PRE-REMEDIAL DESIGN INVESTIGATION 2 PROJECT PLAN

Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Prepared for: Port of Bellingham

Project No. 210368-B-02 • September 28, 2022 FINAL

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CONSULTING

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1 Introduction

This Pre-Remedial Design Investigation (PRDI) 2 Project Plan (Plan) supports the Chlor-Alkali Remedial Action Unit (RAU) cleanup at the GP West Site (Site). The cleanup action selected in the RAU Cleanup Action Plan (CAP) includes removal of remnant structural obstructions and then *in-situ* solidification/stabilization (ISS) treatment of soils containing visible elemental mercury (Hg) in the Chlorine Plant Area. The PRDI Plan defines the field pilot testing and laboratory treatability testing necessary to complete the remedial design for this key component of the cleanup action.

In August 2009, the Washington State Department of Ecology (Ecology) and the Port of Bellingham (Port) entered into Agreed Order No. DE 6834 (Order) to clean up the GP West Site. In August 2013, an amendment to the Order separated the GP West Site into the Pulp/Tissue Mill and Chlor-Alkali RAUs. In September 2021, Ecology issued the final Cleanup Action Plan (CAP) for the RAU (Ecology, 2021). In March 2022, Ecology issued a minor modification to the Order that revised a Schedule of Deliverables for Remedial Design for the RAU, including this PRDI 2 Project Plan as Deliverable D.1a (Ecology, 2022).

Accordingly, the following PRDI activities will be conducted to inform the remedial design for the removal of obstructions and ISS treatment of soils containing visible Hg in the Chlorine Plant Area:

- **Field Pilot Testing –** A field pilot test will evaluate the means and methods of obstruction removal for a portion of the Cell Building foundation (Figure 1). The portion targeted includes three pile caps and associated grade beams and timber pilings. The timber pilings extend to depths greater than the contact between the Hg-contaminated fill and underlying native silt aquitard unit, and they will be cut at or just below that contact. All structural debris removed during the pilot test will be disposed of at a Subtitle C landfill. No ISS soil mixing will be conducted during the field pilot test. The field pilot test area will be regraded and paved with asphalt restoring to existing condition.
- **Laboratory Treatability Testing** – Soil, groundwater, and makeup water will be collected during the field pilot test for use in laboratory treatability testing. The laboratory treatability testing will evaluate eleven ISS mix designs using two soil homogenates – the evaluation will be based on strength, hydraulic conductivity, and leachability performance criteria.

The subsequent sections of this PRDI Plan are organized as follows:

- **Section 2** – Background
- **Section 3** – Field Pilot Testing
- **Section 4** – Laboratory Treatability Testing
- **Section 5** – Site Survey
- **Section 6** – Schedule and Reporting

2 Background

This section outlines the prior interim cleanup actions conducted in the Chlorine Plant area, and the CAP's cleanup approach for that portion of the RAU, as necessary background for defining the PRDI Plan activities.

2.1 Completed Interim Cleanup Actions

2.1.1 2013-2014 Caustic Plume-Cell Building Interim Action

The First Amendment to Agreed Order No. DE 6834 required that the Port perform an interim action to remove mercury-contaminated soils and building materials from the Chlorine Plant Area, then termed the Caustic Plume subarea (Ecology, 2011). The goal of the interim action was to permanently control substantial sources of mercury contamination to groundwater, surface water, and air. The Caustic Plume-Cell Building interim action removed the highest concentrations of mercury detected in Site soil (soil containing visible Hg), and elevated mercury concentrations in building materials not removed during Georgia-Pacific's 2000 decommissioning of the Chlorine Plant.

In total, the completed interim action achieved permanent removal of approximately 6,880 tons of Hg-contaminated soil and debris[1] from the areas shown on Figure 2. Bench-scale treatability studies were conducted to design the chemical stabilization for excavated soils to comply with applicable federal land disposal restrictions (LDRs) for remediation waste prior to disposal of the soil at a Subtitle C landfill. The treatability testing determined a mix design of 45 units of Portland cement (by weight) and 5 units elemental sulfur with 100 units of contaminated soil and 15 to 20 units water (or as required to generate a mixable and flowable mixture). The Portland cement and elemental sulfur dosages used were intentionally conservative because the cost of treatment failure was exceptionally high.[2] During the interim action, Hg toxic characteristic leaching procedure (TCLP) results for batches of treated soil were typically two orders of magnitude below the treatment objective (0.25 mg/L TCLP Hg), confirming the conservatism in treatment design. To control air emissions, the on-site stabilization was performed inside a treatment enclosure erected within the Cell Building by the Contractor. Air within the enclosure was captured and treated prior to discharge to the atmosphere, and air monitoring was conducted within the work zone and at the perimeter of the project limits.

During the interim action, the Contractor pumped groundwater from the shallow Fill Unit aquifer to facilitate excavation and handling of unsaturated contaminated soil, and pumped groundwater from the deeper, confined, Lower Sand aquifer to depressurize it.[3] The groundwater extracted was treated and discharged to the Port's Aeration and Settlement Basin (ASB) in accordance with the Port's NPDES permit for the facility. A

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[1] Includes the Cell Building above-grade structure.

[2] Transport under manifest to Waste Management's Mercury Waste Solutions facility in Wisconsin for retort treatment (LDR treatment standard under 40 CFR 268.40) and then Subtitle C landfill disposal.

[3] To limit the chance that the Lower Sand's artesian pressure would breach the aquitard unit on top of it when the overlying contaminated fill was removed.

total of approximately 1,100,000 gallons of groundwater were removed during the interim action.

The Caustic Plume-Cell Building interim action also included demolition and off-site disposal of the remaining Cell Building structure (building shell and floor slab). Following removal of the upper concrete floor slab, visible Hg was observed within the original (1960s-vintage) floor troughs and soil-filled floor sump into which the troughs drained. Therefore, the floor troughs were individually saw-cut (more than 1,000 linear feet) to segregate them from the remaining floor slab which did not contain visible Hg. Substantial quantities of visible Hg were encountered in subsurface soil beneath the Cell Building floor slab near the former floor troughs and sump during the interim action. In September-October 2014, a test pit exploration program was conducted to investigate the extent of Hg-impacted materials across the entire area of the former Chlorine Plant. Based on the collective information, the areas containing visible Hg are shown on Figure 2.

