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Mr. Matt McClincy
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Northwest Region
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Subject: Scope of Work for Geotechnical Evaluation and Slurry Compatibility Testing in Support of the Groundwater Source Control Interim Remedial Measure
Arkema Inc. Portland Facility

Dear Matt:

ERM-West, Inc. (ERM) has prepared this letter on behalf of Legacy Site Services LLC (LSS) to present the proposed scope of work for a geotechnical evaluation and slurry compatibility testing to support design of a Groundwater Source Control Interim Remedial Measure (IRM) at the Arkema Inc. (Arkema) site in Portland, Oregon (the "site"). The primary purpose of this testing is to support remedial alternative selection, design, and installation of the proposed groundwater barrier wall. In addition, the data collected during this project will aid in the design of the proposed groundwater extraction system.

The compatibility testing described in this scope of work has been designed to evaluate the performance and feasibility of a slurry barrier wall. However, as discussed in the *Scoping Technical Memorandum, Groundwater Source Control Interim Remedial Measure* (ERM 2007) and LSS's responses to Oregon Department of Environmental Quality (ODEQ) and United States Environmental Protection Agency (USEPA) comments dated 15 March 2007, a sheet pile barrier wall will be considered as an alternative in the forthcoming Focused Feasibility Study (FFS). The compatibility of steel sheet piles with the constituents of concern (COCs) at the site are well understood; therefore, no site-specific sheet pile compatibility testing is needed or proposed. However, the

proposed geotechnical investigation and evaluation described in this work plan will be applicable to either a slurry or sheet pile construction.

The following sections describe the proposed scope of work and schedule for the geotechnical evaluation and slurry compatibility testing.

SCOPE OF WORK

The scope of work included in this plan consists of the following four tasks:

- Task 1 – Sample Collection and Analysis;
- Task 2 – Geotechnical Engineering Analysis;
- Task 3– Soils and Slurry Compatibility Testing; and
- Task 4 – Barrier Wall Route Surveying.

These tasks are described in detail below.

Task 1 – Sample Collection and Analysis

Task 1 consists of the following subtasks:

Cone Penetrometer Testing

Cone penetrometer testing (CPT) will be performed to provide stratigraphic and lithologic data (e.g., depth to basalt, soil types, and soil characteristics). The parameters measured and recorded while pushing the CPT tool into the formation will include tip resistance, sleeve friction, and formation pore pressure. The CPT tool will be pushed from the surface to resistance indicating the contact with basalt at the base of the unconsolidated formations. CPT borings will be advanced at approximately 250-foot intervals along the planned alignment of the groundwater barrier wall, except for locations near prior borings where ERM has previously measured the depth to the basalt contact (see Figure 1). It is expected that four CPT borings will be performed. The CPT

contractor will provide continuous logs of each CPT push, interpreted soil behavior type, and interpreted soil shear strength.

Mud Rotary Drilling and Soil Sampling

The purpose of mud rotary drilling will be to collect samples for chemical and geotechnical analyses, to allow soil strength testing, and to verify the results of the CPT investigation. Samples collected for the slurry compatibility testing will be used to simulate a "worst case scenario" for compatibility between a potential slurry wall and site soil/groundwater. Therefore, samples will be collected from the wells containing the highest concentrations of site contaminants. ERM will obtain soil samples at two representative locations along the groundwater barrier wall route using mud rotary drilling equipment and tools.

At each location, ERM will obtain a continuous representative sample of the soil from the ground surface to the total depth of the boring (at the contact with basalt). ERM will obtain one set of samples from the portion of the site with elevated total dissolved solids (TDS) (i.e., former Chlorate Plant area), and a second set of samples from the part of the site with elevated volatile organic compound (VOC) concentrations (i.e., former Acid Plant area) (see Figure 1). ERM will obtain disturbed soil samples at 2-foot depth intervals and will record, but exclude from the sample, particles greater than 1-inch nominal diameter. Boring locations will be grouted to the ground surface upon completion.

During mud rotary drilling and sampling, ERM will perform a standard penetration test at intervals in accordance with American Society for Testing and Materials (ASTM) D1586 in order to evaluate soil strength. ERM will perform standard penetration testing at each of the two locations (i.e., former Chlorate Plant area and former Acid Plant area) at the following intervals:

- Five-foot intervals to a depth of 25 feet below ground surface (bgs); and

- Ten-foot intervals below 25 feet bgs to the total depth of the boring.

A maximum of two Shelby Tube samples will be collected from each boring for laboratory testing for shear strength and dry unit weight by the geotechnical laboratory.

Soil Sample Analysis

Soil samples will be analyzed for both physical and geotechnical parameters to assist in the geotechnical engineering evaluation and the slurry compatibility testing. Soil testing will be performed by Sierra Testing Laboratories, Inc. (Sierra) in Sacramento, California. A supplemental analytical laboratory, TestAmerica in Beaverton, Oregon, will be utilized for those analyses which cannot be performed cost-effectively by the materials testing laboratory.

At each of the two mud rotary sample locations, representative samples of each soil type will be subjected to materials testing. At least one soil sample from each of the three water-bearing zones (shallow, intermediate, and deep) and the confining silt separating the shallow and intermediate water-bearing zones will be analyzed. Each sample will be tested for:

- Bulk unit weight (for intact cohesive samples only) in accordance with a method approved by ERM;
- Water content in accordance with ASTM D2216;
- Atterberg limits in accordance with ASTM D4318;
- Particle size distribution in accordance with ASTM D422 (including hydrometer for samples with plastic limit > 5);
- TDS in accordance with appropriate method;
- pH in accordance with ASTM D4972;
- Dry unit weight (total of four samples, collected in Shelby tubes); and
- Standard direct shear tests (total of two samples).

Groundwater Sample Collection and Analysis

Groundwater samples will be collected to evaluate the compatibility of potential slurry mixes with site groundwater. ERM will obtain representative samples of affected groundwater from the areas of the site containing the upper range VOC and TDS concentrations – conditions which may be adverse to barrier wall effectiveness and construction. Each of the wells sampled will be located within 50 feet of the proposed groundwater barrier wall location, to the extent practical. Groundwater samples will be collected concurrently with samples collected for the groundwater treatability study.

One five-gallon sample of groundwater will be obtained from the monitoring well with the highest VOCs concentration along the proposed barrier wall route (MWA-67si). A second five-gallon sample of groundwater will be obtained from the monitoring well with the highest TDS concentration along the proposed barrier wall route (MWA-30). These sampling locations are depicted on Figure 1. ERM will obtain each groundwater sample using low flow sampling techniques and after observing stable indicator parameters.

ERM will obtain additional aliquots of each of the groundwater samples and, after measuring these samples for field parameters, will submit these samples to TestAmerica for analysis of the following parameters:

- Dissolved oxygen;
- Specific gravity;
- Total suspended solids;
- Total dissolved solids;
- Specific conductance;
- Oil and grease;
- Total organic carbon; and

- Total organic halogens.

ERM will provide the results of the groundwater field and laboratory test results to Sierra to allow selection of appropriate combinations of soil, clay additive, and groundwater for slurry and slurry backfill mix design and compatibility testing. ERM will transmit the five-gallon samples of groundwater to Sierra for use in the slurry compatibility testing (Task 3).

Task 2 - Geotechnical Engineering Analysis

A geotechnical engineering analysis will be prepared in support of the design of an effective and adequately stable groundwater barrier wall as described below. This analysis will be performed by Shannon and Wilson, Inc., under the direction of a professional engineer licensed in Oregon. ERM will provide appropriate site data needed to perform the engineering analysis (e.g., slope stability analysis) of the various elements of the groundwater barrier wall construction, including:

- Barrier wall route clearance trench excavation;

- Pre-construction sewer excavation support; and

- Slurry barrier wall construction (including conventional clay slurry-soil trench construction, clay slurry vibrated beam groundwater barrier wall construction, and cement slurry vibrated beam groundwater barrier wall construction).

Each critical short-, intermediate- (rapid drawdown), and long-term loading condition for the barrier wall will be analyzed to evaluate:

- Slurry trench and backfilled groundwater barrier wall stability, including limitations on the offset location of a potential slurry mix pad and/or materials supply vehicles and equipment;

- Limitations on the magnitude and location of surface and foundation loads in the vicinity of the groundwater barrier wall;

- Land-side and river bank stability at each stage of the construction of the groundwater barrier wall;

- Recommended limitations on operation of construction equipment and placement of fill on the river bank during and after construction;

- Recommended limitations (e.g. resulting slope) on future possible excavation of river bank; and

- Comparison and comment on calculated factors of safety for the groundwater barrier wall and related improvements.

ERM and the geotechnical engineering firm will document the procedures used and the results of the geotechnical engineering analysis in a summary report. The report will be prepared as an appendix to the FFS.

Task 3 – Soils and Slurry Compatibility Testing

Several tests and studies will be performed by Sierra to evaluate:

- Suitability of various materials (clay/clay-cement, native soil, and city water/deionized water) for use in the slurry and slurry backfill mixes; and

- Resulting physical and chemical characteristics of various clay/water slurry mixes.

These tests are described below.

Materials Characterization and Suitability Testing

ERM will obtain representative samples of:

- One standard commercial manufacture bentonite clay;

- One standard commercial manufacture attapulgite clay;

- One standard commercial manufacture specialty clay-cement material; and

- Site potable (city) water.

Samples of these materials, along with samples of site soil and groundwater as previously described in Task 1, will be sent to Sierra for testing.

Clay additive samples (i.e., bentonite, attapulgite, and clay-cement) will be analyzed for the following parameters:

- Water content in accordance with ASTM D2216;
- Atterberg limits in accordance with ASTM D4318; and
- Free swell in accordance with ASTM D5890.

ERM will use the results of these analyses to verify the quality of the clay additives to be used for in subsequent testing.

Site potable water samples will be analyzed at the time of collection for the following parameters:

- pH with a field test meter; and
- Specific conductance with a field test meter.

Slurry Mix Evaluation

This task includes evaluation of both the slurry mix (liquid used during installation of the barrier wall) and slurry backfill mix (more solid slurry used to construct final barrier).

To evaluate the slurry mix, each of the three clay additives will be mixed with site potable water and a sample of laboratory-grade deionized water (i.e., six mixtures) and analyzed for Atterberg limits in accordance with ASTM D4318. ERM will use the results of the clay additive mix testing to adjust the range of the subsequent clay-water mix ratios, if necessary.

A range of slurry mix ratio samples will be prepared by mixing varying quantities of potable water and de-ionized water with each of the three clay additives (bentonite, attapulgite, and clay-cement). Three mix ratios

of water and each clay additive (a total of six slurry mixes) will be evaluated.

The clay-mix water slurries will be tested at regular intervals (0, 1, 2, 4, 8, and 24 hours after mixing) for the following parameters:

- Unit weight in accordance with API RP 13B-1;
- Marsh Funnel Viscosity in accordance with API RP 13B-1; and
- pH by field portable instrument.

The three clay slurry mixtures from each soil sampling location will be adjusted until the design criteria are met for the following tests:

- Unit weight in accordance with API RP 13B-1;
- Slump in accordance with ASTM C143; and
- Water content in accordance with ASTM D2216.

Each of the six slurry mixtures will be subjected to hydraulic conductivity testing using an aliquot of site groundwater collected from the area adjacent to the corresponding soil sampling location, plus, as a separate control sample, a de-ionized water sample (i.e., a total of twelve hydraulic conductivity tests). Samples will be tested for hydraulic conductivity in accordance with ASTM D5084 for a period sufficient to allow transmission of at least one test specimen pore volume of permeant through the sample and to obtain a stable value of the measured resulting hydraulic conductivity.

Results of the slurry compatibility testing will be summarized in a report, which will be included as an appendix to the FFS.

Task 4 - Barrier Wall Route Surveying

This task will involve surveying of the potential barrier wall route and soil sampling locations by David Evans and Associates to obtain detailed northing, easting, and elevation data.

PROJECT SCHEDULE

The expected duration of each task is as follows:

- Task 1 – Sample Collection and Analysis (4 weeks)
- Task 2 – Geotechnical Engineering Analysis (6 weeks)
- Task 3 – Soils and Slurry Compatibility Testing (18 weeks)
- Task 4 – Barrier Wall Route Surveying (2 weeks)

Several of the tasks will be performed concurrently. The total expected project duration is approximately 5 months.

The geotechnical evaluation and slurry compatibility testing represent a critical path for the Groundwater Source Control IRM. As such, ERM and LSS will endeavor to sequence and expedite tasks, to the extent practical, in order to meet the overall project schedule. We have scheduled the mud rotary drilling contractors to begin soil sample collection on 2 April 2007. CPT drilling is currently scheduled to begin on April 9.

ERM and LSS appreciate the agencies' expedited review of this work plan. If you have any questions or require additional information, please feel free to contact Erik at (425) 462-8591.

Sincerely,

Erik C. Ipsen, P.E.
Project Manager

David P. Edwards, P.G.
Partner

ECI/DPE /jjr/0063836
Attachment
cc: Todd Slater -LSS
Larry Patterson

Figure

Project No. 0063836.03
Date: 03/22/07
Drawn By: R. Olson
CAD File: G:\0063836\03\006383603-01.dwg

LEGEND

- Existing Shallow Zone Monitoring Well
- Existing Shallow–Intermediate Zone Monitoring Well
- Existing Fractual Basalt Zone Monitoring Well
- Proposed Location Of Mud Rotary Boring
- Proposed Location of Cone Penetrometer Boring
- Site Boundary
- Preliminary Removal Action Area
- Approximate Lot Boundary
- Preliminary Upland Portion of the Arkema Site
- Conceptual Barrier Wall Location

TRUE NORTH
PLANT NORTH
0 200
FEET

Note:
Most buildings and structures noted on this diagram have been demolished and/or removed.

Figure 1
Proposed Boring Locations
Groundwater Source Control IRM
Arkema Inc.
Portland, Oregon

ERM 03/07