Technical Memorandum

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Re: **Draft Work Plan Outline**
Monitored Natural Attenuation Evaluation for Feed Makeup Area

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The following provides a draft outline of the proposed scope of work to evaluate the Monitored Natural Attenuation (MNA) of the constituents of concern (COCs) in the Feed Markup Area (FMA). The results of this evaluation, along with evaluations of other applicable remedial technologies, will be used to prepare a Focused Feasibility Study (FFS) for the FMA. Upon approval of this proposed MNA evaluation work scope, a full work plan will be prepared for review and approval which will include any additional figures and tables discussed here, but not attached.

Introduction

The primary COCs at the FMA include radium and acidity. The proposed work scope includes the collection of soil and groundwater samples for analysis of contaminant speciation, subsurface minerology, mass of reactants, and attenuation stability parameters. The results of this testing will be used to evaluate the natural attenuation of the COCs at the Site in accordance with U.S. Environmental Protection Agency (EPA) Guidance for use of Monitored Natural Attenuation for inorganic contaminants (EPA 2015). This guidance consists of the following four tiers of analyses containing associated potential data types and analysis:

- **Tier I: Demonstrate Plume Stability**
    - Groundwater flow direction, aquifer hydrostratigraphy
    - Contaminant concentrations in groundwater
    - General groundwater chemistry
- **Tier II: Determine Mechanisms and Rates of Attenuation**
    - Detailed characterization of groundwater chemistry
    - Contaminant speciation (groundwater and aquifer solids)
    - Subsurface minerology

    - Evaluate reaction mechanism (site data, laboratory testing, develop chemical reaction model)
- **Tier III: Determine System Capacity and Stability of Attenuation**
    - Determine contaminant and dissolved reactant fluxes
    - Determine mass of available solid phase reactant(s)
    - Lab testing of immobilized contaminant stability (ambient groundwater; synthetic solutions)
    - Perform model analyses to characterize aquifer capacity and to test immobilized contaminant stability
- **Tier IV: Design Performance Monitoring and/or Identify Alternative Remedy**
    - Monitoring design, parameters, frequency, triggers for re-evaluation, etc.

This work plan will describe data that will be collected to evaluate Tiers I-III of the EPA Guidance.

First, Tier I groundwater chemistry data will be collected from the monitoring well network to determine contaminant concentrations and the general chemistry of groundwater (which affects fate and transport of site contaminants) (Table 1). Soil samples will also be collected within and downgradient of the source area to evaluate attenuation mechanisms, rates, and stabilities (Tiers II-III). As shown in Tables 2 and 3, soils will be analyzed to determine the types and quantities of aquifer minerals responsible for attenuation. Data will be used to develop a conceptual site model (CSM) of contaminant attenuation; it will be additionally used in geochemical model calculations to predict future stability.

Additional Assessment Tasks

The work plan will outline the following tasks to be completed.

Task 1: Groundwater Flow Evaluation

Groundwater potentiometric maps over the last two years for the Extraction Area show a groundwater mound centered on the FMA. Additional groundwater data is required to determine if this groundwater mound is present, and if present, if it is due to the unlined ponds adjacent to the FMA. To address this, transducers will be installed and data will be collected once per day for a period of approximately three months. Proposed transducer locations are provided below.

- Pond 1B
- Pond 2
- EW-2
- PW-28A
- PW-50A
- PW-51A
- PW-52A
- PW-102A
- PW-103A

Task 2: Groundwater Monitoring Well Installation and Sampling

Three additional groundwater monitoring wells will be installed between the FMA and the compliance boundary. The proposed location of these wells is shown on Figure 2.

- The monitoring wells will be completed within the Linn Gravel unit to evaluate the attenuation of COCs in groundwater.
- Wells will be installed using either a direct push or sonic drilling rig so anoxic soil samples can be collected within the aquifer.
- Once total depth is reached and anoxic samples are collected, a permanent groundwater monitoring well will be installed.
- Wells will be completed with 4-inch PVC riser, 10 feet of screen, and flush mount cover.
- Monitoring wells to be sampled include:
    - The 3 new monitoring wells,
    - Compliance boundary wells PW-23A and PW-24A,
    - Perimeter well PW-27A,
    - FMA source area wells PW-28A, PW-50A, PW-52A, PW-102A, and PW-103A.
- Wells will be sampled in accordance with the following.
    - Measure the static water level.
    - Purge the well using low-flow sampling protocol while monitoring field parameters (temperature, pH, and specific conductivity) for stabilization.
    - Collect the groundwater quality sample to be analyzed for parameters outlined on Table 1.
    - Document field sampling activities (purge volumes, sample times, field observations, etc.).