Because of the unanticipated and extensive increase in quantity of materials containing visible Hg encountered as the interim action progressed, Ecology and the Port agreed to terminate the interim action without further soil removal, and to address the residual elemental Hg as part of the final cleanup of the Chlor-Alkali RAU. A stockpile of excavated mercury-impacted material (approximately 430 cubic yards [CY]) was left on-site. The entire Cell Building excavation area, including the soil stockpile, was covered with a single sheet of 12-mil-thick, waterproof, reinforced, UV-resistant cover to eliminate contact with precipitation and restrict fugitive Hg vapors. The entire Site, including the Cell Building area, was (and remains) fenced with public access prohibited. Aspect (2014) provides additional details regarding the 2013-2014 interim action.

2.1.2 2017 Removal of Mercury-Contaminated Soil at Cell Building

In 2016, Ecology required the Port to remove the estimated 430 CY of stockpiled mercury-impacted material left from the 2013-2014 interim action. This removal was conducted in Fall 2017 as an interim action.

The stockpiled soil was chemically stabilized in an on-site treatment process similar to that used in the 2013-2014 interim action. However, additional treatability testing was first conducted to re-evaluate the amendment dosage requirements. The treatability testing informed the Portland cement dosage (per 100 units of contaminated soil), which was reduced from 45 to 25 units (by weight) and the elemental sulfur dosage was reduced from 5 to 2 units. There was also a corresponding reduction in the amount of water that needed to be added to generate a mixable and flowable mixture, to approximately 10 units. The on-site stabilization was again performed inside a treatment enclosure (tent) with capture and treatment of air within the enclosure. Air monitoring was conducted within the work zone and around the perimeter of the project limits.

A total of 533 tons of contaminated soil was treated in 28 treatment lots, each of which achieved the TCLP Hg treatment objective of 0.25 mg/L for Subtitle C disposal purposes.

After soil treatment was completed, the steel road plates that covered open excavation areas within the Cell Building footprint were removed, and the voids were backfilled with imported gravel borrow. The entire Cell Building footprint was then paved with a 3-inch thickness of hot mix asphalt. Prior to paving, the steel road plates were placed on the ground surface in the northern portion of the footprint to help stabilize the saturated soils in this area. A separation geotextile was then placed to separate underlying contaminated materials from overlying clean import materials, followed by a layer of gravel borrow graded to slope (drain) and then crushed surfacing base course (also for the purpose of stabilizing the ground surface to facilitate paving). Relevant Cell Building as-built drawings are included in Appendix A.

2.2 Cleanup Action Plan

The cleanup action for the Chlor-Alkali RAU includes removal of obstructions and ISS treatment of soils containing visible Hg, all of which occur within the vicinity of the former Chlorine Plant. Outside of the ISS-treatment, the cleanup action includes removal and capping of soils with hazardous substance concentrations that exceed soil cleanup levels. Institutional controls in the form of an environmental covenant will provide notification regarding the presence of residual contaminated soils and groundwater, regulate the disturbance and management of those soils and the cleanup action components, prohibit groundwater use, and provide for long-term monitoring and stewardship of the cleanup action.

2.2.1 ISS Component of Cleanup Action Plan

The area of residual Chlorine Plant area soils with visible Hg to be treated with ISS is shown on Figure 4 and comprises an estimated 15,000 CY of soil. Much of this soil is situated within dense arrays of foundation pilings that supported the Cell Building and other Chlorine Plant infrastructure. In order to conduct ISS treatment, it is first necessary to remove the concrete grade beams and pile caps resting on the timber pilings. Then Fill Unit soils will be moved as needed to expose the timber pilings down to the aquitard so that they can be cut off at the Fill Unit/aquitard interface (roughly 15-foot depth). Soils from the Fill Unit containing visible Hg will then be treated via ISS. The ISS of all soils containing visible Hg will achieve the following remedial action objectives (RAOs):

- Prevent direct contact with and erosion of mercury-contaminated soils by physical solidification of soil into a monolith.
- Prevent vapor intrusion from elemental-mercury-contaminated unsaturated soils or groundwater by physical solidification and thereby reduced volatilization.
- Significantly reduce mercury leaching to groundwater from mercury-contaminated soils and prevent discharge to the Whatcom Waterway of mercury-contaminated groundwater.

The remedial design of the ISS cleanup action requires implementation of (1) a field pilot test (Pilot Test) for complete removal of structural obstructions down to the aquitard layer and (2) laboratory treatability testing (Treatability Testing). Section 3 outlines the Pilot Test. The Treatability Testing will evaluate ISS mix designs based on performance criteria of strength, permeability, and leaching as defined in Section 4.

3 Field Pilot Testing

The Pilot Test will evaluate means and methods of obstruction removal for a portion of the Cell Building. The Pilot Test will remove obstructions consisting of all subsurface structures associated with three pile caps of varying configuration and timber piling support. The specific objectives for the Pilot Test are to:

1. Determine optimal means and methods of grade beam and pile cap removal
2. Determine optimal means and methods for cutting timber pilings at the aquitard surface and removing them
3. Evaluate grade change after obstruction removal and backfill of excavated soils
4. Evaluate stability of the aquitard during removal of Fill Unit soils and obstructions
5. Evaluate water management (dewatering) level of effort to accomplish obstruction removal to the aquitard
6. Evaluate Hg vapor emissions and mitigation method

No ISS soil mixing will be conducted during the Pilot Test. The ISS treatment objectives will be evaluated in the Treatability Testing described in Section 5. Site soil, groundwater, and tap water source (for construction) will be collected during the Pilot Test for use in the Treatability Testing. The Pilot Test will involve proper landfill disposal of all structural debris removed, consistent with the final cleanup action. The Pilot Test will not involve offsite disposal of contaminated soils that are temporarily stockpiled within the area of contamination[4] in order to expose the aquitard.

Aspect will subcontract with Strider Construction Co. Inc. (Contractor) to conduct the Pilot Test under Aspect's direction. The following sections outline the Pilot Test scope of work.

3.1 Mobilization and Site Preparation

The Contractor will mobilize equipment, materials, and labor required for the Pilot Test and will stage equipment and materials within the footprint shown on Figure 3.

The Contractor will prepare a Temporary Erosion and Sediment Control (TESC) Plan that describes erosion and sedimentation control best management practices (BMPs) to be installed and maintained by the Contractor to manage and prevent stormwater and fugitive dust emissions from leaving the Pilot Test area. The TESC Plan and BMPs implemented will be in accordance with City of Bellingham design standards for temporary erosion control. The TESC Plan will be approved by Aspect prior to mobilization.

The Pilot Test area is paved with approximately 3 inches of asphalt (Appendix A-2). The asphalt and subgrade borrow, base course, and geotextile will be carefully removed to the

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[4] The CAP identifies Ecology agreement that soils containing visible mercury may be moved within the area of contamination to the extent required for pile removal and subsequent ISS treatment without generating a remediation waste under the Resource Conservation and Recovery Act (RCRA).

extent necessary to conduct the Pilot Test. Materials above the separation geotextile will be segregated from underlying contaminated structures and soils.

The following activities will also be conducted to prepare for the Pilot Test:

- Construction of the temporary stockpile area defined in Section 3.6
- Mobilize and setup water management system and construct discharge conveyance defined in Section 3.7
- Materials preparation and staging for Hg vapor mitigation defined in Section 3.8
- Establish exclusion zone for excavation area and Level C personal protective equipment (PPE) discussed in Sections 3.2 and 3.8

3.2 Health and Safety

The subsurface materials to be exposed and handled during the Pilot Test will contain high concentrations of Hg including non-aqueous phase liquid Hg that generates high concentrations of Hg in air. Mercury vapors are invisible and have no odor and represent a significant health and safety exposure risk to be monitored and mitigated during the Pilot Test.

The Contractor will prepare, maintain, and implement a site-specific Health and Safety Plan (HASP) for the Pilot Test work in conformance with Washington Administrative Code (WAC) 296-843-120. The HASP will cover all aspects of the Pilot Test and require that workers within the exclusion zone wear Level C personal protective equipment (PPE) including air-purifying respirators with Hg vapor cartridges. The HASP will be prepared or approved by a Certified Industrial Hygienist, and by Aspect prior to Pilot Test mobilization. Aspect will also prepare a HASP to protect Aspect staff conducting oversight during the Pilot Test.

The Hg vapor monitoring, mitigation, and contingency mitigation for protection of onsite workers and the offsite public is discussed in Section 4.8.

3.3 Temporary Soil Removal

Soil will be excavated and temporarily stockpiled within the area of contamination, as needed, to expose and remove the specified three pile caps and their timber pilings down to the aquitard surface expected at a depth of approximately 15 feet bgs (pile caps J4, J5, and L4 shown on Figure 4). The Contractor will excavate the minimum quantity of soil needed to expose the timber pilings down to the aquitard surface with adequate space to cut the pilings at that interface. Soil removal to create a working bench below existing grade, if necessary, will be conducted in the area noted on Figures 3 and 4.

Beneath the separation geotextile, fill soils to be temporarily removed consist of loose silty sands with varying degrees of Hg contamination, including the presence of elemental Hg. Soil excavation will be done in such a manner as to not displace the timber pilings in such a way that would create voids or fracture the integrity of the aquitard present beneath the contaminated fill soil being excavated. Aspect will oversee the excavation and direct Contractor regarding the depth to excavate to encounter the underlying aquitard.

All soils excavated to expose the grade beams, pile caps, and timber pilings to be removed will be temporarily stockpiled until debris removal is complete, at which time the excavated soil be placed back into the excavation and compacted as described in Section 3.9. Only soil comingled with the removed structures, and bulk soil samples to be used in Treatability Testing (Section 4.2) will be removed from the Site. A high level of care will be taken to ensure that no excavated soil is spilled or otherwise dispersed outside of the stockpile area contained within the area of contamination. Any soil that is inadvertently spilled will be immediately removed.

3.4 Pile Cap and Grade Beam Removal

The Pilot Test targets removal of three pile caps and associated timber pilings, denoted as J4, J5, and L4, located on the western side of Cell Building foundation as shown on Figure 4. The letter-number combinations assigned to the three pile caps are derived from the Cell Building Ground Floor Framing Plan (sheet C-1 in Appendix A-1).[5] Based on sheet C-1, the grade beams appear to connect all three pile caps and extend to approximately 3 feet below existing grade. Additional grade beams appear to connect the pile caps to the east, west, and north. The Contractor will remove the minimum length of grade beams necessary to remove the three pile caps and associated timber pilings down to the aquitard surface.

The three pile caps to be removed during the Pilot Test begin approximately 3 feet below existing grade and are approximately 2.5 to 3.0 feet thick. Dimensions and details of each of the pile caps (types P9, P3, and P5 at locations J4, J5, and L4 respectively) can be found on the Cell Building Pile Cap Details drawing C-2 in Appendix A-1.

Demolition of grade beams and pile caps will be conducted with an excavator with cracker attachment and/or hydraulic breaker, if necessary. Demolition and removal of the grade beams and pile caps will be done in such a way as to minimize the disturbance to the underlying timber pilings. The pile caps will be pre-drilled on a one-foot grid and filled with demolition grout (Dexpan) to fracture pile caps, ease removal, and minimize disturbance of timber pilings (Dexpan specification sheet and safety data sheet [SDS] in Appendix D). Also, soil will not be removed deeper than bottom of pile cap during pile removal to maintain stability of wooden pilings.

An estimated 65 tons of concrete debris will be generated from grade beam and pile cap removal. All concrete debris removed during the Pilot Test will be disposed off-Site as hazardous waste at a Subtitle C landfill as described in Section 3.10.

3.5 Timber Piling Removal

The Pilot Test targets cutting and removing the timber pilings connected to pile caps J4, J5, and L4. Cutting will occur at the aquitard interface and to the extent practical, target 1 foot below the aquitard interface (i.e., depth of approximately 16 feet bgs). The anticipated pilings to be removed are shown on the Cell Building Piling Plan North drawing; sheet C-3 in Appendix A-1).

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[5] The north arrows on sheets C-1 and C-3 were determined to be incorrect based on field observations conducted during the 2013-2014 interim action. The mill-north arrows annotated onto those sheets match the mill-north orientation on Figures 1 through 3.

The pile cap J4 is shown as having seven pilings on drawing C-3; however, it is anticipated that nine pilings are present at that location, including up to four battered pilings[6]. The pile cap P3 at location J5 is connected to three vertical pilings. The pile cap P5 at location L4 is assumed to be connected to five vertical pilings. Therefore, a total of 13 vertical pilings and 4 battered pilings are anticipated to be removed.

The Pilot Test will target cutting the timber piling 1 foot below the top of the aquitard to the extent practical to minimize the remaining piling interfering with the ISS cleanup action. Soil will be removed from the cut timber pilings to the extent practical. The portions of the pilings extending below the cut (and through the aquitard) are to remain in place and not be disturbed. If the timber pilings extending into the aquitard are displaced during the Pilot Test, the area around the disturbed piling will be backfilled with a self-hardening controlled density fill (CDF) within 24 hours.

Once the timber piling is exposed at the aquitard interface as directed by Aspect, it will be cut with an excavator-mounted hydraulic shear attachment. The hydraulic shear will be positioned at the base of the timber piling. The shear attachment includes a grapple that will secure the upper portion of the piling during cutting and remove it once cut.

If obstructions or equipment fouling with fine soils prevent the hydraulic shear attachment method from achieving the Pilot Test objectives, then a second cutting method will be evaluated. The second piling cutting method consists of shoring the excavation with a trench box to allow for worker entry and piling cutting with a chainsaw by a worker with appropriate PPE.

All wooden debris (less than 1 ton anticipated) removed during the Pilot Test will be disposed off-Site as hazardous waste at a Subtitle C landfill as described in Section 3.10.

3.6 Temporary Stockpiling

The temporary stockpile area shown on Figure 3 will be divided into one discrete area for excavated soils pending their return to the excavation as backfill, and a second discrete area for excavated debris pending loading for off-site disposal. All concrete and wood pilings removed during the Pilot Test will be one hazardous waste stream for subsequent transportation and disposal and so will be stockpiled together within the stockpile area.

All contaminated debris may be direct loaded for transportation or temporarily stockpiled until loaded for transport.

Each stockpile area will be prepared by removing any rock or debris from the asphalt and established by a polyethylene geomembrane with a minimum thickness of 10 mils. Adjacent geomembrane sections will be continuously overlapped by a minimum of 3 feet, with sealing of seams between adjacent geomembrane sections. Berms will be constructed around the stockpile area to a minimum height of 9 inches and will contain sufficient area to allow for ponding of water potentially draining from the stockpiled materials. Any liquid accumulating within the bermed stockpile areas will collected and handled in accordance with Section 3.7.

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[6] This anticipated condition is based on the P9 pile cap shown at the J4 location on drawing C-1 in Appendix A-1.

Stockpiles will be covered when not in use with polyethylene geomembrane with a minimum thickness of 10 mils and anchored as needed to prevent it from being removed by wind or other disturbance. Tears or discontinuities in the geomembrane underliner or cover will be repaired immediately.

3.7 Dewatering and Water Management

Dewatering is necessary to remove groundwater in the Fill Unit soils to expose the pilings at the aquitard interface in unsaturated conditions. All water accumulating in stockpile areas and water generated from excavation dewatering will be collected and conveyed to the Contractor’s onsite water treatment system and from there to the Owner’s ASB pump station (discharge point shown on Figure 1).

The Contractor is responsible for maintaining dry conditions in the Pilot Test excavation. Dewatering will be conducted by submersible pumps installed in slotted casing pipe surrounded by drain rock. Dewatering water will be conveyed to a 11,000-gallon settling tank equipped with a series of weirs to both reduce settleable solids and capture separate-phase oil, if present.

The weir tank effluent will be conveyed to the Port’s ASB pump station located approximately 1,500 feet northeast of the Pilot Test area (Figure 1), from which it will be pumped automatically to the Owner’s ASB under the terms of their NPDES permit (Permit No. WA-000109-1). Conveyance to the ASB pump station is anticipated to be constructed with welded 4-inch-diameter high-density polyethylene (HDPE) pipe.

The Contractor is responsible for all operation and maintenance activities associated with the water management equipment. Aspect will monitor effluent water quality from the Contractor’s water treatment system and may direct the Contractor to alter operations as needed to achieve Project Water Quality Performance Standards of total settleable solids below 50 milliliters per liter (ml/L) and no visible separate-phase oil (including sheen) in water discharged to the ASB pump station.

3.8 Air Monitoring and Mitigation

The elemental Hg present within the exclusion zone is a highly volatile contaminant. Throughout the Pilot Test, the area of open excavation area at any one time will be minimized to limit Hg vapor emissions from the Pilot Test area. All personnel, Aspect and Contractor, within the exclusion zone are required to use Level C PPE including air-purifying respirators with Hg vapor cartridges.

Air monitoring for Hg will be conducted by Aspect within the breathing zone for the purpose of worker health and safety, and around the Pilot Test area perimeter to monitor fugitive emissions, using a using a hand-held mercury air monitoring instrument (Lumex®). The perimeter air monitoring will be conducted at the approximate four locations shown on Figure 3. The following action levels for Hg in air will be enforced during the Pilot Test:

- **Within the worker breathing zone:** the 100 micrograms per cubic meter (ug/m^3) Occupational Safety and Health Administration (OSHA) permissible exposure limit.
- **At the perimeter monitoring locations:** a 5 ug/m^3 Model Toxics Control Act (MTCA) air remediation level that is a modified Method B (unrestricted) air

cleanup level derived in Aspect (2016). That action level assumed a 6-week duration of vapor generation from exposed Hg (thus exposure); the duration of vapor generation from this Pilot Test is anticipated to be 2 to 3 weeks and therefore the action level should be conservative.

If an air action level is exceeded, Pilot Test operations will be suspended and the Contractor will implement additional vapor suppression methods and/or adjust their operations to reduce Hg emissions to below the air action levels.

Vapor suppression methods will include application of Hg vapor suppressants. The Contractor will have 300 gallons of Hg vapor suppressant solution prepared on standby in the event that mitigation is required for vapor emissions from the excavation or stockpile area. A 12-mil liner, cover material, and 6-mil visqueen materials will also be available for vapor suppression from temporary stockpile area. To further reduce Hg air emissions, the Contractor will also maintain dust-free traffic routes and surfaces during the Pilot Test.

3.8.1 Contingency Vapor Mitigation

If the vapor mitigation methods described above cannot adequately suppress vapors below the action levels, a contingency is included to mitigate vapors using a vapor enclosure and air treatment system like that used in the prior two interim actions. This approach is included as a contingency measure for this Pilot Test because, relative to the prior two interim actions that involved active *ex situ* mixing of soils containing elemental Hg, the magnitude and duration of exposure to elemental Hg will be substantially less.

If necessary based on air monitoring data, the Contractor will procure a vapor control enclosure large enough to encompass the Pilot Test area and remobilize to the Site to complete the Pilot Test within it. The top and sides of the enclosure will be water-tight and generally air-tight, including at the seam where the enclosure walls meet the ground. The enclosure must function during all weather conditions for the remaining duration of the Pilot Test process.

A blower(s) will be installed at one end of the treatment enclosure to actively draw air from inside the enclosure for treatment. The blower will be sized to displace a minimum of three enclosure volumes of air per hour. The air discharged from the blower will be treated to achieve Hg concentrations at or below an action level of 50 micrograms of Hg per cubic meter of air (50 ug/m^3) at the air treatment system discharge point,[7] as measured by Aspect. The air treatment system will use activated carbon pre-treated with sulfur or iodine to remove vapor-phase Hg. The system will also, to prevent premature clogging of the activated carbon, include means to effectively filter the air for particulate matter upstream from the activated carbon. If Hg concentrations measured at the air treatment system discharge point exceed the action level, the Contractor will terminate operations and reconfigure the treatment enclosure, the blower, and/or the air treatment system to achieve the action level. At the end of the Pilot Test, all filter media, activated carbon, and other materials from the air treatment system will be properly disposed of in accordance with applicable laws, regulations, and permits.

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[7] As derived in Aspect (2016) to comply with Chapter 173-460 WAC, Controls for New Sources of Toxic Air Pollutants.

3.9 Debris Management

All concrete debris (grade beams and pile caps) and wooden pilings removed during the Pilot Test will be designated as characteristic hazardous waste debris (D009). The combined concrete and wood debris removed during the Pilot Test will be loaded and transported under manifest to the Chemical Waste Management (CWM) Subtitle C Landfill in Arlington, Oregon, where it will be treated by macroencapsulation to meet LDRs for hazardous debris in accordance with 40 CFR 268.45 and then disposed of in the Subtitle C landfill. This same approach was used to manage hazardous debris generated during the prior two interim actions.

3.10 Backfill and Restoration

The Pilot Test excavation area will be backfilled using stockpiled soil. The backfill area will remain within the area of contamination to be treated with ISS. If needed to account for the volume of debris removed during the Pilot Test, common borrow will be imported and used to complete backfill to approximately 6 inches below surrounding asphalt grade. Any materials imported for backfill will be virgin native rock or aggregate produced from a quarry, with no man-made or recycled materials within it.

All of the backfill deeper than 2 feet below final grade will be placed in loose lifts no greater than 24 inches and tamped with an excavator bucket. Backfill placed within 2 feet of final grade will be compacted in loose lifts no greater than 8-inches-thick with a vibratory compactor or an equivalent method. During placement and compaction of backfill, the Contractor will control water inflow to the excavation such that the backfill material can be compacted as specified.

After placement of the backfill, the Contractor will restore the Pilot Test area by constructing a hot mix asphalt (HMA) pavement section to match the surrounding existing asphalt surface. The HMA section will consist of, from bottom up:

- A minimum of 3 inches of Crushed Surfacing Base Course (CSBC) per Section 9-03.9(3) of the 2022 WSDOT Standard Specifications
- 3 inches of HMA Class ½”, PG 64-22

The perimeter of the new HMA surface will be tapered to match surrounding grade to make a smooth transition that is drivable by automobile.

3.11 Cultural Resources and Inadvertent Discovery Plan

The Pilot Test area lies within zones of moderate to high probability for encountering archaeological materials, as determined by Northwest Archaeological Associates as part of the Waterfront District New Whatcom Environmental Impact Statement (Appendix M to Blumen and Associates, 2008). If present, archaeological materials would be expected near the top of the native beach/tideflat deposits that underlie the fill.

It should be noted that Ecology reviewed planned cleanup activities within the GP West Chlor-Alkali RAU in 2019 (Department of Archaeology and Historic Preservation [DAHP] Project No. 2019-04-03038) under Executive Order 05-05 and determined that cultural resources and historic properties are unlikely to be impacted by the cleanup action. This determination was made following consultation with DAHP, the Lummi

Nation, and the Nooksack Indian Tribe. DAHP comments to Ecology required completion of excavation work in accordance with an Inadvertent Discovery Plan (IDP).

Consistent with the 2022 PRDI 1 Project Plan activities conducted on the Lignin Operable Unit, the Pilot Test excavation work will be completed in accordance with the IDP included as Appendix C. The IDP defines the stop-work and notification procedures for Aspect's field personnel to perform in the event of discovering potential archaeological materials while completing the excavation.

4 Laboratory Treatability Testing

The Treatability Testing will be conducted to evaluate ISS performance criteria by creating laboratory-scale monoliths of Site soil with a range of mix designs using two soil homogenates.

4.1 ISS Performance Criteria

ISS as a remediation technology targets reduction of contaminant flux from soil to groundwater by solidifying a soil mass and reducing its hydraulic conductivity. ISS is constructed by mixing cementitious reagent(s) with impacted Site soils, resulting in a solidified monolith of increased strength and reduced hydraulic conductivity in comparison to existing Site soil conditions. After ISS, groundwater is diverted around the solidified treatment zone, limiting contact of groundwater and treated soils, thereby reducing leaching of contaminants to groundwater.

The Treatability Testing will evaluate the efficacy of different ISS mix designs and results will be evaluated based on the following strength, hydraulic conductivity, and leachability performance criteria:

1. Achieve an unconfined compressive strength of at least 50 pounds per square inch (psi) according to American Society for Testing of Materials International (ASTM) D1633
2. Achieve an average hydraulic conductivity of the treated soils equal to or less than 1 x 10^{-6} centimeters per second (cm/s) according to ASTM D5084 (flexible wall permeameter)
3. Reduce leachability of Hg as determined by EPA’s leaching environmental assessment framework (LEAF; SW-846 Method 1315). The reduction in Hg leaching from the treated monolith will be sufficient to ensure the groundwater cleanup level for Hg of 0.059 micrograms per liter (ug/L) is achieved at the groundwater conditional points of compliance established in the RAU’s CAP.

4.2 Sample Collection

Soil, groundwater, and tap water will be collected from the Chlorine Plant area for use in Treatability Testing. Two bulk soil samples will be collected:

- Soil #1 will be collected from soils containing elemental Hg visible during the Pilot Test. The Soil #1 sample will be considered worst-case conditions during Treatability Testing with respect to ISS performance criteria.
- Soil #2 will be collected from soils not containing visible elemental Hg. Soil #2 will be considered representative of soils on the perimeter of the ISS-treated monolith, and where groundwater contact and thus leaching would predominantly occur.

Soil samples will be collected during the Pilot Test. In order to represent the entire vertical profile of soil to be treated with ISS, the soil sample will be collected by cutting the sidewall during the Pilot Test from top to bottom (approximately 15 ft. bgs), to the extent practical. The cut Fill Unit soils will be collected with the Pilot Test equipment and homogenized within the exclusion zone. The soil samples will be collected and placed within a small plastic containment within the temporary stockpile area where it will be homogenized into one bulk sample. During homogenization, any material greater than ½” will be removed for Treatability Testing. After homogenization, each bulk sample will be transferred into 5-gallon buckets with tight fitting lids. Three 5-gallon buckets of Soil #1 and two 5-gallon buckets of Soil #2 will be collected.

Approximately 5 gallons of groundwater will be collected from EMW-4S for use in Treatability Testing described in Section 4.3.3. There is no existing monitoring well positioned perfectly upgradient of the planned ISS areas. However, EMW-4S is positioned near and cross-gradient of the planned ISS area and is considered reasonably representative of groundwater flowing toward the planned ISS areas (location shown on Figure 1). Well EMW-4S had groundwater pHs of 6.45 and 6.47 when measured in 2009 and 2010, respectively. EMW-4S also has very low dissolved Hg concentrations (0.00032 ug/L and less than 0.00094 ug/L (non-detect) in 2009 and 2010, respectively (Aspect, 2013). This is advantageous when interpreting the leaching test results because it reduces uncertainty regarding the source of dissolved Hg measured in the test leachate. The groundwater will be sampled at a rate less than 500 mL/min and containerized in 1-gallon plastic containers.

Approximately 5 gallons of tap water collected from the Site to be used for Treatability Testing. The tap water will be used to represent the water source used to create reagent grout during the ISS cleanup action, and the groundwater collected from EMW-4S will be used to represent the groundwater within the saturated soil within the ISS treatment area. The tap water will also be collected in a 1-gallon plastic container. A mix of these two water sources will be used for soil mixing in Treatability Testing to simulate the water to be used for the ISS cleanup action construction.

All soil and water samples will be transported to Anchor QEA’s Environmental Geochemistry Laboratory (EGL) in Portland, Oregon, by Aspect staff. All samples will be transported in a secure and covered space isolated from the vehicle cab during transit. Additional sampling and transport details are included in Anchor QEA’s Sampling and Analysis Plan (Appendix B).

4.3 Treatability Test Design

The Treatability Testing will be conducted at Anchor QEA’s EGL. Anchor QEA’s Sampling and Analysis Plan (Appendix B) details additional laboratories to be used in Treatability Testing.

4.3.1 Baseline Testing

The Soil #1 and Soil #2 homogenates will be initially characterized to establish baseline conditions. Only one of the 5-gallon buckets from each soil homogenate will be used for baseline testing. Each soil homogenate will be mechanically mixed prior to any sample collection in accordance with the EGL SAP (Appendix B).

One sample of each homogenate will be submitted for physical parameters, total Hg, total organic carbon, and leach testing (Table 1). These baseline results will be used to verify total Hg concentrations in soil and determine the leachability of Hg from the untreated soils. Total Hg analysis will be conducted in duplicate. The leach testing will consist of a modified synthetic precipitation leaching procedure (SPLP) for each soil sample, with the modification being using the EMW-4S Site groundwater as the leachant. The SPLP leachate will be analyzed for total and dissolved mercury (Table 1).

The baseline testing methods are all detailed in Anchor QEA's Sampling and Analysis Plan (Appendix B).

4.3.2 Reagent Mix Design

Portland cement (PC) and elemental sulfur were successfully used together *ex-situ* to solidify/stabilize Chlorine Plant area soils containing visible elemental Hg for the purpose of off-Site disposal during the prior interim actions (Section 2.1). The results of that completed work is a consideration of Treatability Testing design.

ISS of soil can be achieved through the addition of cementitious reagents. The most commonly utilized additives are PC and ground-granulated blast furnace slag (BFS), with various other pozzolanic or chemically reactive reagents available for inclusion if dictated by Site conditions.

While elemental Hg will complex with elemental sulfur to form Hg sulfide,[8] any sulfate created by the introduction of elemental sulfur will increase the creation of the mineral ettringite[9] in the monolith. The formation of ettringite leads to an increase in solid volume, resulting in expansion and cracking of the concrete mass that, over a period of years, can drastically increase the hydraulic conductivity of the ISS monolith. Because the primary mechanism for reducing contaminant leachability within an ISS monolith is the physical encapsulation of the contaminant source and reduction of hydraulic conductivity (thus groundwater contact with the encapsulated contaminants), using elemental sulfur as an ISS reagent would be counterproductive and is not planned.

The three materials selected for Treatability Testing are all locally available and commercially viable for the future full-scale ISS cleanup action. Specification sheets for each material are included in Appendix D. The ISS Treatability Testing will evaluate the performance of three reagent mix designs:

1. MaxCem – A pre-mixed reagent of 70% Type 1L PC and 30% NewChem BFS
2. Terraflow – A pre-mixed reagent of 25% Type 1L PC and 75% NewChem BFS
3. A mixed reagent of 50% Type 1L PC and 50% NewCem BFS

A total of eleven mix designs will be evaluated using each soil homogenate with a total cement content of 5, 10, 15, and 20 percent (Table 2). Mix designs will be prepared by mixing the soil homogenate and the reagents at the specified percentages, with the addition of water as 50/50 groundwater and tap water collected from Site. Mix design will be prepared in 2-inch-diameter by 4-inch-tall plastic cylinder containers and in accordance with the EGL SAP (Appendix B). A total of 99 cylinders will be cast for the Soil #1 mix designs, and a total of 66 cylinders for the Soil #2 mix designs.

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[8] Arsenopyrite, a natural ore form of mercury in which the mercury is not volatile.

[9] Calcium sulfoaluminate.

4.3.3 Treatability Testing

The Treatability Testing to optimize Treatability Testing to the highest performing mix designs. The immediate performance of each mix design using temperature, slump measurements, pH, and pocket penetrometer to estimate initial strength after 1 and 4 days of cure time (Table 3). All Treatability Testing methods are detailed in Appendix B.

After the initial estimates of mix strengths are determined, a series of laboratory tests will be performed to evaluate mix designs against the ISS performance criteria of strength, hydraulic conductivity and leaching established in Section 4.1 (Table 4).

4.3.3.1 Strength Testing

The strength performance will be evaluated using unconfined compressive strength (UCS) by ASTM D1633 after 7, 14, 28, and 49 days of cure time for Soil #1. The highest performing seven mix designs (selected from the 11 evaluated in Phase I) will be analyzed for UCS after 7-days. Based on the results of the 7-day UCS results, four of those mix designs will be analyzed for UCS after 28 days and of those four, three will be analyzed for UCS after 49 days. This sequential strength testing allows the optimization of the Treatability Testing to the highest performing mix designs for strength criteria.

The Soil #2 will only be analyzed for UCS after 49 days. The 49-day UCS for both Soil #1 and Soil #2 will be conducted in triplicate. All UCS analysis will be conducted in accordance with methods detailed in Appendix B.

4.3.3.2 Hydraulic Conductivity Testing

The hydraulic conductivity performance will be measured using ASTM D-5084 after 49 days of cure time for the highest performing two mix designs for both Soil #1 and Soil #2 as determined by the strength testing results. The 49-day hydraulic conductivity test will be conducted in duplicate in accordance with methods detailed in Appendix B.

4.3.3.3 Leachability Testing

The leachability performance will be evaluated using EPA’s LEAF SW-846 Method 1315 for mass transfer rates of constituents in monolithic or compacted granular materials using a semi-dynamic tank leaching procedure. This leaching test was developed specifically for larger monoliths and thereby better represents *in situ* leachability than do leaching test methods like the TCLP or Synthetic Precipitation Leaching Procedure (SPLP) that require particle size reduction. As discussed in Section 4.2, the Site groundwater from well EMW-4S will be used at the leachant during the LEAF method to best represent leaching of the treated material in contact with ambient groundwater in the Chlorine Plant area. All LEAF analysis will be conducted in accordance with methods detailed in Appendix B.

5 Site Survey

A topographic survey is a necessary pre-remedial design investigation activity to complete the remedial design, including stormwater drainage, for the multiple cleanup projects to be conducted across the RAU in accordance with the CAP. Aspect will subcontract a Washington state-licensed surveyor, Wilson Engineering LLC, to complete a topographic survey of the Chlor-Alkali RAU. The survey will also include survey of existing stormwater structures including rim elevations and pipe size, direction, and invert elevations if discernable. All survey will be tied to the City of Bellingham horizontal and vertical datums (NAD83 and NAVD88). Additionally, for cleanup action remedial design, stormwater solids in stormwater catch basins adjacent to the former Cell Building will be sampled and analyzed for waste characterization purposes.

The completed site survey will be used for preparation of Chlor-Alkali RAU cleanup action construction plans and specifications.

6 Schedule and Reporting

The results of Plan activities will be reported in the PRDI 2 Data Report in accordance with the schedule outlined in Table 5. The PRDI 2 Data Report will include the reporting of Pilot Test methods and evaluation of test results with respect to the Pilot Test objectives in Section 3. This includes discussion of the recommended means and methods for obstruction removal to be employed during the ISS cleanup action. The PRDI 2 Data Report will also include the Treatability Testing results and the recommended ISS mix design that best meets the ISS performance criteria.

The PRDI 2 Data Report once approved by Ecology will serve as the primary basis for the ISS cleanup action remedial design to be described in the Engineering Design Report for the Chlor-Alkali RAU cleanup action, and then refined in the construction plans and specifications for the Chlorine Plant ISS cleanup action (Project C as identified in the Chlor-Alkali RAU CAP).

Table 5. Agreed Order Schedule of Deliverables

Deliverable	Due Date
Final PRDI 2 Plan	September 30, 2022
Ecology Draft PRDI 2 Data Report	Due 120 days after completion of PRDI 2 activities
Final PRDI 2 Data Report	60 days after Ecology comments on Draft

The estimated schedule for PRDI 2 activities is outlined in below.

Table 6. Estimated Schedule of PRDI 2 Activities

Activity	Assumed Duration (days)	Estimated Date
Start Field Pilot Testing	35	October 17, 2022
Start Treatability Testing	90	October 31, 2022
Complete PRDI 2 Activities	0	February 1, 2023

7 References

Aspect Consulting, LLC (Aspect), 2013, Remedial Investigation, Georgia-Pacific West Site, Bellingham, August 5, 2013.

Aspect Consulting, LLC (Aspect), 2014, Caustic Plume/Cell Building Interim Action Report, Georgia-Pacific West Site, Bellingham, October 10, 2014.

Aspect Consulting, LLC (Aspect), 2016, Interim Action Work Plan, Removal of Mercury-Contaminated Soil at Cell Building, December 26, 2016.

Washington State Department of Ecology (Ecology), 2011, First Amendment to Agreed Order No. 6834, Georgia-Pacific West Site, Bellingham, Washington, August 30, 2011.

Washington State Department of Ecology (Ecology), 2021, Cleanup Action Plan, Chlor-Alkali Remedial Action Unit, Georgia-Pacific West Site, Bellingham, Washington, September 7, 2021.

Washington State Department of Ecology (Ecology), 2022, Georgia-Pacific West Bellingham Site—Minor Modification to Third Amendment to Agreed Order No. 6834, March 22, 2022.

8 Limitations

Work for this project was performed for Port of Bellingham (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports will govern in the event of any dispute regarding the content of electronic documents furnished to others.

TABLES

Table 1. Soil Homogenate Baseline Tests

Project No. 210368-B, Chlor-Alkali RAU, GP West Site, Bellingham, Washington

	Moisture Content ASTM D2216	Grain Size Analysis (with hydrometer) ASTM D422	Atterberg Limits ASTM 4318	Specific Gravity ASTM D854	pH by ASTM D4972	Organic Content by ASTM D2974	Mercury (Total)	Modified SPLP (EPA Method 1312)
Soil 1	X	X	X	X	X	X	X	X
Soil 2	X	X	X	X	X	X	X	X

Notes:

ASTM - American Society of Testing and Materials International

The modified SPLP will be conducted using EMW-4S groundwater; the leachant will be analyzed for total and dissolved mercury.

Table 2. Treatability Test - Mix Designs

Project No. 210368-B, Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Soil Homogenate	Mix No.	MaxCem	Terraflow	Type 1L Portland Cement	NewCem (Pure BFS)	Total Cement Content
		% dry soil weight	% dry soil weight	% dry soil weight	% dry soil weight	%
Soil 1	Mix-1	5				5
	Mix-2		5			5
	Mix-3	10				10
	Mix-4		10			10
	Mix-5			5	5	10
	Mix-6	15				15
	Mix-7		15			15
	Mix-8			7.5	7.5	15
	Mix-9	20				20
	Mix-10		20			20
	Mix-11			10	10	20
Soil 2	Mix-12	5				5
	Mix-13		5			5
	Mix-14	10				10
	Mix-15		10			10
	Mix-16			5	5	10
	Mix-17	15				15
	Mix-18		15			15
	Mix-19			7.5	7.5	15
	Mix-20	20				20
	Mix-21		20			20
	Mix-22			10	10	20

Notes:

Water is 50% Site tap water, 50% groundwater

ASTM - American Society of Testing and Materials International

BFS - blast furnace slag

All cements from LafargeHolcim's Seattle Plant

MaxCem is 70% Type 1L Cement and 30% NewCem ground granulated blast furnace slag

Terraflow75 is 25% Type 1L Cement and 75% NewCem ground granulated BFS

Table 3. Treatability Test Matrix (Days 0 to 7)

Project No. 210368-B, Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Soil Homogenate	Mix No.	Mix Description	Water to Cement Ratio^1 %	Temperature After Mixing °F	Slump Measurment		pH by ASTM D4972	Pocket Penetrometer Results		UCS (ASTM D2166)
					Miniature Slump	Standard Slump		1-day	4-day	7-day
Soil 1	Mix-1	3.5% PC, 1.5% BFS	x	x	x	x	x	x	x	x
	Mix-2	1.25% PC, 3.75% BFS	x	x	x	x	x	x	x	x
	Mix-3	7% PC, 3% BFS	x	x	x	x	x	x	x	x
	Mix-4	2.5% PC, 7.5% BFS	x	x	x	x	x	x	x	x
	Mix-5	5% PC, 5% BFS	x	x	x	x	x	x	x	x
	Mix-6	10.5% PC, 4.5% BFS	x	x	x	x	x	x	x	x
	Mix-7	3.75% PC, 11.25% BFS	x	x	x	x	x	x	x	x
	Mix-8	7.5% PC, 7.5% BFS	x	x	x	x	x	x	x	x
	Mix-9	14% PC, 6% BFS	x	x	x	x	x	x	x	x
	Mix-10	5% PC, 15% BFS	x	x	x	x	x	x	x	x
	Mix-11	10% PC, 10% BFS	x	x	x	x	x	x	x	x
Soil 2	Mix-12	3.5% PC, 1.5% BFS	x	x	x	x	x	x	x	--
	Mix-13	1.25% PC, 3.75% BFS	x	x	x	x	x	x	x	--
	Mix-14	7% PC, 3% BFS	x	x	x	x	x	x	x	--
	Mix-15	2.5% PC, 7.5% BFS	x	x	x	x	x	x	x	--
	Mix-16	5% PC, 5% BFS	x	x	x	x	x	x	x	--
	Mix-17	10.5% PC, 4.5% BFS	x	x	x	x	x	x	x	--
	Mix-18	3.75% PC, 11.25% BFS	x	x	x	x	x	x	x	--
	Mix-19	7.5% PC, 7.5% BFS	x	x	x	x	x	x	x	--
	Mix-20	14% PC, 6% BFS	x	x	x	x	x	x	x	--
	Mix-21	5% PC, 15% BFS	x	x	x	x	x	x	x	--
	Mix-22	10% PC, 10% BFS	x	x	x	x	x	x	x	--

Notes:

1. Water to cement ratio will be determined during mixing to provide a standard slump ranging between 4 and 7 inches
2. Enough material should be created and placed into curing cylinders for each mix design assuming all test in the matrix are conducted.

ASTM - American Society of Testing and Materials International
BFS - blast furnace slag
PC - Type 1L portland cement
UCS - Unconfined Compressive Strength

Table 4. Treatability Test Matrix (Days 8 to 49)

Project No. 210368-B, Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Soil Homogenate	Mix No.	Mix Description	UCS (ASTM D2166)			Hydraulic Conductivity (ASTM D5084)	Leaching (SW846 Method 1315M)[1]
			14-day	28-day	49-day (triplicate)	49-day (duplicate)	49-day
Soil 1	Mix-1	3.5% PC, 1.5% BFS	7 Mixes	4 Mixes	3 Mixes	2 Mixes	1 Mix
	Mix-2	1.25% PC, 3.75% BFS					
	Mix-3	7% PC, 3% BFS					
	Mix-4	2.5% PC, 7.5% BFS					
	Mix-5	5% PC, 5% BFS					
	Mix-6	10.5% PC, 4.5% BFS					
	Mix-7	3.75% PC, 11.25% BFS					
	Mix-8	7.5% PC, 7.5% BFS					
	Mix-9	14% PC, 6% BFS					
	Mix-10	5% PC, 15% BFS					
	Mix-11	10% PC, 10% BFS					
Soil 2	Mix-12	3.5% PC, 1.5% BFS	--	--	3 Mixes	2 Mixes	1 Mix
	Mix-13	1.25% PC, 3.75% BFS					
	Mix-14	7% PC, 3% BFS					
	Mix-15	2.5% PC, 7.5% BFS					
	Mix-16	5% PC, 5% BFS					
	Mix-17	10.5% PC, 4.5% BFS					
	Mix-18	3.75% PC, 11.25% BFS					
	Mix-19	7.5% PC, 7.5% BFS					
	Mix-20	14% PC, 6% BFS					
	Mix-21	5% PC, 15% BFS					
	Mix-22	10% PC, 10% BFS					

Notes:

1. Enough material should be created and placed into curing cylinders for each mix design assuming all test in the matrix are conducted.
2. Testing shown in matrix are for scoping purposes only. Actual test selection will be determined iteratively during treatability testing.

ASTM - American Society of Testing and Materials International
BFS - blast furnace slag
PC - Type 1L portland cement
UCS - Unconfined Compressive Strength

FIGURES

Site Location Map

Pre-Remedial Design Investigation 2 Project Plan
Chlor-Alkali RAU - GP West Site
Bellingham, Washington

JUL-2022	BY: AAF / SCC	FIGURE NO. 1
PROJECT NO. 210368	REVISED BY: NLK	

Basemap Layer Credits || Esri, HERE, Garmin, (c) OpenStreetMap contributors
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Copyright:(c) 2014 Esri

GIS Path: G:\projects\ChlorAlkaliRAU 210368\Delivered\GPWest\PreRemedialDesign\01 Site Location Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/28/2022 || User: nkochie || Print Date: 7/28/2022

GIS Path: G:\projects\ChlorAlkaliRAU_210368\Delivered\GPWest\PreRemedialDesign\02 ISS Cleanup Action Limits.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/28/2022 || User: nkochie || Print Date: 7/28/2022

🟫 Completed 2014 Interim Action Excavations

Cell Building Area Cleanup Action

🟫 Soil Removal/Offsite Disposal

🟪 Aggressive Removal of Obstructions and In Situ Stabilization of Soils

Notes:

1. The areas of previous soil removal are assumed to be capped along with the surrounding soils that exceed cleanup levels, although capping of these areas would not be required.

2. Areas of current soil removal are capped where impacted soils remain at depth.

ISS Cleanup Action Limits

Pre-Remedial Design Investigation 2 Project Plan
Chlor-Alkali RAU - GP West Site
Bellingham, Washington

Aspect CONSULTING	JUL-2022	BY: SJG / HRL	FIGURE NO.
	PROJECT NO. 210368	REVISED BY: PPW / RAP / SCC / NLK	2

Basemap Layer Credits || