2. This leach fluid is not representative of conditions at the Site, so regional groundwater will be used instead. Geochemical analysis of leach fluids will follow standard methods. Method-specific analytical quality assurance/quality control (QA/QC) will be performed by an accredited laboratory and audited by INTERA.

### 2.4.2 Coring Near MW-124

The resolution of information obtained from drill cuttings is not as accurate as that obtained from drill core. As a result, drill core will be obtained near MW-124 (**Table 2**, C-124 Alt) during the next phase of drilling (**Figure 1**). Details of coring are provided in Section 2.9. The cores will be logged for rock type, fracturing, and mineralization. As described previously for the MW-124 drill cuttings, samples for further analysis will be selected based on similarities to the metal-rich layers in LVF core samples (INTERA, 2018a; Appendix 4E). Core samples from selected intervals will be analyzed for mineralogy and leachable metals. Mineralogy will be determined with X-ray diffraction (XRD), petrographic analysis, and scanning electron microscopy (SEM). Leachable metals will be determined by the method described in Section 2.4.1. These data will be used to identify potential chemical impacts to groundwater from naturally occurring minerals within the BCA.

## 2.5 Stock Well Pumping Impacts

The DWMRC's RAI-2d requests additional evaluation of local pumping impacts from a stock well on private land, SW-1, that is located north of, and adjacent to the northwest preliminary LTSM boundary (**Figure 1**). The well is used to irrigate crops during the growing season and to water livestock year-round. Pumping of SW-1 imparts a stress on the aquifer at the northwest corner of the groundwater flow system and represents a potential exposure pathway for both the north and south plumes. Reconnaissance of SW-1 was conducted in late 2018 to determine the depth and construction of the well. The well is located close to the ERM LVF and is thought to be completed in the alluvium. The pumping rates and volumes extracted over time are not known. Installation of a water level logger and flow meter will be proposed and completed with permission from the well owner.

Additional characterization of the aquifer near SW-1 will include installation of a monitoring well, MW-131 (**Table 2**), near the stock well (**Figure 1**). Well MW-131 will be drilled to a similar depth as SW-1. Since SW-1 is assumed to be installed in alluvium, it is anticipated that MW-131 will also be installed in alluvium to allow monitoring in the same aquifer as SW-1. Aquifer tests conducted on MW-131 while monitoring water levels in SW-1 will provide data for characterizing aquifer parameters and for evaluating groundwater pathways in the area. Groundwater will be sampled in MW-131 and samples will be submitted for laboratory analysis. The data collected from both SW-1 and MW-131 will be used to inform the CSM and the flow and transport model.

## 2.6 Groundwater Treatment Options

The DWMRC requests an evaluation of treatment options for currently impacted groundwater in in the BCA (RAI-3). This type of evaluation was performed as part of the most recent ACL application (Lewis, 2001), which considered the following options: (1) natural attenuation, (2) source control or containment, (3) groundwater extraction, (4) groundwater injection and extraction, (5) active and passive *in situ* treatment, and (6) various water treatment and disposal technologies (Lewis, 2001). The most recent ACL application also described the corrective action activities implemented at the Site up to that time. Early corrective action programs initiated in 1982 included an attempt to create a grout curtain and install extraction wells, both in the northern BCA (Lewis, 2001). Both programs were abandoned due to improper sealing of the curtain and poor well yields, respectively (Lewis, 2001). The longer-term Corrective Action Program (CAP) began in 1990 and was designed to intercept tailings seepage by pumping groundwater from four wells in the northern BCA and two wells in the southern BCA. The extracted groundwater was then discharged into ponds for natural and enhanced evaporation. Lewis (2001) notes that over ten years of CAP operation, a significant mass of COCs was removed from the system, but groundwater quality did not improve, especially in the northern BCA. Ultimately, the CAP was terminated when the ACL application was approved by the Nuclear Regulatory Commission (NRC) in 2004.

The above treatment options will be re-evaluated considering technological advances in recent decades, and the more detailed CSM informed by additional site data. Because uranium is the most mobile among the COCs, uranium will be the element of highest priority when evaluating possible treatment options. This evaluation will focus on pre-existing treatment systems used to remediate uranium at other sites and consider the feasibility of such treatment systems at the Site. The feasibility of a given treatment system will depend on site conditions. The treatment evaluation will consider known and estimated site conditions, design and installation practicality, and overall cost-benefit analysis. Evaluated technologies will be ranked, and the highest-ranking options will be recommended for consideration.

## 2.7 Background Concentrations and COC Evaluation

The DWMRC's RAI-2e, RAI-2f, and RAI-5 refer to the need for an updated evaluation of background groundwater conditions at the Site, and RAI-6 requests an evaluation of the potential need to update the list of COCs for the Site. Geochemical analysis presented in the HSSA revealed several issues relating to background concentrations established for the Site (INTERA, 2018a). These issues include the following:

- Multivariate statistics showed that different water types exist within the preliminary LTSM boundary, including three different types of background groundwater. Background groundwater at the Site includes (1) upgradient northern BCA; (2) upgradient southern BCA; and (3) fault-impacted BCA. Background concentrations of COCs are variable among these groundwater types. At sites with significant spatial variation in the natural background, the intrawell approach is more appropriate than the interwell approach to background comparisons (USEPA, 2009). Intrawell analysis compares new well data to its own historical data and assumes that the well has not been impacted by human activities. Using this approach, background at the Site can be determined more locally.

- Background levels for some COCs set for the two background wells in the License, MW-5 and MW-13, are lower than what would be recommended based on statistical analysis of current, complete datasets. Documentation for how these background levels were determined is lacking in historical records.
- The current list of COCs in the License is limited, and an evaluation of additional potential COCs is necessary.

Each of these issues will be addressed in a single report (Background Evaluation Report). This report will include statistical analysis of upgradient and fault-impacted wells and comparison of constituent concentrations to drinking water standards and appropriate background levels. Further details on how this evaluation will be conducted are provided below.

### 2.7.1 Statistical Analysis of Upgradient and Fault-Impacted Wells

Statistical analysis of upgradient and fault-impacted wells will be completed following the USEPA guidance for calculating background values from groundwater monitoring data (USEPA, 2009). Statistical calculations will be performed with the R (v.3.5.3) and ProUCL (v.5.1) software programs. Datasets will be analyzed for summary statistics, type of distribution, time-series trends, and outliers. Proposed background concentrations will be based on estimates of the upper limits for each dataset. These upper limit estimates will depend on the distribution type and the presence or absence of significant time-series trends. For example, the mean plus two standard deviations is an appropriate upper limit estimate for normal distributions, but when a distribution is non-parametric, upper tolerance limits or upper prediction limits may be more appropriate (USEPA, 2009). Datasets for all wells included in the analysis will be compared to one another to test for heterogeneity. Significant differences among datasets will support the need for an intrawell approach to establishing background at the Site.

Mixing analysis like that described in the HSSA (INTERA, 2018a, Section 4.2.4) will be used to differentiate background groundwater areas. The wells for the background evaluation will include, but are not limited to, those presented in **Table 3**. The wells in **Table 3** were chosen based on water levels (INTERA, 2018a, Figure 3.15) and/or fault-impact as determined and presented in the HSSA (INTERA, 2018a, Figure 4.7). The well locations, designated water types, and number of unique sampling events that have already been completed for the current COCs (arsenic, molybdenum, selenium, uranium) are presented in **Table 3**.

Table 3. Wells to be Included in the Background Evaluation.

| Well Location | Water Type | Number of Completed Sampling Events |
|---|---|---|
| LW-1 | upgradient northern BCA | 27 (all COCs) |
| MW-5 | upgradient northern BCA | 105 (As), 82 (Mo), 134 (Se), 70 (U) |
| MW-100 | upgradient northern BCA | 9 (all COCs) |
| MW-104 | upgradient northern BCA | 8 (all COCs) |
| H-63 | upgradient southern BCA | 39 (As, Mo), 38 (Se), 37 (U) |
| MW-13 | upgradient southern BCA | 80 (As, Se), 65 (Mo), 79 (U) |
| MW-105 | upgradient southern BCA | 9 (all COCs) |
| MW-120 | upgradient southern BCA | 7 (all COCs) |
| UW-1 | upgradient southern BCA | 8 (all COCs) |
| MW-107S | fault-impacted | 7 (all COCs) |
| MW-116 | fault-impacted | 9 (all COCs) |
| MW-125 | upgradient southern BCA, fault-impacted | 6 (all COCs) |
| MW-126 | fault-impacted | 6 (all COCs) |

The USEPA guidance document (USEPA, 2009) recommends that at least 8 data points be considered in any statistical analysis for calculating background concentrations. **Table 3** shows that most wells included in the analysis already meet this criterion, except for MW-107S, MW-120, MW-125 and MW-126. These wells will have at least eight (8) data points following the sampling event in October 2019, so the background evaluation will be finalized after that time.

Some datasets for upgradient wells contain a notable proportion of non-detect (ND) results. In these cases, the proportion of ND values will determine how ND values are treated in the statistical analysis. At minimum ND proportions (1 to 3%), substitution of ND values with half the detection limit is acceptable, whereas at maximum ND proportions (e.g., > 50%), meaningful statistics for the dataset may not be possible (USEPA, 2009). Care will be taken to follow USEPA guidance for treatment of ND values in each dataset.

### 2.7.2 Updating Site COCs

The current list of COCs in the License includes arsenic, molybdenum, selenium, and uranium. Documentation for why these are the only constituents included in the License is lacking in available historical records. In 2015, a more comprehensive list of analytes began to be measured regularly in License and Hydrogeology wells. With an expanded analyte list, groundwater chemistry for all wells will be compared to Utah Code R317-6, and background levels determined for the Site, to assess the need for updates to the list of COCs. In addition, constituents that are uniquely elevated in the tailings porewater will be considered for inclusion in the list of COCs. For example, as shown in the tracer and mixing analysis (INTERA, 2018a, Section 4.2.4), tailings-impacted groundwater in the northern BCA contains nitrate concentrations that are greater than the Utah groundwater quality standard (10 mg/L), and greater than most other water types on site (INTERA, 2018a; Figure 4C.17). Tailings leakage is a likely source of nitrate on site, but given that MW-105, which is upgradient of tailings impact, also shows nitrate concentrations that are comparable to the tailings-impacted wells (data to be reported in the HSSA4), other sources are likely to exist.

## 2.8 Additional Aquifer Characterization and Plume Monitoring Wells

In addition to the new wells discussed previously, four additional wells (MW-134, MW-136, MW-137, and MW-138; shown on **Figure 1** and discussed in **Table 2**) are planned to 1) refine the northern hydrogeological boundary conditions and 2) define the geochemistry and extent and magnitude of uranium concentrations in BCA groundwater. Information obtained from these wells will be used to refine the boundary conditions and inputs to the groundwater flow and transport model.

Well MW-134 will be drilled to characterize the hydrogeology north of WCW. MW-134 will not be cored but an aquifer test will be conducted. Well MW-136 is proposed in response to the DWMRC's RAI-4 and will fill a spatial data gap in the southern aquifer plume down-gradient of the LTI, roughly between wells ML-1 and MW-129. Well MW-137 will be placed below and close to the LTI to provide groundwater quality information to support an appropriate source term. Proposed well MW-138 will be placed downgradient of MW-124 (**Figure 1**), in the BCA (INTERA, 2018a, Figure 4.6) and is strategically placed for long-term monitoring.

Wells MW-136, MW-137, and MW-138 will be cored. The cores will be logged for rock type, fracturing, and mineralization, and samples from the core will be submitted for geochemical analysis (see Section 2.9). Details of well installation, coring, and aquifer testing are provided in Section 2.9.

## 2.9 Field Implementation Plan

Eight core holes and 11 new monitoring wells are planned (**Figure 1** and **Table 2**) as part of the Phase 4 investigation. A Field Implementation Plan (FIP) will be completed prior to initiation of field activities. The FIP will include (but may not be limited to) a detailed description of the following preparatory and field activities:

- Confirm locations for new wells, cores, and borings to be installed.

- Design well pad configurations.
- Apply for well permits from the Utah Division of Water Resources.
- Clear underground utilities.
- Develop a health and safety plan to reflect site-specific requirements.
- Conduct trenching and drilling operations.
- Conduct well installation and well development.
- Conduct aquifer testing.
- Survey the new trenching and drilling locations.

Drilling operations on BLM land require appropriate approvals from the BLM. One aspect of the permitting process is for BLM to conduct wildlife surveys in the areas that will be disturbed to determine if there are sensitive areas where access restrictions are required. The surveys are conducted in March through May to allow for identification of raptor nesting sites. A similar approach will be applied to areas on private land where drilling is planned. Due to the time frame for obtaining drilling permits, it is anticipated that well drilling will commence in mid- to late-summer 2019. Trenching, coring, borehole drilling, geophysical logging, and well installation will follow methods established during the HSSA field investigation in 2017 (INTERA, 2018a).

Coring will follow procedures established during the 2017 HSSA investigation (INTERA, 2018a). Core will be logged for rock type, fracturing, and mineralization. Coring will also provide solid material for geochemical analysis and characterization of possible COC sources and attenuation. Samples of selected intervals of core will be analyzed for mineralogy, ferrihydrite content, and leachable metals. Mineralogy will be determined by XRD, petrographic analysis, and SEM. Ferrihydrite content and leachable metals will be estimated using the first three steps in a sequential leach procedure outlined by Dold (2003a). Each leach step targets the following fractions: (1) water-soluble elements; (2) exchangeable elements that are adsorbed to surfaces and substituted into mixed-layer clays; and (3) elements absorbed into Fe (III) oxyhydroxides, including ferrihydrite. The latter step targets the less crystalline (i.e., low order) ferrihydrite phase (Dold, 2003a, and 2003b), which is one of the first secondary iron phases to precipitate from solution at near neutral pH (Schwertmann and Cornell, 1991). The COCs released in steps 1 and 2 of the procedure will be considered part of the leachable fraction of the solids, including COCs that may be adsorbed to ferrihydrite, and step 3 of the procedure will provide an estimate of ferrihydrite content and the concentration of COCs absorbed by ferrihydrite. The combined results of these analyses will be used to estimate the most likely COC attenuation processes at a given location (e.g., sorption to ferrihydrite and/or ion exchange with clay minerals).

All core holes and borings will be geophysically logged. New monitoring wells will be constructed following Utah Division of Water Rights (2011) guidelines (**Appendix D**). Wells will be screened in the lower 20 ft of the aquifer and all wells will be developed. Methods for logging, well construction, and well development will follow methods and procedures established during the 2017 HSSA field investigation (INTERA, 2018a). Aquifer testing will be conducted using pneumatic methods, as was done during the HSSA field investigation (INTERA, 2018a), or standard pumping tests, depending on what is considered the most suitable method for a given location and whether pumped water would need to be treated as Investigation-Derived Waste (IDW).

## 2.10 Update CSM and Flow and Transport Model

The DWMRC's RAI-2g refers to filling data gaps in order to further refine the CSM and complete the groundwater flow and transport model. Once data collection, compilation, and analysis are completed, the CSM will be updated. The updated CSM will provide the basis for updating the numerical flow and transport model. Components of the model to be updated include:

- Alluvium-bedrock contacts and aquifer-aquitard contacts;
- Location and characterization (both structural and hydraulic to the extent possible) of faults, including the LVF and subsidiary faults of interest within Lisbon Valley;
- Identification of boundaries and boundary conditions northwest of the preliminary LTSM near WCW;
- Structural controls of Coyote Wash spring;
- Discharge rates of Coyote Wash spring as either a boundary condition or calibration target;
- Surface water-groundwater interaction in WCW, including addition of Rattlesnake Ranch Reservoir #2 as a boundary condition;
- Pumping at SW-1 to be implemented as a boundary condition in the model;
- Adding the low hydraulic conductivity zone within the BCA identified in the HSSA (INTERA, 2018a) into the numerical model;
- Evaluating options for COC source terms as described in the HSSA (INTERA, 2018a);
- Attenuation of COCs (described further in Section 2.10.1);
- Recharge estimates and distribution;
- Tailings leakage rates and concentration representing the source term in the model; and
- Incorporating newly collected water level and chemistry data as calibration targets in the model.

Geologic data collected during the investigation will be added to the geologic block model developed using Leapfrog software. The updated Leapfrog model will be used to produce an updated flow model grid that represents new interpretations of site geology and hydrogeology. The model will be calibrated to water level and chemistry data. Once the model is calibrated, a sensitivity and uncertainty analysis will be conducted, and predictive scenarios evaluated.

Predictive scenarios will include results of alternate cover configurations evaluated as part of the Tailing Water Balance (Section 2.1) and the effects of climate change. Climate change scenarios will be simulated based on future climate projections for the Site.

### 2.10.1 Estimates of COC Attenuation

Estimates of COC attenuation, including approaches to calculating COC partition coefficients (or distribution coefficients, also known as Kd values) are essential to: 1) support completion of the groundwater flow and transport model, and to 2) provide additional context for the approach to calculating Kd values, as outlined in the HSSA (INTERA, 2018a) and described further below. As described in previous sections, this Work Plan includes a broader distribution of core samples and additional analytical techniques to better characterize likely attenuation processes, which will in turn improve the representativeness of Kd calculations.

As noted in the HSSA, all COC concentrations appear to decrease between near-tailings wells and downgradient wells (INTERA, 2018a, Figures 4.3 to 4.6), due to dilution and/or attenuating reactions. The most likely attenuating reactions include ion exchange with clay minerals, sorption to solids, and precipitation. Quantifying the extent to which COCs are attenuated as a result of each of these processes is challenging. More commonly, the net effect of all attenuating processes is quantified with an empirical partition coefficient or distribution coefficient (Kd).

The Kd value can be expressed as the following:

$$K_d = \frac{C_{solid}}{C_{aqueous}} \qquad \text{(equation 1)}$$

where $C_{solid}$ mole per kilogram (mol/kg) is the concentration of the constituent associated with the solid, and $C_{aqueous}$ mole per liter (mol/L) is the concentration of the dissolved constituent remaining in solution, both at equilibrium.

USEPA reviewed different approaches to estimate Kd values and noted that the Kd model is an integral part of current methodologies for modeling contaminant and radionuclide transport and risk analysis (USEPA, 1999b). In this review, the USEPA describes some of the most common methods for determining Kd values for inorganic constituents as follows (USEPA, 1999a):

1) Laboratory Batch Method: solids from the field are reacted with solutions of varying compositions, including contaminant concentrations, and solid to liquid ratios. This method is relatively quick and inexpensive, but the results can be difficult to relate to the field.

2) Laboratory Flow-Through Method: solids from the field are reacted with solutions in a flow-through cell. This method is similar to the batch method, with the added advantage that using field flow rates, hydrodynamic effects such as dispersion can be measured. This method is relatively expensive and requires a lot of time.

3) *In situ* Batch Method: a saturated sample is collected from the field, then solids and liquids are separated and analyzed. This method is advantageous because it considers the solid and aqueous phases that are most relevant to the field, but samples can be expensive to collect and analyze.

4) Field Modeling Method: an iterative method that treats the Kd value as an adjustable parameter in a flow and transport model. This method is ideal when information about the solids in the aquifer are limited, and contaminant concentrations in groundwater are well characterized over time and space. This method requires a well calibrated groundwater flow model.

Among the methods for calculating Kd values described above, the *in situ* method was one of two methods applied in the HSSA (INTERA, 2018a). This method is more easily applied to saturated sediments than it is to saturated bedrock. As a result, the method was modified for the HSSA (INTERA, 2018a). Instead of measuring COC concentrations in the porewaters in contact with the core samples, which would be technically challenging, concentrations in the aqueous phase were used from groundwater collected from the eventual monitoring well.

Concentrations of COCs in the solid phase were based on whole-rock chemical analysis, which was largely unsuccessful given the relatively high detection limits for COCs in the presence of such high silicon and aluminum concentrations in the whole rock (INTERA, 2018a; Table 4H.1). The concentrations of COCs in the solid phase will be re-evaluated with a leach analysis, rather than a whole-rock analysis.

Core and/or cuttings from select existing and new wells will be analyzed in the same manner as described previously (Section 2.9). Samples will be analyzed for mineralogy, ferrihydrite content, and leachable metals (additional details provided in Section 2.9). The combined results of these analyses will be used to estimate the most likely COC attenuation processes at the given location (e.g., sorption to ferrihydrite and/or ion exchange with clay minerals). The concentrations of COCs associated with the leachable fraction and/or ferrihydrite fraction of the solids will be used as the concentration of COCs in the solids for the *in situ* Kd method. The COC concentrations measured in this way are less likely to be obscured by major elements (e.g., silicon), and are more representative of the portion of dissolved COCs that can be naturally attenuated.

In the USEPA's review of different approaches to estimate Kd values, they briefly describe "mechanistic adsorption models" (USEPA, 1999a). They note that these models are a less common way to estimate Kd values because they require collection of site-specific data, and inclusion of this information into computer codes that honor existing thermodynamic data for the elements of interest. These models account for "the dependency of Kd values on contaminant concentration, competing ion concentration, variable surface charge on the adsorbent, and solute species solution distribution" (USEPA, 1999a, pg. 2.26). As such, these "models become more robust and, perhaps more importantly from the standpoint of regulators and the public, scientifically defensible," (USEPA, 1999a, pg. 2.26).

The estimate of Kd values based on the "pH-dependent" approach outlined in the HSSA (INTERA, 2018a, Section 4.4.2.2) is an example of a mechanistic adsorption model. The Kd values calculated using this approach depended on measurements of ferrihydrite concentrations in the BCA at four different locations, and a complete suite of pH, redox potential, and major and trace elements in groundwater across the Site. In other words, this approach combined site-specific data with the thermodynamic data used to predict how elements will behave under certain environmental conditions. As expected, calculated Kd values differed over orders of magnitude across the Site depending on groundwater chemistry. Because Kd values determined this way tend to be more robust (USEPA, 1999a), the pH-dependent Kd values were used in the preliminary flow and transport model presented in the HSSA (INTERA, 2018a).

The additional characterization of BCA solids and associated COCs described in this Work Plan will be used to refine pH-dependent (i.e., mechanistic adsorption model) estimates of Kd values across the Site. These Kd values will then be compared to those calculated by the revised *in situ* Kd approach described above. At best, the Kd values determined using both approaches for a given location will be the same order of magnitude. The Kd values calculated using both approaches will provide reasonable upper and lower estimates of COC attenuation in different areas of the Site, thereby improving predicted COC transport in the future. These proposed improvements to modeling COC attenuation and transport will aid in selecting credible and defensible ACLs for the Site, and/or estimate necessary adjustments to the preliminary LTSM boundary.

## 2.11 New ACLs and TALs

ACLs are site-specific and constituent-specific groundwater protection standards assumed to be adequate for the compliance period of 1,000 years. It must be demonstrated that the proposed ACL at the Point of Compliance (POC) is adequately protective of human health and the environment at the POE. The License also includes additional compliance locations designated as trend wells with designated TALs.

The flow and transport model completed for the HSSA will be updated with the data collected during HSSA Phase 4. Following model calibration, predicted COC concentrations in space and time will be evaluated using this tool. Since the DWMRC requires that Utah drinking water standards (or background) be met for all areas outside of the LTSM boundary, the updated model will be used to evaluate COC flow and transport over a 1000-year period to determine ACL concentrations at the POC that will ensure POE concentrations are at or below the drinking water standards or background concentrations for each COC. This evaluation may include potential changes to tailings cap configuration, the location of the preliminary LTSM boundary, and/or the need for additional groundwater remediation in order to achieve this goal.

## 2.12 Reporting

Documentation of the work will be provided in a revised Site Water Balance Report, a Background Evaluation Report, and the HSSA4 report. The HSSA4 report will include (1) documentation of the 2018 and 2019 site characterization activities (e.g., drilling, aquifer testing, and groundwater sample analysis and interpretation); (2) the updated CSM; (3) a description of the flow and solute transport model; and (4) presentation of results, conclusions, and recommendations, including new ACLs. A meeting with the DWMRC to review the updated CSM will be held prior to completion of the HSSA4 report. A final draft report will include revisions based on comments from the DWMRC. After completion of the HSSA4 report and acceptance by the DWMRC, an ACL application and associated License amendment will be developed and submitted to the DWMRC.

# 3.0 SCHEDULE

The proposed schedule for the components of this Work Plan is provided in **Appendix E**. The Background Evaluation Report will be submitted in Spring of 2020. Tasks for the tailings water balance are scheduled to be completed by August 2020. The field components of this Work Plan started in 2018 and are scheduled to be completed in 2019, unless unexpected delays occur, in which case the field components will be completed in 2020. Possible delays in drilling are reflected in the schedule provided in **Appendix E**. Geochemical analysis of core samples will begin after collection and should be completed by Spring of 2021. Geochemical and hydrogeological modeling are scheduled to be completed by the Spring of 2021. Evaluation of groundwater treatment options will take place during the Spring and Summer of 2021. It is anticipated that the completed HSSA4 will be submitted in October 2021. RAML will work closely with BLM and DWMRC in order to meet this schedule.

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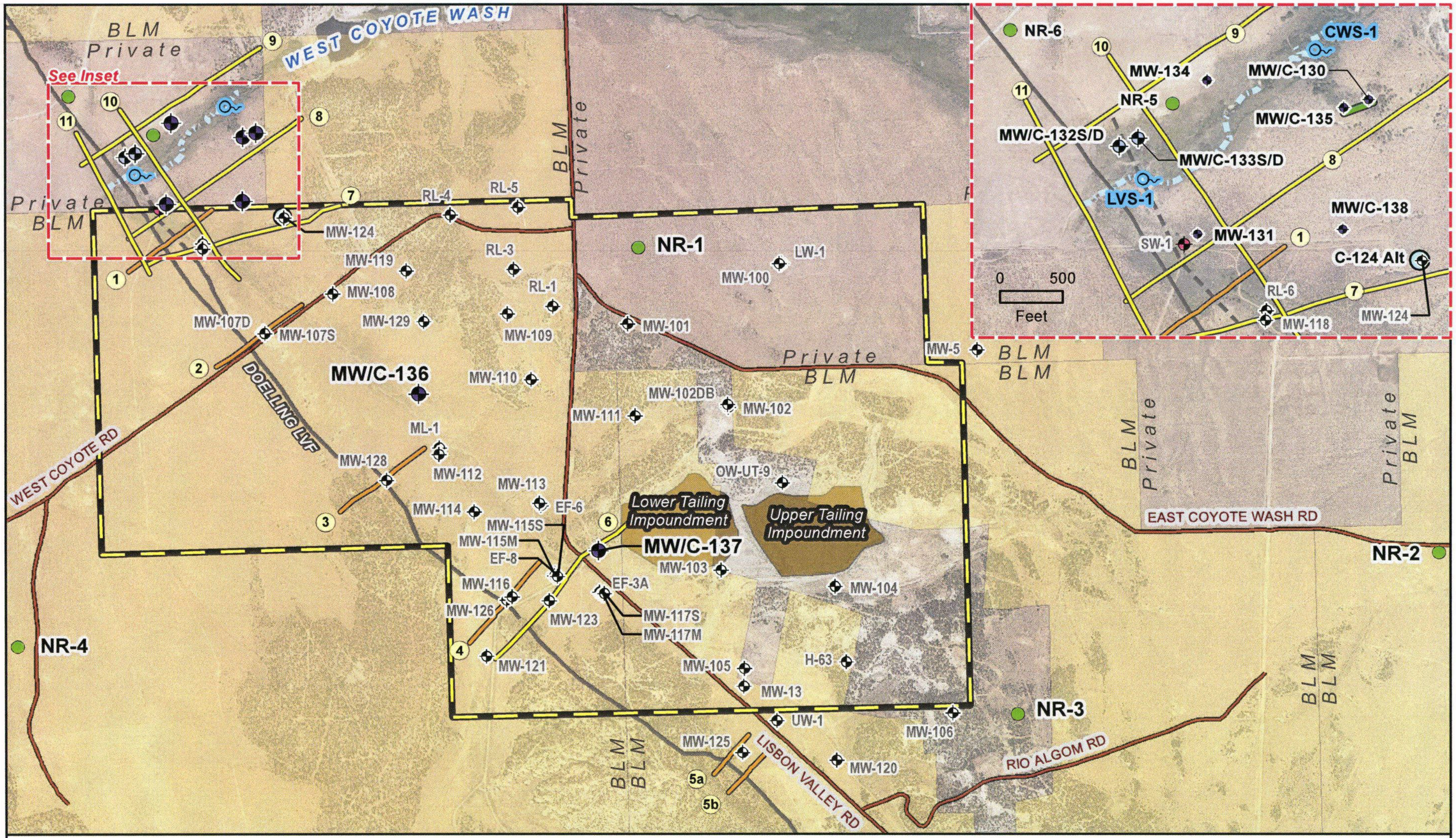
FIGURES




Preliminary Long Term Surveillance & Maintenance Boundary
Stream
ERM LVF
2018 ERM Survey
2017 ERM Survey
Proposed Trench

**Owner Agency**
BLM
Private
Existing Monitoring Well
Spring or Seep Sample

**Proposed Installations**
Monitoring Well
Nested Monitoring Well
Stock Well
Natural Recharge Point
Core Only

2,200 0 2,200
Feet
N

INTERA
Source(s): Aerial – NAIP imagery, dated 2018

Figure 1
Proposed Installations
Work Plan HSSA, Phase 4
Lisbon Facility

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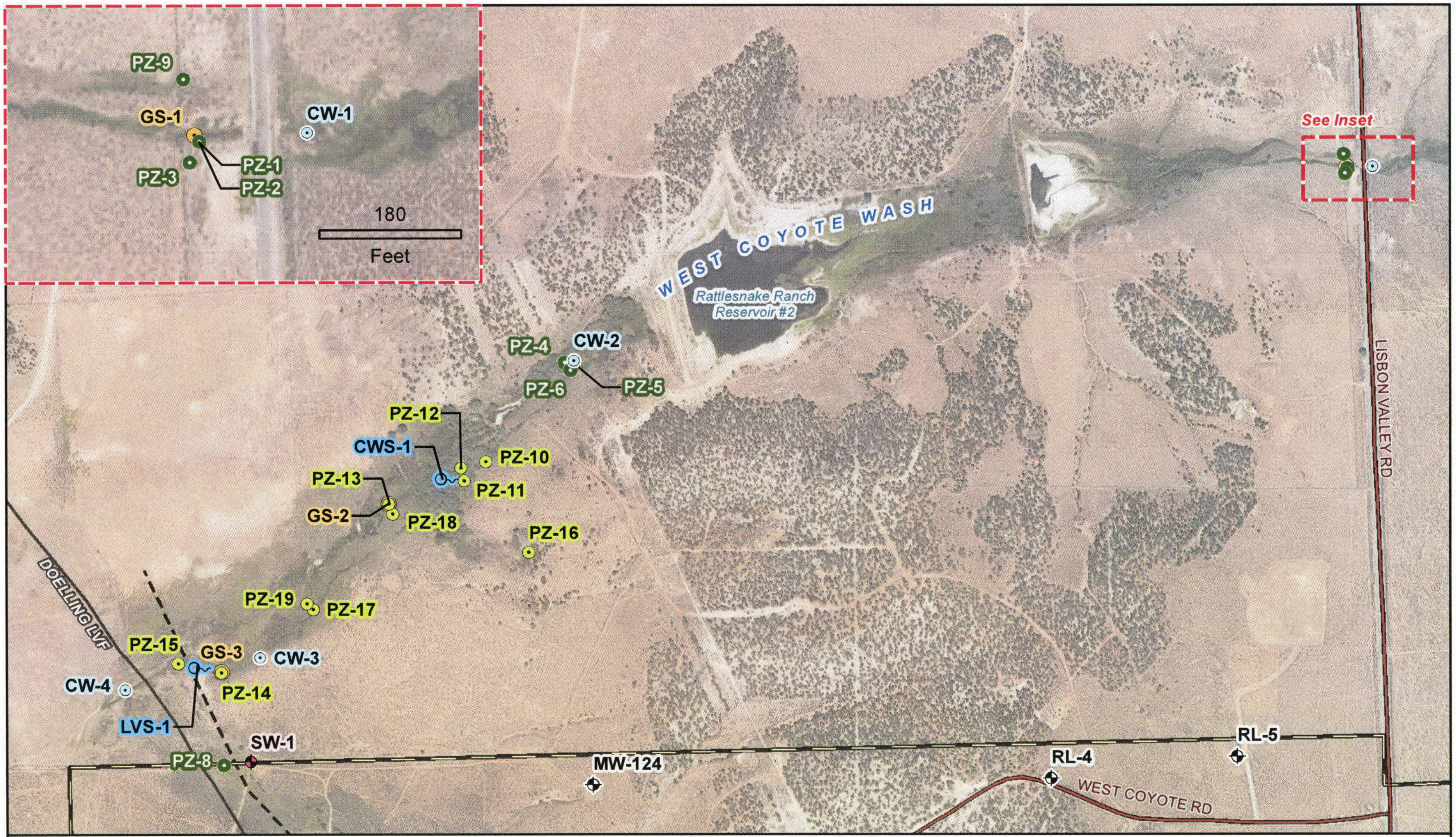


Preliminary Long Term Surveillance and Maintenance Boundary

ERM LVF*

**Station Type**

Monitoring Well

Stock Well

Gaging Station

Piezometer (Installed 2018-2019)

Piezometer

Surface Water Sample

Spring or Seep Sample

800 400 0 800

Feet

N

* Note: ERM LVF determined from ERM survey results.

INTERA

Source(s): Aerial – NAIP imagery, dated 2018

Figure 2
Piezometer Installation
Work Plan HSSA, Phase 4
Lisbon Facility

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Preliminary Long Term Surveillance and Maintenance Boundary

ERM LVF*

MW-110 Not included in analysis.

**Station Type**

Monitoring Well

Stock Well

Surface Water Sample

Spring or Seep Sample

Drinking Water Well

Piezometer

* Note: ERM LVF determined from ERM survey results.

1,600 800 0 1,600

Feet

N

INTERA

Source(s): Aerial – NAIP imagery, dated 2018

Figure 3
Surface Water and Groundwater Sample Locations
Work Plan HSSA, Phase 4
Lisbon Facility

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# APPENDIX A

## DWMRC's Request for Additional Information

## Appendix A. DWMRC's Request for Additional Information (RAI)

**RAI-1.** Per findings regarding the Tailings Impoundments Water Balance Modeling Report, it was noted that the final covers at the Facility are designed to meet performance objectives of limiting radon flux to the atmosphere but are not designed to provide an adequate EZD. Recommendations of the Tailings Report include a need to better characterize the percolation values for the tailings impoundments and to likely provide additional control to increase the EZD and decrease percolation through the bottom of the tailings impoundments.

**Request for Additional Information**: Per the tailings impoundments findings and discussion during a conference call on April 10, 2019, please provide a plan and time schedule to better characterize long term percolation values for the current cover, and proposed improvements (updated design) to the Facility tailings impoundment covers to reduce percolation rates into the groundwater.

The general goal or broad objective referenced in the Utah Administrative Code R313-24 and Criterion 1 of 10 CFR 40 Appendix A for siting and design decisions is the permanent isolation of 11e.(2) byproduct material by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance over a finite time frame, for at least 200 years as per Criterion 6. The primary emphasis of this Criterion is on the long-term isolation of 11e.(2) byproduct material, which is a function of both site conditions and engineering design, and shall be accomplished in a manner that no active maintenance is required. Proposed updates to the design cover should consider these long term maintenance issues and provide isolation of the tailings and reduction of tailings wastewater from percolation into the groundwater to the degree practicably achievable.

**RAI-2.** Per the HSSA Section 7.2, additional data needs to be collected to update the conceptual site model. The Division agrees that this information is needed in order to complete the flow and transport model. These issues are included in the request for additional information below.

**Request for Additional Information**: Per the HSSA Section 7.2, please provide a plan and schedule to complete the following bulleted items as recommended in the HSSA:

a) Provide further evaluation of the LVF's influence on groundwater flow to the north and northwest of the Site to provide the basis for specification of the flow-model boundary conditions in this area.
b) Provide further evaluation of potential localized flow conditions associated with the LVF and related subsidiary faulting. Specifically provide additional evaluation to support claims made that uranium concentrations in monitoring well MW-124 (nearly 4 times the uranium groundwater quality standard) are not being caused by the northern plume. Also provide additional study to support claims that downward leakage is occurring along portions of the LVF.
c) Provide further evaluation of surface water/groundwater interaction at the north-northwestern boundary of the LTSM and related potential boundary effects. Specifically provide additional data in the north-northwest area to evaluate flow and clarify the source of water discharging from the seep to the north of the site.

d) Provide further evaluation of local pumping on groundwater flow and transport at the northern LTSM boundary: Specifically provide additional evaluation regarding pumping well SW-1.
e) Provide further evaluation regarding the impacts of natural mineralization on groundwater quality at the site. Specifically provide additional information regarding claims that uranium groundwater concentration above the State groundwater standard (approximately 4 times the groundwater standard) are due to totally or in part to natural background uranium concentrations.
f) Provide additional evaluation regarding determination of groundwater background concentration and further evaluation of tailings leakage rates as discussed in the HSSA Section 7.2. These issues have been broken out into separate requests for information in this letter. It is noted, however, that these same needs for evaluation were identified by the RAML consultant.
g) Section 7.3 of the HSSA outlines strategies for site investigation to fill these data gaps. The Division agrees that these investigations are appropriate and requests that the outlined supplemental site investigation and geochemical analysis be completed.

**RAI-3**. Per review of the HSSA and preliminary flow and transport modeling efforts, and regarding increasing uranium concentration trends at point of compliance and trend monitoring wells in the northern plume, this data supports a need for consideration of additional plume treatment or entrapment to the degree practicable. In conjunction with conceptual and numerical modeling, the data also supports the need to evaluate the adequacy of the current long term monitoring surveillance boundary as adequate to maintain a boundary with groundwater constituent concentrations at or below the groundwater standard or agreed upon background concentrations. This objective should be determined in conjunction with the further evaluation listed in the "request for information" no. 2 above. A passive reactive barrier system and or other potentially feasible treatment systems is requested to be evaluated and included as part of the hydrogeological assessment to determine if appropriate conditions exist for construction and implementation.

**Request for Additional Information**: Per the contaminant transport findings based on current data and modeling assumptions and discussion during the April 10, 2019 conference call, please provide a plan and schedule to include an evaluation of treatment of the north contamination plume and an evaluation of contaminant transport with and without additional potential passive treatment.

**RAI-4.** Flow and transport of contaminants in the south plume, as delineated in the HSSA, are migrating through fractured and friable bedrock and on a path adjacent to the BCA (See HSSA Figures 4.2 through 4.6 esp. figure 4.6 delineation of the uranium plume based on recent median uranium concentrations). It was noted that monitoring wells are not in place in proximity of the plume along the northern areas of the plume. Trend wells should be placed in areas agreed to for long term monitoring of the plume and potential "dry zones."

**Request for Additional Information**: Provide a plan and time schedule for additional evaluation and proposed locations to monitor northwestern migration of the southern plume adjacent to the unsaturated BCA. Area of concern is to the east of trend well RL-1 between the plotted leading edge of the uranium plume and monitoring well MW-129.

**RAI-5.** Per the HSSA findings it appears that geochemical processes along the LVF have created a geochemical environment of naturally caused high concentrations of certain constituents in groundwater. Site background conditions should be evaluated using an appropriate statistical methodology. Part 7.3.2 of the HSSA identifies this issue as a needed element of site and plume characterization.

**Request for Additional Information**: Provide a plan and time schedule for evaluation of Site background conditions and an updated statistical evaluation including proposed background concentrations. As recommended in the HSSA, groundwater background should be evaluated on an intrawell basis.

**RAI-6.** Per meetings and discussions between the Division and RAML, evaluation needs to be conducted regarding an updated list of monitoring constituents (most prevalent constituents in tailings solution and mobile constituents in groundwater) to use for the HSSA and for long term and License required groundwater monitoring. This issue is additionally included in Section 7.3.2 of the HSSA which notes that there is no available historical information clarifying why the list of current list of "Constituents of Concern (COC's) (arsenic, molybdenum, selenium and uranium) was used.

**Request for Additional Information**: Provide a plan and schedule for evaluation and proposal for updated COC's to be used for groundwater monitoring at the site. Revised and approved COC's will be used for continuing hydrological assessment and as compliance based parameters to be used in the Facility License and Long Term Surveillance Monitoring Plan. The evaluation should consider the concentration and mobility of constituents in the tailings wastewater and/or LVF zone.

# APPENDIX B

## Data Quality Objectives for the Work Plan HSSA, Phase 4

# Appendix B. Data Quality Objectives for the Work Plan HSSA, Phase 4

| STEP 1<br>State the Problem | STEP 2<br>Identify the Goal of the Study | STEP 3<br>Identify Information Inputs | STEP 4<br>Define the Boundaries of the Study | STEP 5<br>Develop the Analytic Approach | STEP 6<br>Specify Performance or Acceptance Criteria | STEP 7<br>Develop the Plan for Obtaining Data |
|---|---|---|---|---|---|---|
| **DQO 1. Re-evaluate tailings water balance to determine long term seepage rates** | | | | | | |
| The Help Model is used to determine seepage rates for water leaving the tailing impoundment and entering the groundwater system Tailing seepage rates are used as source terms to the groundwater flow and transport model Uncertainties in data characterizing the tailing impoundments lead to uncertainty in the HELP Model results Improvements to the calibration of the initial water balance simulations using new data will reduce uncertainty and increase accuracy of the HELP Model predictions | The study consists of two field tasks to collect data for model calibration. The objective of the natural recharge (NR) laboratory and field evaluation is to collect information in undisturbed areas in proximity to the site that would provide information to calculate (estimate) historical long-term percolation of precipitation to groundwater (i e , recharge) in a natural setting The objective of the impoundment covers field evaluation is to better understand and document the evaporation-zone conditions within the existing UTI and LTI covers The new data will be used to inform the HELP Model This objective addresses RAI-1 and RAI-2f | Natural Recharge study A soil profile will be developed by advancing and inspecting soil borings and test pits at several undisturbed locations surrounding the tailings within the upper tens of feet of soil and alluvium Data to be collected will include soil moisture, permeability, total chloride, soil and rooting profiles, and trench logs Impoundment covers study Data to be collected from trenches in the covers include soil and rooting profiles, and trench logs | Natural Recharge study 6 borings up to 30 ft deep outside the impoundment area with an adjacent trench approximately 4 ft in depth and 8 to 10 ft in length. Impoundment cover study 4 to 6 trenches approximately 3 to 4 ft in depth and approximately 8 to 10 ft in length. The study period is indicated in **Appendix E** | Using a portable hollow-stem auger drill rig, split spoon samples will be used to collect soil samples Samples from split spoon sampler will be submitted for laboratory analysis of soil index properties (geotechnical properties) and determination of chloride concentration Selected samples will be sent to an established laboratory to determine saturated hydraulic conductivity and unsaturated hydraulic conductivity characteristics. For trenches near Natural Recharge auger holes and on the tailing impoundments, soil and rooting profiles will be developed. | Data for natural recharge analysis using chloride will be collected and analyzed using established methodology described in Allison and Hughes (1978) and Stephens and Coons (1994) All work will meet Good Engineering Practices. | A portable hollow-stem auger drill rig will be used to collect split-spoon samples at 6 sites. A rubber-tired backhoe will be used for trenching at 6 NR sites and 4-6 sites on each of the impoundments Soil and rooting profiles will rely on trench logs and photographic documentation of the trenches Samples from split-spoon samplers will be submitted to qualified laboratories for analysis of chloride concentrations, soil moisture, and saturated/unsaturated hydraulic conductivity The complete plan for obtaining data for this objective can be found in Section 2 1 |
| **DQO 2. Additional evaluation of surface water/groundwater interactions to the north-northwest of the Site** | | | | | | |
| West Coyote Wash (WCW) is located beyond the northern boundary of the Site. Its interactions with potentially impacted groundwater in the Burro Canyon aquifer are critical to flow and transport modeling, and ACL development | Locate areas where WCW is gaining or losing water If stream water is gained, determine if it is from alluvium and/or the BCA This objective addresses RAI-2c | Monitoring bore and core logs, lithologic and geophysical, water level and aquifer testing data; water level data and lithology from piezometers within the WCW drainage, WCW stream discharge measurements, surface water and groundwater geochemistry. | The study area is between the northern preliminary LTSM and WCW. To date, 19 piezometers have been installed in the WCW drainage, and two stream gauges have been installed in WCW. Water levels are continuously monitored in the piezometers and stream gauges Proposed wells in this area include MW-130, MW-131, MW-132D/S, MW-133D/S, MW-134, MW-135 WCW surface water and new monitoring wells will be sampled at least annually for a complete suite of analytes (e.g., INTERA, 2018a Table 4 2). Stream discharge measurements were carried out in November 2018. The study period for new work is provided in **Appendix E.** | Compare piezometer and well lithologic logs, compare water levels in piezometers and wells, measure for changes in stream discharge, evaluate aquifer test results for surface water influences, evaluate flows using model calibrated to site data, compare surface water and groundwater geochemistry considering the entire Site and just the WCW area. | Drilling, coring, well installation, and aquifer testing will be conducted using accepted practices consistent with the 2017 drilling program (INTERA, 2018a), monitoring wells will be of standard construction and will be consistent with well construction methods in 2017 to ensure comparability (INTERA, 2018a), water levels will be collected using calibrated sounders and pressure transducers that meet accuracy and precision requirements, aquifer tests will be conducted using pre-established methodology, pre-existing data (ERM, water level, aquifer tests, lithology) has been previously evaluated for representativeness and comparability, stream discharge measurements will follow (Payn et al , 2009) and precision will be determined with replicate measurements Geochemical analysis of surface water and groundwater will follow standard methods. Method-specific analytical quality assurance/quality control (QA/QC) will be performed by an accredited laboratory and audited by INTERA. Precision will be determined with replicate analyses | Piezometers and stream gauges were installed to monitoring surface water and shallow groundwater along and near WCW. Stream discharge measurements were conducted to determine whether WCW is a gaining or losing stream near the LVF ERM surveys were conducted to determine the location of faults and depth of the alluvium. Monitoring wells will be installed near WCW to determine groundwater flow directions and test for surface water influences during aquifer testing The complete plan for obtaining data for this objective can be found in Section 2 2 and Section 2 9 |

# Appendix B. Data Quality Objectives for the Work Plan HSSA, Phase 4

| STEP 1 State the Problem | STEP 2 Identify the Goal of the Study | STEP 3 Identify Information Inputs | STEP 4 Define the Boundaries of the Study | STEP 5 Develop the Analytic Approach | STEP 6 Specify Performance or Acceptance Criteria | STEP 7 Develop the Plan for Obtaining Data |
|---|---|---|---|---|---|---|
| **DQO 3. Fault influence on groundwater flow** | | | | | | |
| The Lisbon Valley Fault (LVF) was characterized in detail for the HSSA and found to be highly mineralized with numerous subsidiary faults. The system is complex and in one area of the fault, based on preliminary model calibration, groundwater may be flowing down the fault The northwest portion of the flow and transport model, including the northwest model boundary condition, may not accurately represent flow in that area which would affect groundwater flow and transport behavior in the model. | The goal of the study is to further evaluate the potential for some groundwater leaving the Site to flow down or across the Lisbon Valley Fault, identify subsidiary fault zones and determine the influence of these fault zones on groundwater flow, and to use this information to inform the CSM and the flow and transport model. This objective addresses RAI-2a. | Lithology, water level, and aquifer test data collected from new wells (MW-130, MW-132D/S, MW-133D/S, MW-135), trenching near MW-130 and MW-135, electrical resistivity mapping (ERM) data previously collected, existing geologic and hydrogeologic data collected during previous investigations | The entire Site plus the area north of the preliminary LTSM boundary near WCW Proposed wells for this objective include MW-132S, MW-132D, MW-133S, MW-133D, MW-130, and MW-135. New monitoring wells will be sampled at least annually for a complete suite of analytes (e.g., INTERA, 2018a Table 4.2). The study period is provided in **Appendix E** | Compare new ERM results with previous results, look for connections in trenching survey and monitoring well logs, compare aquifer testing results to results at other wells, compare water levels in wells on each side of the fault zone, incorporate the information into the groundwater flow model for the Site. Geochemical data collected from core and groundwater samples will be compared to all other core and water samples collected to date. Data analysis (flow, compartmentalization, mixing of different groundwaters using geochemistry) of groundwater near the fault will be conducted, the calibrated numerical flow model will be used to further assess flows towards the fault. | See drilling, coring, well installation, and aquifer testing criteria for DQO 2 Trenching will be conducted using accepted methods outlined for the 2017 field program (INTERA, 2018a) New ERM surveys were conducted by a qualified contractor | The additional ERM survey has been completed Trenching, coring, installation of additional monitoring wells, and aquifer testing will occur during the HSSA 4 drilling program. The complete plan for obtaining data for this objective can be found in Section 2 3 and Section 2 9. |
| **DQO 4. Determine if natural mineralization has caused impacts to water quality at MW-124** | | | | | | |
| Groundwater samples from MW-124 reveal concentrations of uranium several orders of magnitude above the State of Utah drinking water standards This well is very close to the preliminary LTSM Several lines of evidence obtained during the drilling of this well indicate that it may be located within a subsidiary fault to the LVF and groundwater conditions may be influenced by natural mineralization | Determine whether uranium concentrations observed at MW-124 are from natural mineralization or a result of impacts from the northern plume migrating from the tailings impoundment. This objective addresses RAI-2b and RAI-2e. | Results of leach tests conducted on MW-124 drill cuttings, geochemical results of core collected near MW-124 ( C-124), comparison of these new data to all hydrogeology and geochemistry results for the Site | This study will focus on MW-124 drill cutting leach results and C-124 characterization results These results will be available several months after the first phase of the next drilling program is complete These results will be compared to those for other samples previously reported in the HSSA The study period for geochemical analysis is provided in **Appendix E.** | Geochemical data collected from C-124 and MW-124 groundwater samples will be compared to all other core and groundwater samples collected to date to determine if the water type is representative of a mineralized zone, tailings impact or a mixture of water types Analytical methods for solids will include a modified Method 1312 leach of cuttings and core samples, and mineralogical characterization with X-ray diffraction, petrographic analysis, and scanning electron microscopy | Drilling and coring will be conducted using accepted practices consistent with the 2017 drilling program. Geochemical analysis of leach fluids, groundwater, and core will follow standard methods Method-specific analytical quality assurance/quality control (QA/QC) will be performed by an accredited laboratory and audited by INTERA Precision will be determined with replicate analyses. | Collection of core samples will occur during the next drilling program, and geochemical characterization will occur in the following several months. The complete plan for this objective can be found in Section 2 4 and Section 2 9 |
| **DQO 5. Evaluate stock well pumping effects on groundwater flow** | | | | | | |
| Rattlesnake Ranch, a private ranch to the north of the Site, has been using groundwater for irrigation and watering livestock for decades The existing production well for this activity, SW-1, is adjacent to the northwest corner of the preliminary LTSM boundary. The well is identified as a potential receptor for COCs and acts as an internal boundary in the aquifer. The well's influence on groundwater flow and transport is unknown | The goal of the study is to characterize the impact of pumping at SW-1 on groundwater flow The results will be used as input to the CSM and flow and transport model This objective addresses RAI-2d. | Existing inputs include the depth of the well and a video log of the well that shows the screen interval and condition of the well Data targeted for collection (pending land owner's permission) includes pumping schedule, transient water level, flow rate, and hydraulic parameters New monitoring well MW-131, to be installed near SW-1, will provide a lithologic log, water levels, and hydraulic parameters from aquifer tests. | Well SW-1 and nearby monitoring wells, especially new well MW-131 Water levels will be collected in SW-1 for a minimum of 1 year, flow measurements at SW-1 will be collected for a minimum of 1 year. Data collection at SW-1 per land owner's permission. The study period is provided in **Appendix E** | Install well MW-131 close to SW-1 and perform aquifer tests to estimate hydraulic parameters Install water level transducer and flow meter on SW-1. | A water level logger in SW-1 with acceptable accuracy and precision, calibrated flow meter with periodic verification measurements, lithology at MW-131 will be determined from rock chips collected during drilling by a qualified geologist, water levels in MW-131 will be collected with a calibrated sounder and water level logger with acceptable accuracy and precision, aquifer tests will be conducted using pre-established, industry-accepted methodology | A video log of this well has been collected. Obtain permission from current land owner to install a transducer and flow meter in SW-1 to gather data during a year of operation. An additional monitoring well MW-131 will be installed near SW-1 during the HSSA 4 field program. The complete plan for obtaining data for this objective can be found in Section 2 5 and Section 2.9. |

# Appendix B. Data Quality Objectives for the Work Plan HSSA, Phase 4

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|---|---|---|---|---|---|---|
| **DQO 6. Evaluate groundwater treatment options for the northern plume** | | | | | | |
| Uranium concentrations in some areas of the Site exceed Utah State Drinking Water Standards It may become necessary to implement an institutional control depending on the outcome of this phase of the investigation | Provide a preliminary evaluation of treatment options for BCA groundwater that could be considered if tailings-impacted water is predicted to migrate beyond the preliminary LTSM boundary. This objective addresses RAI-3. | Contaminant geochemistry, concentration trends, attenuation capacity, plume behavior, fault locations, remedial action objectives, background levels, hydraulic parameters, geotechnical data, model predictions, presumptive remedies, technology demonstrations, prior treatment evaluations for the site, and cost/benefit analysis | The entire Site and its immediate surroundings. The study period is provided in **Appendix E** | Based on estimates and assumptions, performance of pre-existing treatment systems will be evaluated for similarity and applicability to conditions at the Lisbon Site Evaluated technologies will be ranked by feasibility and the highest ranking options will be recommended for consideration. Data gaps will be identified during the evaluation | Provide a defensible list and ranking of treatment options | Complete the feasibility study to determine if appropriate conditions exists for construction and implementation. The complete plan for obtaining data for this objective can be found in Section 2 6 |
| **DQO 7. Determine appropriate background levels and update the COC list for the Site** | | | | | | |
| Constituent concentrations above screening levels at License background wells indicate an inadequate understanding of naturally-sourced constituent concentrations in groundwater, and background concentrations that may not be appropriate | The goal of this study is to determine appropriate background levels and COCs in each unique area of the Site. This objective addresses RAI-2e, RAI-2f, RAI-2g, RAI-4, RAI-5, and RAI-6 | Existing groundwater quality data for all wells, with a particular emphasis on those wells presented in Table 3 (Section 2.7), groundwater contours and flow directions, summary and multivariate statistics, mixing analysis to differentiate background groundwater areas. | The entire Site and its immediate surroundings USEPA guidance suggests that each well considered should have at least 8 data points This criterion will be met after the October 2019 sampling event The study period is provided in **Appendix E** | Mixing analysis, groundwater levels, and multivariate statistics will be used to differentiate background areas Summary statistics, distribution tests, time-series analysis, and outlier analysis will be employed to determine defensible background values on an intrawell basis Groundwater chemistry for designated background wells will be compared to Utah Drinking Water Standards and other background wells to evaluate for additions to the current list of COCs | Statistical evaluation and recommended background levels will follow USEPA's Guidance (USEPA, 2009) for calculating background. | Carry out an updated evaluation of background groundwater conditions and COC list for the Site The complete plan for obtaining data for this objective can be found in Section 2 7. |
| **DQO 8. Update the CSM and the numerical flow and transport model** | | | | | | |
| Significant data gaps exist in the Conceptual Site Model (CSM) and the numerical flow and transport model of the Site. The primary data gaps are associated with the potential migration of COCs across the preliminary LTSM boundary to the northwest towards surface water, a stock pumping well, and areas controlled by faulting | The goal of the study is to update the CSM and flow and transport models to provide more accurate predictions of COC migration over the 1,000-yr prediction period. This objective addresses RAI-2g and RAI-4. | Inputs include the current CSM (informed by cuttings and core lithologic logs; geophysical data, water level data from wells and piezometers, aquifer test results, rock samples, and groundwater geochemistry), the current flow and transport model, and new data of similar types collected from existing and proposed monitoring wells and core. | The entire Site and its immediate surroundings, especially the area north and northwest of the preliminary LTSM boundary, including WCW. All new data described in previous DQOs, and data from new wells MW-136, MW-137, and MW-138 will be used to update the model The study period is provided in **Appendix E** | Data collected at the Site, and the analysis of that data (e.g., aquifer test analysis), will inform the conceptual site model, the updated CSM will lay the framework for updates to the flow and transport model. | See drilling, coring, well installation, and aquifer testing criteria for DQO 2 The flow and transport model will be updated to reflect new data and the updated conceptual model of the Site, model calibration will be conducted using accepted industry methods and standards (Anderson et al., 2015, Spitz and Moreno, 1996) | Update of the models will be performed in three phases collection and analysis of new Site data, update the CSM, and update the numerical flow and transport model The complete plan for obtaining data for this objective can be found in Section 2 8, Section 2 9, and Section 2.10. |

# APPENDIX C

## Analytical Results for the Northern Area Surface Water and Groundwater Samples

## Appendix C
## Analytical Results for the Northern Area Surface Water and Groundwater Samples
### Work Plan HSSA, Phase 4
### Lisbon Facility

| Station Name | Description | Date | Dissolved Oxygen | Temperature | pH | Oxidation Reduction Potential | Total Dissolved Solids | Iron | Uranium | Arsenic | Calcium | Copper | Magnesium | Molybdenum | Potassium | Selenium | Sodium | Bicarbonate | Chloride | Sulfate | Dissovled Organic Carbon | Bromide |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units | | | mg/L | C | s.u. | mV | mg/L | | | | | | | | | | | | | | | |
| CW-1 | WCW surface | 4/19/2018 | 14.5 | 6.5 | 8.24 | 26.2 | 1270 | <0.02 | 0.0032 | <0.001 | 206 | <0.005 | 38 | <0.001 | 1 | <0.001 | 139 | 338 | 37 | 623 | 3.0 | 0 1 |
| CW-2 | WCW surface | 4/19/2018 | 7.19 | 4.7 | 7.75 | -87.8 | 736 | 0.08 | 0.0005 | 0.003 | 108 | <0.005 | 35 | 0.002 | 1 | <0.001 | 88 | 323 | 27 | 284 | 4.2 | 0.1 |
| CW-3 | WCW surface | 4/19/2018 | 9.33 | 10.7 | 8.07 | -37.7 | 835 | 0.02 | 0.003 | 0.002 | 129 | <0.005 | 37 | 0.003 | 2 | <0.001 | 71 | 269 | 30 | 365 | 1.9 | 0.2 |
| CW-4 | WCW surface | 4/19/2018 | 10.4 | 10.1 | 8.25 | -11.1 | 828 | <0.02 | 0.003 | 0.002 | 128 | <0.005 | 37 | 0.003 | 2 | <0.001 | 76 | 273 | 30 | 364 | 1.9 | 0.2 |
| CWS-1 | spring | 10/11/2018* | 5.28 | 11.1 | 7.07 | 171 | 807 | 0.07 | 0.0037 | 0.002 | 132 | <0 005 | 35 | 0.004 | 2 | <0.001 | 67 | 274 | 28 | 349 | 1.0 | 0.1 |
| LVS-1 | seep | 4/19/2018 | 4.71 | 11.6 | 7.54 | -51.0 | 641 | 0.04 | 0.0094 | <0.001 | 112.0 | <0.005 | 35 | 0.277 | 4 | <0.001 | 44 | 258 | 32 | 254 | 0.7 | 0.2 |
| SW-1 | stock well, alluvium | 4/18/2018 | 9.09 | 10.4 | 7.46 | 13.3 | 693 | 0.03 | 0.0072 | 0.002 | 133 | <0.005 | 40 | 0.006 | 2 | 0.003 | 48 | 263 | 32 | 291 | 0.6 | 0.3 |
| PZ-8 | peizometer, alluvium | 4/18/2018 | 2.49 | 9.7 | 7.35 | 10.3 | 1190 | <0.03 | 0.0274 | 0.003 | 178 | <0.005 | 81 | 0.020 | 2 | 0 006 | 74 | 337 | 70 | 541 | 2.6 | 0.4 |
| East Well | drinking water well, Navajo ss | 4/18/2018 | 7.10 | 12.2 | 7.30 | 16.4 | 1110 | 0.03 | 0.0059 | <0.001 | 219 | <0.005 | 56 | <0.001 | 2 | <0.001 | 88 | 422 | 50 | 454 | 1.9 | 0.4 |
| West Well | drinking water well, Navajo ss | 4/18/2018 | 4.57 | 12.0 | 7.26 | 18.0 | 1170 | 0.03 | 0.0048 | <0.001 | 218 | 0.0 | 48 | <0.001 | 2.0 | <0.001 | 95 | 371 | 42 | 512.0 | 1.9 | 0.3 |

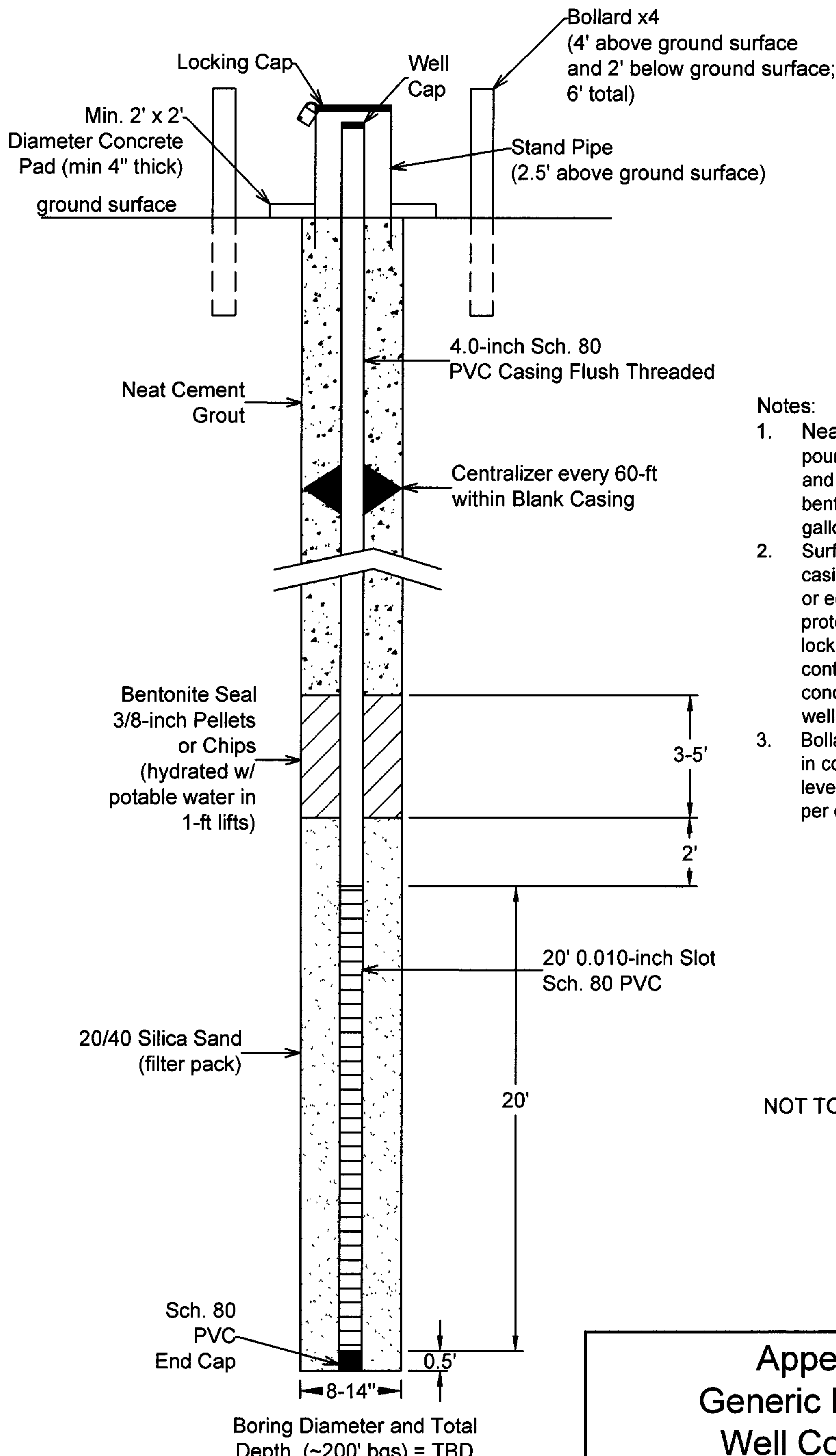
**Notes:**

WCW = West Coyote Wash
C = celsius
s.u. = pH standard units
mV = millivolts
mg/L = millgrams per liter

*Field parameters (temperature, pH, ORP, DO) reported for CWS-1 were collected on 11/16/2018, whereas all other parameters were collected on 10/11/2018

# APPENDIX D

## Generic Monitoring Well Completion




Notes:

1. Neat cement grout: 1 x 94 pound sack of Portland cement and 4.7 pounds of powdered bentonite with no more than 6 gallons of clean water.
2. Surface completion: 2.5-ft PVC casing stick up with PVC well cap or equivalent; standard steel protective casing with locking lid, lock and key to be provided by contractor, casing painted yellow; concrete pad sloping away from well casing.
3. Bollards: 4 metal traffic posts set in concrete, 4-ft above ground level, painted yellow, positioned per direction of field supervisor.

NOT TO SCALE

# Appendix D
# Generic Monitoring Well Completion

Work Plan HSSA, Phase 4
Lisbon Facility

S \ABQ\RIOAL RIOALGOM\GRAPHICS\LISBON\MAPDOCS\HSSA4_WP\APPENDIXD_GENERICWELLCOMPLETION DWG

# APPENDIX E

## Schedule for the Lisbon Work Plan HSSA, Phase 4

Appendix E. Schedule for the Lisbon Work Plan HSSA, Phase 4

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | **Tailings Water Balance** | **281 days** | **Mon 8/5/19** | **Mon 8/31/20** | |
| 2 | Field Recharge Investigation | 85 days | Mon 8/5/19 | Fri 11/29/19 | |
| 3 | HELP Modeling Updates | 87 days | Mon 12/2/19 | Tue 3/31/20 | 2 |
| 4 | Water Balance Report (Section of HSSA4 Report) | 109 days | Wed 4/1/20 | Mon 8/31/20 | 3 |
| 5 | **Hydrogeological Supplemental Site Assessment, Phase 4** | **805 days** | **Mon 10/1/18** | **Fri 10/29/21** | |
| 6 | Surface water-groundwater field investigation | 175 days | Mon 10/1/18 | Fri 5/31/19 | |
| 7 | Background COC Evaluation | 280 days | Wed 5/1/19 | Tue 5/26/20 | |
| 8 | Fault field investigation | 500 days | Mon 10/1/18 | Fri 8/28/20 | |
| 9 | MW-124 Analysis | 305 days | Mon 10/1/18 | Fri 11/29/19 | |
| 10 | Drill, core, install, and test new monitoring wells and core holes | 85 days | Mon 8/5/19 | Fri 11/29/19 | |
| 11 | Delayed drilling for remaining new monitoring wells and core holes due to weather or other delays | 45 days | Mon 7/20/20 | Fri 9/18/20 | |
| 12 | CSM Geochemical evaluation updates | 325 days | Mon 12/2/19 | Fri 2/26/21 | 10,9 |
| 13 | CSM Hyrdogeological evaluation updates | 325 days | Mon 12/2/19 | Fri 2/26/21 | 10,9 |
| 14 | Update groundwater flow and transport model | 45 days | Mon 3/1/21 | Fri 4/30/21 | 13,12 |
| 15 | Evaluation of Groundwater Treatment Options | 60 days | Mon 5/3/21 | Fri 7/23/21 | 14 |
| 16 | Determine new ACLs and TALs | 80 days | Mon 5/3/21 | Fri 8/20/21 | 12,13,14 |
| 17 | HSSA4 Report | 130 days | Mon 5/3/21 | Fri 10/29/21 | 14,16 |