Hydrometrics, Inc.
consulting scientists and engineers

2736 White Pines Drive
Coeur d'Alene ID 83815
(208) 660-8548
Fax: (208) 765-5286
www.hydrometrics.com

March 10, 2016

Mr. Guy Barrett, LHG
Washington Department of Ecology
300 Desmond Drive
Lacey, WA 98503

Subject: **Kaiser Mead NPL Site – Submittal of Work Plan for Ex Situ Treatability Study 2016 Activities**

Dear Mr. Barrett:

On behalf of the Mead Custodial Trust (Trust) enclosed please find three copies of the final Work Plan that incorporates responses to Washington Department of Ecology (Ecology) comments dated February 9, 2016. The responses were accepted by Ecology email on March 1, 2016. We are proceeding with implementing the Work Plan.

Sincerely,
HYDROMETRICS, INC.

Antonio Chavez, P.E.
Senior Engineer

Enclosure.

Cc: Dan Silver, Trustee – Mead Custodial Trust (via email)
Carl Reitenbach – AIG (via email)
Ken Baker – AIG (via email)

WORK PLAN FOR EX SITU TREATABILITY STUDY 2016 ACTIVITIES FOR KAISER MEAD NPL SITE

Prepared for:

Mead Custodial Trust
606 Columbia St. NW, Ste. 212
Olympia, WA 98501

Prepared by:

Hydrometrics, Inc.
2736 White Pines Drive
Coeur d'Alene, ID 83815

March 2016

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WORK PLAN FOR EX SITU TREATABILITY STUDY 2015 ACTIVITIES FOR KAISER MEAD NPL SITE

1.0 INTRODUCTION

This Work Plan has been prepared to comply with the request by the Washington Department of Ecology (Ecology, 2014) to Mead Custodial Trust dated December 8, 2014, to proceed with certain actions as a continuation of the Supplemental Feasibility Study (SFS) for the Kaiser Mead NPL site (Kaiser Mead). The purpose of the SFS is to develop and evaluate cleanup action alternatives for the contaminated groundwater at Kaiser Mead and to recommend a remedial alternative to be implemented to achieve compliance with groundwater cleanup requirements established for this site. The purpose of the activities described in this Work Plan is to provide sufficient information to support the selection of a preferred remedy in the SFS.

1.1 BACKGROUND

In 2013, Hydrometrics conducted field and laboratory studies in an effort to develop and evaluate additional remedial alternatives for the Site. Based on the completed work alternatives were developed that included (Hydrometrics, 2014):

- Alternative A, no additional actions;
- Alternative B, implementation of a grout curtain to divert A-zone groundwater around the potential secondary sources;

- Alternative C, implementation of an in situ treatment zone to treat contaminated groundwater;
- Alternative D, ex situ treatment technologies to treat contaminated groundwater; and
- Alternative E, implementation (in a phased approach) of the grout curtain (alternative B) and ex situ treatment technologies.

Alternative E was selected as the preferred remedial alternative. The Department of Ecology subsequently requested the Trust to conduct further evaluations to support selection of a supplemental remedy by conducting the following tasks:

- Develop a groundwater model to estimate the response of groundwater conditions to installation of cutoff wall;
- Install a pilot-scale[1] cutoff wall to test installation technique, assist in design and develop cost estimates for full scale implementation, and provide additional data that may be implemented into subsequent model simulations;
- Perform additional field characterization activities, including drilling additional subsurface borings and collection of soil samples for geochemical analysis, installing test wells and monitoring wells, updating estimates on the extent of potential secondary contaminant sources away from the spent potliner (SPL) pile and providing data for refinement of the groundwater model;

[1] As described in USEPA (1992) and used in this Work Plan, pilot-scale and bench-scale tests are small-scale tests intended to provide quantitative data regarding effectiveness and cost of potential technologies. Bench-scale tests are generally smaller scale and shorter duration than pilot-scale tests and are typically conducted in a laboratory in a batch treatment mode (e.g., jar tests) or a combination of batch and continuous (e.g., flow-through column) treatment mode. Pilot-scale tests are commonly performed in the field, for longer duration, and under continuous or flow-through conditions. Bench-scale tests provide rough design and cost information whereas pilot-scale tests provide detailed design and cost information including quantitative performance, optimization and reliability data.

- Perform bench-scale tests of ex situ treatment technologies for cyanide (all forms) and fluoride; and

- Perform additional bench-scale laboratory tests of in situ groundwater treatment reagents for cyanide forms and fluoride.

1.2 WORK PLAN ORGANIZATION

This Work Plan addresses the bench-scale ex situ treatment tasks outlined in the Ecology request. The groundwater model Work Plan, which has been submitted as a standalone document, was approved by Ecology in January 2015. The Work Plans for the remaining two tasks were submitted as separate plans. Section 2 presents the goals and objectives of the ex situ activities. Section 3 describes the scope of work and methods for the ex situ activities. Section 4 describes how the activities and results will be reported.

2.0 GOALS AND OBJECTIVES

The purpose of the wetland and electro-coagulation (EC) testing is to determine the potential effectiveness of these technologies on Site groundwater and the potential size of the wetland and EC systems that would be needed. This data will allow a better comparison of estimated costs and benefits of the wetland/EC system with other remedial alternatives. The overall goal of wetland/EC system is the same as for other alternatives which is to achieve, or contribute to achievement of cleanup goals. Similar to other ex situ and in situ methods tested, the ultimate target for treatability testing is to achieve cleanup levels (0.2 mg/L free cyanide and 4 mg/L fluoride) in effluent.

The groundwater is considered contaminated environmental media by Ecology and the groundwater must meet the contained-in requirements for environmental media including the specific numeric standards that must be met to no longer be considered a hazardous waste. Once treated to meet the Ecology standards for cyanide and fluoride, it will no longer be considered hazardous waste. Also sludge and solids generated from the treatment would be considered hazardous waste per the derived from rule.

The goals of the tasks described in this Work Plan are to provide sufficient information to support the selection of a preferred remedy in the Supplemental Feasibility Study. A description of the objectives of the ex situ tasks is presented in the following sections.

2.1 EX SITU TREATMENT TESTS OBJECTIVES

The objectives of the tests for ex situ treatment of groundwater for fluoride and cyanide include:

- Provide data for the evaluation of effectiveness (on site groundwater) of constructed wetland processes to treat cyanide forms in the presence of fluoride;

- Provide data for the evaluation of effectiveness (on site groundwater) of electrocoagulation (EC) processes to treat fluoride following the wetland treatment of cyanide;

- Provide data for design of field pilot-scale and full scale constructed wetland treatment systems and determining the configuration of the EC units required for effective treatment of cyanide and fluoride of Site groundwater; and

- Develop full scale cost estimates for ex-situ cyanide and fluoride treatment systems.

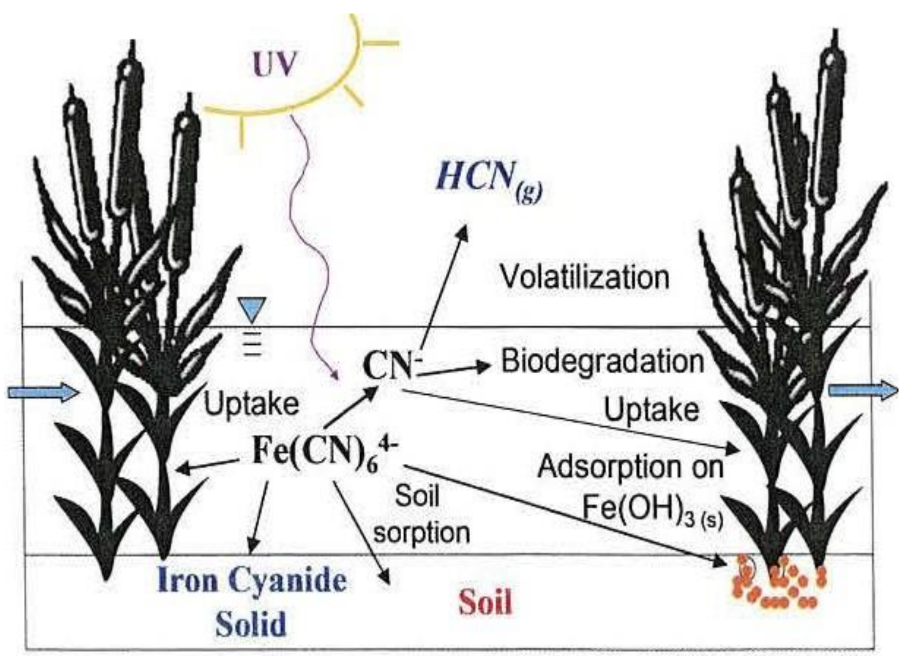
3.0 SCOPE OF WORK

The 2015 tasks of ex situ laboratory scale testing were developed to supplement the previous work in support of the SFS. To perform the testing, Hydrometrics has enlisted expertise from Alcoa for the wetland scope and Kaselco for the electro coagulation scope. Alcoa is currently utilizing working wetlands for treatment of cyanide impacted waters at a number of their aluminum smelters and Kaselco has implemented electro coagulation units at other cleanup sites in the northwest. The scope of work is discussed in the following sections.

3.1 EX SITU WETLAND TREATMENT MECHANISMS

The primary mechanisms of wetland treatment utilize the free surface wetland system to allow photo-dissociation of iron cyanide complexes followed by biodegradation of free or weakly complexed cyanide. Figure 3-1 indicates the general schematic of the cyanide destruction in a free surface wetland system.

FIGURE 3-1. GENERAL SCHEMATIC OF CYANIDE DESTRUCTION VIA FREE SURFACE WETLAND SYSTEM



Based on detailed mass balance analyses from multiple pilot and full scale cyanide treatment wetlands, it has been demonstrated that the photo-dissociation of iron cyanide to free cyanide followed by the biodegradation of free cyanide are the primary cyanide removal fate processes occurring in the wetland system. It has also been demonstrated that the cyanide removal capacity of the wetland system is a function of hydraulic retention time (HRT) of the wetland system and climatic variations including ambient temperature and solar intensity. Although plant uptake and sediment sorption are not the major cyanide removal processes in the system, they provide suitable conditions for biodegradation by providing degradation sites and organic carbon. In addition, volatilization of free cyanide plays a minor role in influencing the fate of cyanide regardless of the time of the year.

Wetlands will maintain a minimum amount of efficiency during the winter freezing conditions. The primary removal mechanism occurs via diffused sunlight initializing the photo-dissociation of iron cyanide. The photo-dissociation process occurs very rapidly and experience at Alcoa's pilot project in Tennessee is that a relatively small open surface area, free of vegetation, is sufficient to make the process effective. At a full scale operation such as Kaiser Mead it is envisioned that the influent water will be exposed to diffused light at the entrance section of the wetland (Figure 3-2) as the wetland entrance section will be maintained above freezing conditions due to the heat capacity of the groundwater being pumped into the wetland.

Additionally, the absence of vegetation at the wetland entrance maximizes light exposure and consequently photo-dissociation of the iron cyanide. Based on Alcoa Tennessee Operations experience in operating a wetland under freezing conditions, even in presence of few inches of frozen surface, the water underneath flows and cyanide treatment via biodegradation (in the plant root zone) followed by plant root uptake and soil sorption continues to occur at the required efficiencies.

FIGURE 3-2. TYPICAL ENTRANCE TO WETLAND

Rhizospehere mediated biodegradation is the primary form for bio-decay process for cyanide. As such, the root zones of the emergent and submergent species provide the necessary biomass for cyanide degradation, provided a constant source of cyanide is present to propagate the biomass growth and sustain the biomass population. These are ubiquitous processes as long as soils of certain organic content are used for plantation of the submergent species and is not dependent on which geographical location these processes are being carried out.

The rate of biodegradation is dependent on the temperature and root surface availability which are necessary for optimum biomass growth and sustenance. As shown in Figure 3-3, icy conditions and reduced plant active mass were observed in a previously implemented cyanide wetland study during the winter months compared to warmer months when the presence of full grown plants was evident. Although the measured rate of biodegradation of free cyanide was decreased during the winter months in the treatment wetland (see Table 3-1 showing data from an Alcoa wetland treatment system in north-eastern US, Alcoa TN), the wetland system was still successful in removing over 90% cyanide as shown in Figure 3-4.

FIGURE 3-3. WINTER WETLAND CONDITIONS

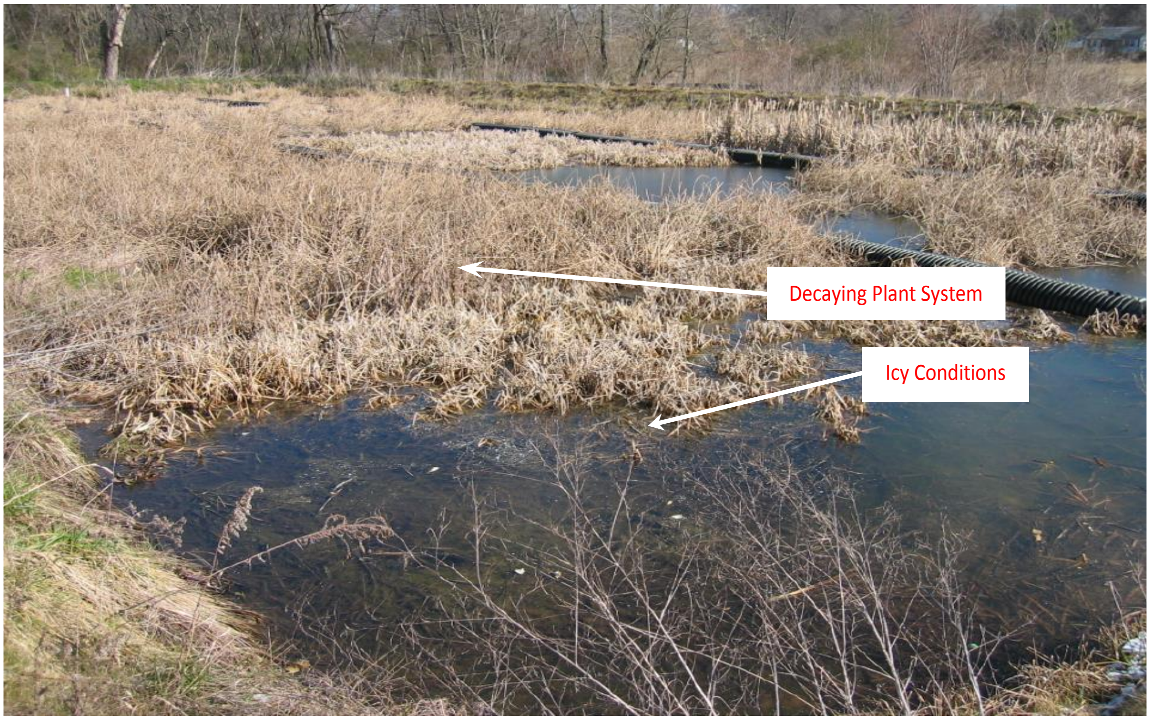
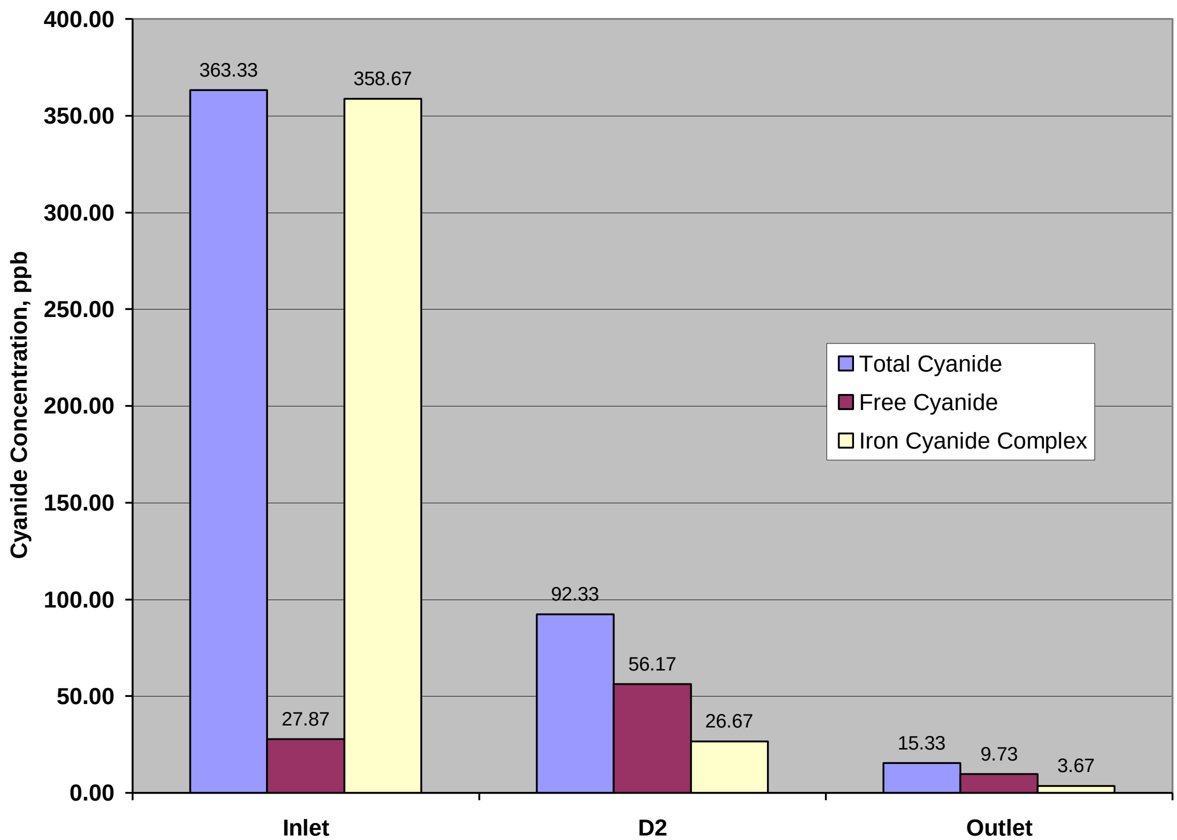


TABLE 3-1. FIRST ORDER FREE CYANIDE BIODEGRADATION RATES

Monitoring Event	First Order Rate, hrs^{-1}
June-July 2004	0.0546
Feb-March 2005	0.0376
August 2005	0.0491

Figure 3-4 shows data cyanide removal efficiency data collected during winter months at a wetland site treating 5-7 gpm of SPL impacted groundwater in the north-eastern US. Location D2 on the figure represents a sampling location half way into the pilot-scale wetland. Design of the wetland system to operate during cold periods is an important part of the testing and design process. If the wetland system is effective on KM site waters under lab testing conditions, further pilot scale testing in the field under actual Spokane winter conditions would be recommended prior to final design of a full-scale wetland system.

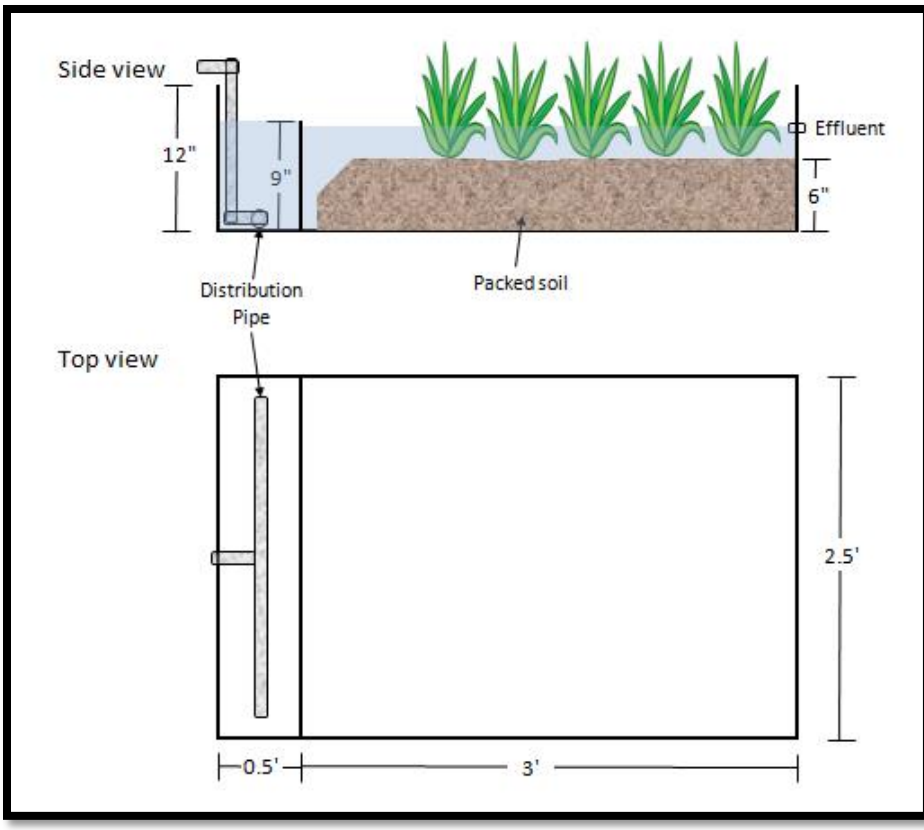
FIGURE 3-4. WETLAND CYANIDE DESTRUCTION DATA DURING A 21-DAY MONITORING EVENT IN FEB-MAR TIMEFRAME



3.2 EX SITU LAB SCALE TREATMENT CONSTRUCTED WETLAND TESTS

The ex situ treatment test will be conducted by Alcoa. The first step in the treatability study will involve a lab scale wetland study to determine cyanide (total, WAD, and free) treatment effectiveness using actual groundwater from the Kaiser Mead site. The lab scale wetland will be constructed at Alcoa's Technical Center (ATC) in New Kensington, PA. The most critical design parameters are the HRT, depth of the water column and the areal extent of the vegetative cover. Once the optimum HRT is established the areal extent of the wetland is then designed to match the required design flow rate for a full scale operation. The planned model scale for treatability screening will be about 2.5 ft. by 3.5 ft. rectangular wetland cell with 3-4 inches of standing water. Perforated distribution pipe will be used at the inlet section to properly distribute water throughout the wetland cell. See Figure 3-5 for a depiction of the lab scale wetland.

FIGURE 3-5. LAB SCALE WETLAND SCHEMATIC



Nominal flow rate through the treatability wetland will be in the range of 11-14 mL/min. This equates to approximately 3-4 days of HRT, which is based on multiple lab-scale and pilot-scale studies conducted by Alcoa. The HRT takes into account the relative rates of photo-dissociation, biodegradation and plant uptake as a function of temperature, cyanide concentrations and general water chemistry. During the lab-scale wetland evaluation stage, provisions will be made to adjust the flowrate to increase the HRT up to 7 days in order to evaluate the free/WAD cyanide removal efficiency. A total volume of 220 gallons of water (four 55 gallon drums) will be required to carry out the treatability portion of the study. Site groundwater from the plume areas will be shipped to Alcoa and upon receipt will be analyzed immediately for characterization (total, free, and WAD cyanide, fluoride, pH, total suspended solids, total and dissolved iron and chemical oxygen demand). The analytical methods used will be consistent with Table 3-2. The drums used for transport will be new clean drums made of plastic. The results will be compared to analysis of the groundwater at the time of extraction at the monitoring well. It is Alcoa's experience that when unpreserved groundwater samples are stored in sealed opaque containers, then cyanide speciation is maintained over weeks. The groundwater from 55 gallon shipping drums will be piped directly in the lab-scale wetland system via opaque tubing to prevent any losses of cyanide (via volatilization). The influent samples will be monitored (twice weekly) for characterization and if a reduction in concentration of the influent sample is reported (when compared to the initial sample analysis), then those changes will be noted and considered during evaluation of project results.

Table 3-3 provides summarizes the scope of the treatability study. The lab scale wetland will be indoors and UV lamp light will be used to simulate photo-dissociation. Starting values to adjust the lamp intensity in the lab-scale unit will be based on experience from 1) measuring photo intensity during field pilot tests at various Alcoa operations, 2) from literature information on optimum photo-intensity for ferro- and ferricyanide photodissociation as a function of temperature; 3) average and minimum solar radiation for Spokane, WA area (3.8 and 1.1 kWh/m^2/day). UV absorption in the water column will be varied and monitored as different UV conditions are evaluated to correlate with varying seasonal conditions and associated removal rates. Alcoa has the ability to adjust the lumens for the lamp that will be employed for the lab-scale wetland evaluation. Both water surface photo intensity as well as actual lamp irradiation intensity will be monitored. Night conditions will be simulated for the lab unit via employment of opaque glass films on the walk-in hood where the lab-scale wetland will be located. A timer will be employed for the solar lamps to simulate day conditions and periodic hand held measurement of incident UV will be performed and recorded. The design of entry section of the lab-scale evaluation

TABLE 3-2. WATER QUALITY ANALYTICAL PARAMETER LIST

Analytes	Proposed Reporting Limit (mg/L unless specified)
Field Parameters	
pH	0.1 su
Temperature	0.1 C
Chemical Oxygen Demand	5.0
Total Suspended Solids	5.0
Specific Conductivity	5 umhos/cm
Major Minerals	
Fluoride (Method 300) Total and Dissolved	10
Iron – total and dissolved	0.060
Cyanide Forms	
Total Cyanide (EPA 335.4)	0.01
WAD Cyanide (SM-4500-CN-I)	0.01
Free Cyanide (ASTM D7237 or D4282)	0.01

As the lab scale wetland will be indoors the temperature will be ambient (continuous monitoring will occur). In a full-scale system, Alcoa does not anticipate winter freezing conditions to significantly impact wetland effectiveness as long as flow continues beneath surficial ice and HRT is appropriately sized to accommodate reduced photoperiod/day length and reduced biodegradation rates in winter. As described in Table 3-4 of the Work Plan, temperature will be decreased to near freezing and solar radiation will be reduced to winter conditions during a portion of the test to further evaluate cyanide removal efficiency under winter conditions. Further refinement of the appropriate HRT for winter conditions would occur during Phase II pilot scale testing at the Site.

The free surface wetland will be constructed using design parameters from a similar wetland system established for treating SPL impacted groundwater at one of the Alcoa sites. This

TABLE 3-3. DETAILED SCOPE OF WORK FOR WETLAND TREATABILITY AND EC STUDY

ID	Tasks	Details	Duration (weeks)
1	Process Environmental Health and Safety Review (PEHSR)	This is an internal process to discuss the process and hazards and safety issues associated with operating the pilot unit and develop safe work practices to eliminate any process and safety hazards.	1 week
2	Engineering Design and Deployment of Pilot Unit	Following the approval of the PEHSR, the next step will be to assemble and construct the pilot unit.	2 weeks
3	Acclimatization of the Pilot Unit	During this step, the pilot system will be acclimitized with flowing water (tap water) and the system hydraulic issues will be addressed. This will be the time to address any issues with UV lamp operation as well as plant life sustainance and other miscelleneous items. This period is also referred as the start-up/commissioning period.	4 weeks
4	Influent Water Characterization and Sample Preparation	During this step, multiple samples from the site water will be characterized for key analytical parameters to ensure the quality of the influent streams. Based on the water characteristics, low and high strength samples will be prepared in sufficient volumes to last the appropriate testing period under maximum flow conditions.	2 weeks (concurrent with Task 3)
5	Pilot test with low strength influent	Following start-up/commissioning, the pilot unit will be exposed to low strength influent from the site wrt cyanide and fluoride levels. The testing will occur under a nominal design flow rate of 12 ml/min, however, slight variation in the flowrate might occur based on the wetland performance. During this testing period, the lumen intensity will be varied, primarily between mean and minimum solar radiation for Spokane area and cyanide removal as a function of lumen intensity and HRT will be monitored. Various other secondary parameters wrt wetland performance will be monitored for design purposes.	4 weeks
6	Acquisition of sample for EC Study	At the end of the wetland test with low strength influent, about 5-10 gallons of wetland effluent sample will be shipped to Kaselco's laboratory in Texas for evaluation of fluoride removal efficiency. In addition to fluoride removal efficiency, Kaselco will also evaluate the energy consumption, sludge generation quantities as well as operating costs in terms of chemicals and consumables.	2 weeks upon sample receipt (Concurrent with Task 7)
7	Pilot test with high strength influent	Following the study with the low strength sample, the pilot unit will be exposed to high strength influent from the site wrt cyanide and fluoride levels. The testing will occur under a nominal design flow rate of 12 ml/min, however, slight variation in the flowrate might occur based on the wetland performance. During this testing period, the lumen intensity will be varied, primarily between mean and minimum solar radiation for Spokane area and cyanide removal as a function of lumen intensity and HRT will be monitored. Various other secondary parameters with respect to wetland performance will be monitored for design purposes.	4 weeks
8	Acquisition of sample for EC Study	At the end of the wetland test with high strength influent, about 5-10 gallons of wetland effluent sample will be shipped to Kaselco's laboratory in Texas for evaluation of fluoride removal efficiency. In addition to fluoride removal efficiency, Kaselco will also evaluate the energy consumption, sludge generation quantities as well as operating costs in terms of chemicals and consumables.	2 weeks
9	Reporting	A comprehensive report summarizing the findings from the study along with pilot and full scale design parameters will be generated.	2 weeks
	Total Span for the Study (excluding the reporting period)		17 weeks

TABLE 3-4. TEST PARAMETERS TO BE EMPLOYED DURING LABORATORY WETLAND EVALUATION

Parameter	Beginning Condition	Duration (Days/Hours)	Planned Variations	Other Criteria
Solar Radiation Intensity	Regional mean solar radiation at a fixed flow rate	7 days	Change to regional minimum at a fixed flow rate	Measure photolysis rate[2] as a function of solar radiation intensity
Flow Rate	12 mL/min	10days	Decrease down to 6 mL/min	Cyanide Removal Efficiency[2] as a function of HRT
Water Temperature	Ambient[1]	4 days	Decrease water temp to near freezing condition	Evaluate Cyanide Removal Efficiency as a function of temperature
Diurnal Cycle	Summer Condition[3]	7 days	Change to Winter Condition[3]	Measure Cyanide Removal Efficiency as a function of seasonal change in diurnal cycle

1) Ambient lab temperature, approximately 18 to 20 degrees Celsius.
2) Photolysis rate and cyanide removal efficiency determined by measurement of total, free, WAD cyanide as well as fluoride at a frequency of 2-3 times a week from the influent, mid-point and effluent sampling points. Other parameters to be monitored include pH, Total Suspended Solids, chemical oxygen demand, and temperature.
3) Summer and winter conditions are 16 and 8 hours of daylight, respectively.

laboratory scale wetland system will be constructed using cyanide and fluoride tolerant grown cuttings of emergent and submergent plant species with a hydraulic residence time in the 3-4 day range. Common in Washington lakes emergent species like cattails will be planted as plugs, while submergent and floating-leaned species (coontail) could be installed as cuttings. Several other Washington state emergent species suitable for the Mead climate/ecotone to increase structural and species diversity will be considered for inclusion in the testing, including:

- Hardstem bulrush (*Schoenoplectus acutus var. acutus*);
- Olney threesquare (*Schoenoplectus americanus*);
- Softstem bulrush (*Schoenoplectus tabernaemontani*);

- Smallfruit bulrush (*Scirpus microcarpus*); and
- Pondweed (*Potamogeton gramineus*).

These other emergent species will likely not enhance treatment performance. The plants selected will be tested (tissue samples) for cyanide concentration prior to exposure to Site groundwater.

The wetland will be primarily sampled for total, free, WAD cyanide, iron as well as fluoride at a frequency of 2 times a week from the influent, mid-point and effluent sampling points. The analytical methods will be consistent with those used for the project groundwater analyses. Other parameters to be monitored include pH, Total Suspended Solids, chemical oxygen demand, and temperature.

The wetland will be tested with two different influent water samples (low and higher concentrations) to cover a wider range of water chemistry:

- The first test could be performed with the lower concentration water sample (taking samples from well TW-1B, exhibiting contaminant concentrations of Total CN of 10.3 mg/L and Fluoride of 3.51 mg/L from a 2015 sampling);

- The second test could be performed with the higher concentration water sample (from well KMCP-3B, exhibiting contaminant concentrations of Total CN of 67.9 mg/L and Fluoride of 28.2 mg/L from a 2015 sampling); and

- Based upon performance of the wetland at the upper influent range a higher influent source may be used to test the limits of the wetland. This higher source would be from KM-11, exhibiting contaminant concentrations of Total CN of 69.1 mg/L and Fluoride of 60.6 mg/L from a 2015 sampling.

Based on the level of initial treatment achieved during the lab-scale trials, design parameters will be adjusted and tested to develop the optimum set of parameters that could be used to design an onsite 5-10 gpm field pilot test (Phase II). The Phase II field pilot will allow focus on key design parameters, such as HRT for winter conditions, photo-intensity, vegetative cover, water column depth, TSS, submergent and emergent species type (pilot design will be based on lab-scale data) such that robust full scale design can be implemented to ensure success of the proposed solution.

After the tests are completed selected plant tissue samples (a composite of plant tissues from entry, middle, and exit areas) will be analyzed for cyanide and fluoride uptake. It is Alcoa's experience that plants will uptake some fluoride and cyanide, of which cyanide is destroyed within the plant body and fluoride is stored. Similarly, a composite of entry, middle and exit area soils will be collected for fluoride and cyanide forms.

3.2.1 Detailed Scope of Work for Laboratory Wetland Studies

The laboratory wetland study will be conducted over a 12-week period following the construction of the system, during which time the wetland system will be acclimatized using site groundwater from background well KM-3, followed by 4 weeks of testing under low strength influent water conditions and 4 weeks of testing under high strength influent water conditions.

As shown in Table 3-3, the entire treatability study will be performed over a period of 17 weeks. At the end of the study, a formal report will be produced summarizing the study findings, including the critical design parameters for the pilot and full scale system.

Table 3-4 shows the critical test parameters that will be varied during the laboratory wetland evaluation (primarily during Task ID 5 and 7 in Table 3-3). The test parameter variation schedule shown here is for initial planning purpose only and at best is directional. Initially the parameter variations will be run at the two stated conditions. The HRT, light and water temperature will be varied under both low and higher influent concentrations. Cyanide removal response may prompt additional variations and those occurrences will be documented.

Depending upon how the study is going, these test parameter variation schedule may be adjusted in order to obtain the most relevant and meaningful information that will be eventually used for wetland design and costing purposes.

3.2.2 Sampling and Analysis Protocols

The following paragraphs describe the sampling and analysis programs to be used for the pilot test.

Sampling Locations and Methods

Throughout the wetland test, water samples will be collected routinely at the inlet and outlet of the wetland cell. Samples will be collected by filling laboratory-provided sample bottles from the inlet/outlet pipes. During the EC test, water samples will routinely be collected at the inlet and outlet of the test apparatus. Samples will be filtered (dissolved iron only), preserved appropriately (see Table below), placed in a cooler with ice, and placed under chain-of-custody seal for transport to the analytical laboratory.

Soil and vegetation samples will be collected from the wetland cell at the end of the wetland test period. One composite soil sample will be collected by compositing soil cores from the entry, middle, and exit area of the wetland cell. One composite plant tissue sample will be collected by compositing surface and subsurface vegetation from the entry, middle, and exit area of the wetland cell. Samples will be preserved appropriately (see Table 3-5 below), placed in a cooler with ice, and placed under chain-of-custody seal for transport to the analytical laboratory.

All samples will be collected with clean laboratory techniques, using pre-cleaned disposable or decontaminated (acid or detergent wash followed by deionized water rinse) equipment. Lab personnel will use latex/nitrile gloves during any procedure with potential for sample contact.

TABLE 3-5. SUMMARY OF SAMPLING, PRESERVATION, AND HOLDING TIME REQUIREMENTS

Water Samples			
Parameter	Container	Preservation	Holding Time
Total, WAD, free cyanide	500 mL amber plastic	NaOH to pH>>12; cool to 4 □ 2°C	14 days
Major minerals , pH, TSS, and Fluoride	1000 mL plastic	Cool to 4 ± 2°C	28 days
Metals-Total	250 mL plastic	HNO_3 to pH<2; cool to 4 ± 2°C	6 months
Metals - Dissolved	250 mL plastic	Filtered (0.45 micron)'HNO_3 to pH<2; cool to 4 ± 2°C	6 months
Chemical Oxygen Demand	250 mL plastic	H_2SO_4 to pH<2; cool to 4 ± 2°C	28 days
Soil and Vegetation Samples			
Total, WAD, free cyanide	500 mL amber glass	NaOH to pH>>12; cool to 4 □ 2°C	14 days
Fluoride	500 mL amber glass	Cool to 4 ± 2°C	28 days
EC sludge Samples			
Total, WAD, free cyanide	500 mL amber glass	NaOH to pH>>12; cool to 4 □ 2°C	14 days
Fluoride	500 mL amber glass	Cool to 4 ± 2°C	28 days
Moisture Content	500 mL glass or plastic bag	None	None

Sampling Frequency

During the 8-week treatment phase of the lab scale wetland test, influent and effluent water will be sampled a minimum of twice weekly to document cyanide removal efficiencies. Samples will also be collected before and after changes in treatment variables (e.g., flow rate etc. as described in Table 3-4).

Soil and plant tissue material samples will be collected from the wetland cell at the end of the test period.

During the EC test, influent and effluent water samples will be collected at the inlet and outlet of the treatment unit as needed to optimize fluoride removal efficiency. Once optimum conditions are identified, an additional 4 water samples will be collected under optimum conditions over an approximately 8-hour period. Sludge sample will be collected at the end of the 8-hour optimum condition test.

Analytical Parameters

Water samples will be analyzed for the parameters in Table 3-2 (Reproduced below) and soil, sludge and plant tissue parameters are in Table 3-6.

Analyte	Method	Reporting Limit (mg/L)
Field Parameters		
pH		0.1 su
Temperature		0.1 C
Specific Conductivity		5 umhos/cm
Major Minerals		
Fluoride	EPA 300	0.1
Chemical Oxygen Demand	EPA 420.4	5
Total Suspended Solids	ASTM 2540D	5
Metals		
Iron- total and dissolved	EPA 200.7	0.060

Cyanide Forms		
Total Cyanide	EPA 335.4	0.01
WAD Cyanide	SM-4500-CN-I	0.01
Free Cyanide	ASTM D7237 or D4282	0.01

TABLE 3-6. SOIL, SLUDGE, AND PLANT TISSUE ANALYTICAL PARAMETERS

Analyte	Method	Reporting Limit (ug/kg)
Major Minerals		
Fluoride	EPA 340	1
Cyanide Forms		
Total Cyanide	EPA 335.4	5
WAD Cyanide	SM-4500-CN-I	1
Free Cyanide	ASTM D7237 or D4282	1

3.2.2 Wetland Testing Documentation

Following completion of the tests described above a report will be prepared providing details of the following:

- Description of the methods and equipment employed (including a discussion of any deviations from the Work Plan with reasons);
- A summary of data collected, including;
  - % removal of total, free and WAD cyanide;
  - Plant tissue and soil analyses results for plant uptake and soil sorption of fluoride and cyanide;
  - Graphs of CN removal efficiency vs incident radiation, HRT and T for each test scenario.

- Design hydraulic retention time (HRT) to achieve maximum cyanide removal;

- Pilot/full scale design parameters to achieve optimum cyanide removal;

- Design and cost estimate to conduct Phase II pilot study based on lab-evaluated design parameters (note the Phase II field pilot study would not occur prior to completion of the final Supplemental Feasibility Study, but would be part of remedial design); and

- Preliminary (+/- 30%) cost estimate for full-scale system.

3.3 ELECTROCOAGULATION TREATMENT MECHANISMS

Electrocoagulation technology has been successfully used by Kaselco for removal of bulk fluoride level from 80 ppm down to <20 ppm with minimum sludge generation. Nonetheless testing with Site waters is necessary to determine how effective (quantitatively) it will be with this particular waste stream, because there are other constituents in this waste stream that will affect the efficiency of fluoride removal. The only way to determine the effectiveness of the process is to run the tests described in this Work Plan.

Typically electrocoagulation produces low volume concentrated sludge in comparison to chemical precipitation processes or adsorption processes for treatment of groundwaters with fluoride levels similar to Kaiser Mead. However without running tests on Site groundwater it is difficult to provide definitive estimates for the volume of sludge that will be generated by electrocoagulation or the associated costs of disposal.

Seasonal variation in water temperature discharging from the wetland may affect both chemical precipitation and the electrocoagulation processes, but unlike the chemical precipitation process, the electrocoagulation process (reactors) generates heat, which will improve the kinetics of treatment in the reactor cells.

Alcoa's experience is the system easily removes reasonable levels of suspended solids from the water column, and the level of solids that is typically found in groundwater pumped from a wetland should not be problematic, but the solids should actually improve separation of the dissolved contaminants. Low levels of organics, such as algae, should be readily oxidized in the reactor cells. Treatment of waste streams with very high levels of organics (15,000 to 50,000 mg/L) can become problematic because the reactions generate high levels of organic acids which then have to be neutralized prior to discharge. Alcoa does not anticipate levels of algae in the groundwater for this application being an issue.

Electrocoagulation using sacrificial monopolar aluminum/iron plate electrodes can successfully treat fluoride by forming aluminum fluoride hydroxide complex [$Al_nF_m(OH)_{3n-m}$] (Emamjomeh and Sivakumar, JEM, 90(2), pp 1204-1212:2009). The key removal mechanisms by electrocoagulation include:

Floc is formed and initially rises to surface due to presence of gas;

The fundamental mechanism of fluoride removal are;

Formation of CaF2 (insoluble);

Formation of FeF2 (slightly insoluble);

Co-precipitation;

Co-precipitation entails;

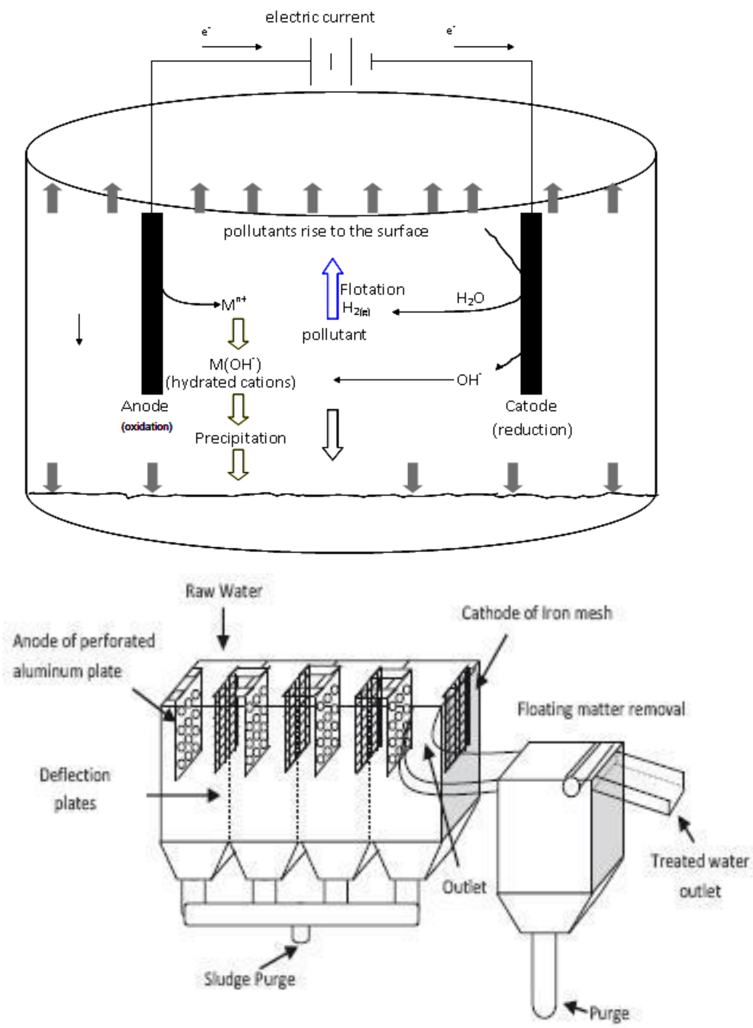
Contaminant adsorption onto freshly formed hydrous ferric oxide colloids;

Solid formation by incorporation into hydrous oxide lattice; and

Physical entrapment of contaminants by the precipitate.

See Figure 3-6 (from Kaselco) for a depiction of the processes.

FIGURE 3-6. ELECTROCOAGULATION SCHEMATICS



Final polishing of the water to compliance level can then be achieved via activated alumina columns (lead and lag combination) with regeneration scheme built-in, if necessary.

3.4 LAB SCALE ELECTRO COAGULATION TESTS

The second step of the treatability study will include treatment of the wetland effluent for fluoride removal using a packaged electrocoagulation (EC) unit that is suitable for treating small flows (~liter/min). This part of the study will be performed in conjunction with the free surface wetland study. The effluent from the free surface wetland will be collected and tested separately at the electrocoagulation vendor's laboratory. Alcoa will use Baker Corporation (dba Kaselco) to perform the EC treatability study. The study will be conducted at Kaselco's facility in Shiner, Texas. The analytical results obtained will provide an indication of the efficiency of the EC system as well as need for Activated Alumina (AA) testing for final polishing. The scope of the EC study entails bench scale tests using Kaselco's bench-scale EC unit to perform the following:

- The scope of work will include tests for 2 samples; a 5-gallon dilute concentration sample (representing diluted water zone) already pre-treated for cyanides through lab-scale wetlands; and a 5-gallon high concentration sample (representing high concentration plume area) already pre-treated for cyanides through lab-scale wetlands.

- The effects of water temperature of the raw water entering the treatment system will be evaluated.

- As part of the EC process, the pH of the waste stream is adjusted prior to processing through the reactors to achieve optimum performance. The optimum pH for treatment usually falls in the range of 7.5 to 8.5. Kaselco will evaluate various levels of pH during bench scale testing to optimize treatment efficiency. The system is designed to automatically adjust the pH of the incoming waste stream to maintain optimum performance.

- In addition, the pre and post treated water using EC will be characterized for fluoride and free cyanide to track any impact the EC treatment has on free cyanide.

As for activated alumina polishing (should it be needed), Alcoa has internal documentation and actual pilot and full scale data which will be used to size the full scale system. No laboratory-scale study will be required for this purpose at this time, but additional testing of EC and AA would be conducted during Phase II field pilot study. The Phase II field pilot study would not occur prior to completion of the final Supplemental Feasibility Study, but would be part of remedial design.

3.4.1 Electro-Coagulation Testing Documentation

After bench testing, Kaselco will prepare a short technical memorandum showing the results of the treatability test and reporting the following:

- % Fluoride and free cyanide removal;
- Quantity of sludge generated per gallon of water treated;
- Sludge characterization results for waste disposal consideration;
- Energy usage per gallon of water treated;
- Chemicals used and consumption per gallon of water treated;
- Consumables needed (including estimated life of the electrodes);
- Cost of replacement of electrodes and their availability;

- Design and cost estimate to conduct Phase II pilot study based on lab-evaluated design parameters; and

- Preliminary (directional) cost estimate for full-scale system.

The results of the treatability study will provide data for development of estimated costs for field pilot tests and estimates for full scale implementation.

3.5 EX SITU EFFLUENT DISCHARGE INFILTRATION

Sizing infiltration ponds will require estimation of infiltration rates of materials underlying the pond. Hydrometrics has collected samples from the seven borings drilled in 2015 of the upper portions of the area sediment profile. These samples will be tested for permeability characteristics using ASTM Methods (7664-10) for estimating infiltration and sizing an infiltration pond. Pond design would be based on calculated infiltration rates and a factor of safety. Multiple cells or redundancy would also be included in the design considerations to assure adequate infiltration capacity.

Areas downgradient (west) of the SPL Pile are being considered for a suitable infiltration site (Figure 3-7). These areas are currently owned by Spokane Recycling Company, the same entity that owns the former smelter facility. Results of the field and laboratory studies conducted this year will provide an indication of the required infiltration rate and results of the infiltration test will indicate how large of an area will be required to infiltrate a projected flow rate. The infiltration test on representative samples will occur during the first quarter 2016. If a Phase II pilot study is warranted and planned then a site specific infiltration test will be conducted, such as the Pit Infiltration Test (Ecology, 2005).

Design and operation of a full scale infiltration system will account for freezing winter conditions so that infiltration of treated groundwater can continue through the winter months.

3.6 EVALUATION OF DATA

The data (and their evaluation) generated by the 2015 field and lab testing activities will be used to determine the feasibility of several remedial alternatives considered in the SFS. As discussed in Sections 3.2.1 and 3.4.1, the results of the wetland and EC laboratory scale tests will be used for evaluating the feasibility of treating impacted groundwater with these technologies.

FIGURE 3-7. POTENTIAL INFILTRATION AREAS

4.0 REPORTING

The majority of the planned activities in this Work Plan are a continuation of the 2013 SFS studies and the completion and assessment of those activities can be reported in the SFS Report and supporting documents. As such, reporting on the 2015 activities will be as follows:

Sediment borings and new well construction, including boring and well logs, analytical results and laboratory data packages will be documented in the *Data Report on Additional Field Characterization for the Kaiser Mead Facility* (Hydrometrics, 2013a).

The updated *Data Report on Additional Field Characterization for the Kaiser Mead Facility* will be used to revise the *Supplemental Site Characterization Analysis* (Hydrometrics, 2013b) and update the *Kaiser Mead Groundwater Conceptual Site Model* (Hydrometrics, 2013c).

Pilot test cutoff wall construction and aquifer tests will be documented and evaluated in the *Technical Memorandum for Source Control Evaluation for Cleanup Actions at the Kaiser Mead NPL Site* (Hydrometrics, 2013d).

The lab scale wetland treatment and electro-coagulation testing will be documented and evaluated in the *Ex Situ Treatability Study for Cleanup Actions at the Kaiser Mead NPL Site* (Hydrometrics, 2013e). The final report will be distributed approximately six months following commencement of the wetland tests.

The above reports and the Groundwater Model Report will be used to update the draft *Supplemental Feasibility Study Report for Kaiser Mead NPL Site* (Hydrometrics, 2014), including an updated Disproportionate Cost Analysis.

5.0 REFERENCES

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Hydrometrics, 2013c. *Draft Kaiser Mead Groundwater Conceptual Site Model (CSM)*. December 2013.

Hydrometrics, 2013d. *Draft Technical Memorandum for Source Control Evaluation for Cleanup Actions at the Kaiser Mead NPL Site*. December 2013.

Hydrometrics, 2013e. *Draft Ex Situ Treatability Study for Cleanup Actions at the Kaiser Mead NPL Site*. December 2013.

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USEPA, 1992. Guidance for Conducting Treatability Studies under CERCLA, Final. EPA/540/R-92/071a. OSWER October 1992.