Task 3: Soil Sampling

Anoxic soil samples will be collected within the Linn Gravel water bearing unit to evaluate the MNA alternative.

- Three soil samples will be collected downgradient of the FMA from borings advanced for the installation of new monitoring wells.
- Two borings to be advanced in the FMA area to collect soil samples in areas with known radium impact (Figure 1).
- Soil cores will be collected and logged during drilling. To provide data representative of the aquifer matrix, the target depth interval for soil samples is mid-way between the water table and the top of the Spencer Formation.
- GSI's field staff will collect the soil samples using an anoxic procedure to minimize the potential of oxidizing the sample to the extent practicable. This includes placing the sample in a mylar bag with oxygen-absorbing packets, purging the bag with nitrogen or argon gas, and then heat seal the bag for transport to the laboratory.

Task 4: Groundwater and Soil Analytical Parameters

As noted above, groundwater and soils will be analyzed for a suite of inorganic parameters to evaluate contaminant concentrations and the general chemistry of groundwater (which affects fate and transport of site contaminants) (Table 1). Soil samples will also be collected within and downgradient of the source area to evaluate attenuation mechanisms, rates, and stabilities (Tables 2 and 3).

Other

The work plan will include necessary elements such as equipment decontamination methods, quality control methods, disposition of investigation derived waste, and survey of boring and well locations.

MNA Evaluation

Data will be used to evaluate the natural attenuation of radium and acidity in groundwater. Components of this evaluation will include identification of the dominant attenuation processes in groundwater (Tier I), quantification of the capacity of the aquifer to attenuate radium and acidity (Tier II), and geochemical stability of the attenuation process (Tier III). Data will also be used to develop a geochemical model of radium fate and transport consistent with site data.

Reporting

Results will be provided in a report for review and approval. MNA data will be evaluated in accordance with applicable EPA Guidance (EPA 2007, EPA 2010, and EPA 2015). Report elements will include:

- Details regarding field activities completed,
- Summary of laboratory and field data obtained,
- Presentation of the MNA evaluation
- Updated CSM for the FMA including contaminant attenuation, and,
- Geochemical model calculations to predict future plume stability.
- Summary and conclusions

Project Schedule

The work plan will include the following project schedule.

- Installation of transducers – within one month of work plan approval.
- Advancement of soil borings and installation of new monitoring wells – within two months of work plan approval.
- Collection of groundwater data – within one month of well installation.
- Laboratory analysis – the analytical suite requires analysis by a specialized laboratory. Data will likely not be provided for at least 6 - 8 weeks from submittal.
- Retrieval of groundwater transducer data – 3 months after transducer installation
- MNA Evaluation
- Submittal of draft MNA evaluation document for review – within 4 months of receipt of analytical data.

References

EPA. 2007. Monitored Natural Attenuation of Inorganic Contaminants in Groundwater, Volume 1, Technical Basis for Assessment. EPA 600-R-07-139. Prepared by U.S. Environmental Protection Agency (EPA), National Risk Management Research Laboratory, Office of Research Development. October 2007.

EPA. 2010. Monitored Natural Attenuation of Inorganic Contaminants in Groundwater, Volume 3, Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium. EPA 600-R-10-093. Prepared by EPA, National Risk Management Research Laboratory, Office of Research Development. September 2010.

EPA. 2015. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites. Directive 9283.1-36. Prepared by EPA, Office of Solid Waste and Emergency Response. August 2010.

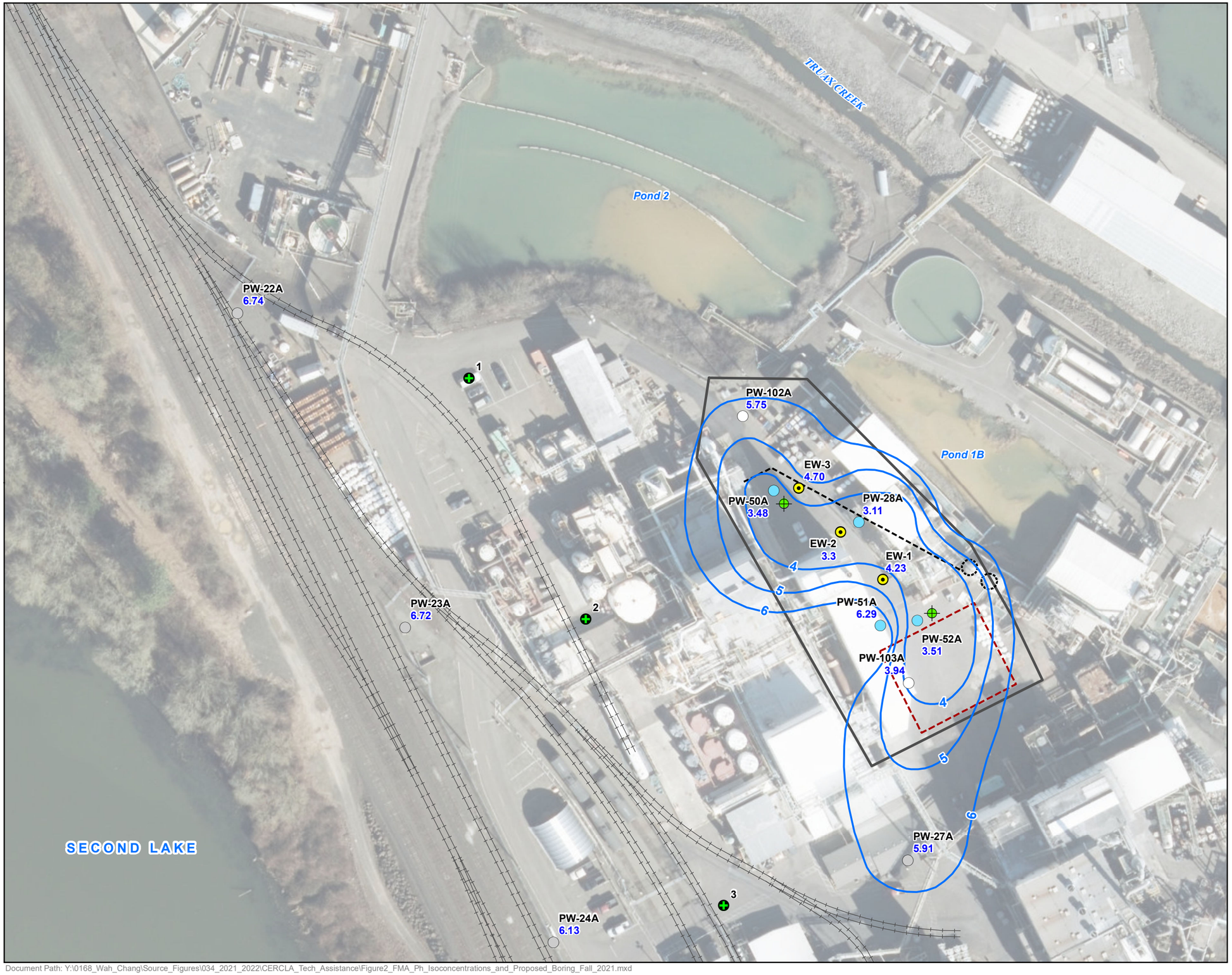

FIGURE 1

pH Isoconcentration Map and Proposed Boring Locations

ATI Millersburg Operations, Oregon

LEGEND

- Proposed Boring Location
- Proposed Monitoring Well Location
- Source Area Monitoring Well
- Background Monitoring Well
- New Monitoring Well
- Extraction Well
- 6.72 Groundwater pH Value
- pH Isoconcentration Line
- Former Feed Transfer Line
- Approximate Project Area
- Former Feed Deck
- Former Feed Tank
- Railroad

NOTE

pH values collected during Fall 2021 Sampling Event.

N

0 40 80 120
Feet

Date: October 15, 2021
Data Sources: BLM, ESRI, ODOT, USGS, GeoTerra imagery (2019)

GSI Water Solutions, Inc.

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Table 1. Proposed Groundwater Testing to Support MNA Evaluations

Analyte Group	Analyte
FIELD PARAMETERS	Dissolved oxygen Oxidation-Reduction Potential pH Specific Conductance Temperature Turbidity
MAJOR CATIONS	Calcium Magnesium Potassium Sodium
MAJOR ANIONS	Alkalinity Bicarbonate Carbonate Chloride Sulfate
REDOX SENSITIVE SPECIES	Ammonia Iron Manganese Nitrate (as N) Nitrate+Nitrite (total N) Nitrite-N Sulfide
RADIONUCLIDES	Radium-226 Radium-228
DISSOLVED METALS	Aluminum Barium Zirconium
MISCELLANEOUS	Dissolved Organic Carbon Dissolved Silica (as SiO2) Fluoride Orthophosphate as P pH Total Dissolved Solids Total Organic Carbon

Table 2. Proposed Solids Testing to Support Radium Monitored Natural Attenuation (MNA) Evaluation

EPA (2015) Tiered Evaluation	Recommended EPA Data (2015)	Parameter Type	Parameter	Rationale
Tier II - Determine Mechanism and Rate of Attenuation	Contaminant Speciation	Radionuclide Concentrations	Ra-226; Ra-228	Current concentrations of isotopes in soil
		Radium Speciation	Sequential Extraction Analysis[1,2]	Operationally-defined mineralogical association of radium in solid samples (current attenuation processes & adsorption potential)
	Subsurface Mineralogy	Major Minerals	X-Ray Diffraction (XRD)	Determine minerals that control groundwater chemistry and radium attenuation
		Organic Carbon	TOC	Available organic carbon concentrations for radium adsorption/attenuation
Tier III - Determine System Capacity and Stability	Mass of Reactants	Acid Neutralizing Capacity	Acid Neutralizing Capacity (ANC)	Quantify amount of acidic groundwater that can be neutralized along groundwater flow path
		Radium Ion Exchange Potential	Cation Exchange Capacity (CEC)	Quantify clay and/or organic carbon exchange sites for radionuclide adsorption
		Radium Attenuation Capacity (Total)	Batch Adsorption Test	Measure Radium removal rates in downgradient soil using source area groundwater
	Attenuation Stability Parameters	Major Cations & Anions	Aluminum, Barium, Calcium, Magnesium, Potassium, Sodium, and Zirconium; Sulfate, Carbonate, Fluoride, Phosphate	Concentrations of elements in soil that affect radium fate and transport
		Redox Indicators	pH, Sulfide, and Iron[2], and Manganese	Distribution of redox-sensitive elements between possible redox states (affects radium fate and transport)

[1] See Table 3 for a description of the sequential extraction tests.

[2] Iron speciation for determining mass and stability of iron oxyhydroxides for radium attenuation determined in sequential extraction analysis

Table 3. Sequential Extraction Procedure for Soil

Step	Targeted Phases	Reagent
1	Soluble / Exchangeable: Exchangeable ions	10 mL of 1 M $Mg(NO_3)_2$, pH 7, 4 hr, 25 °C + 1 water wash (10 mL)
2	Acid Soluble: Carbonates	25 mL of 1 M CH_3CO_2Na, pH 5, 6 hr, 25 °C + 1 water wash (10 mL)
3	Organics/Sulfides: Humic materials and Fe-sulfides	30 mL of 0.1 M $Na_4P_2O_7$, pH 10, 20 hr, 25 °C + 1 water wash (10 mL)
4	Amorphous Oxides: Mn-oxides, ferrihydrite, and secondary U minerals	10 mL of 0.2 M $(NH_4)_2C_2O_4$, pH 3, 4 hr, 25 °C (dark) + 1 water wash (10 mL)
5	Crystalline Oxides: Goethite and Magnetite	25 mL of 0.2 M $(NH_4)_2C_2O_4$ in 0.1 M ascorbic acid, pH 3, 0.5 hr, 95 °C + 1 water wash (10 mL)
6	Alkaline-earth sulfates: Barite	200 mL of 0.11 M Na_2EDTA + 1.7 M NH_4O_4, 4 hr, 95 °C + 1 water wash (10 mL)
7	Residual: Clays, primary Oxides	$HF\text{-}HClO_4$ (Complete digestion)

Notes: Method based on Liu et al. (2011). All extractions use 1 gram of solid and all solutions analyzed for metals (Al, Ba, Fe, Mn, Zn), radium and pH (steps 1-4 for Ca, DOC, and sulfur); Procedure includes digestion/centrifugation, wash/centrifugation, and analysis steps. Finally, steps 1 and 2 will be conducted in a glove box.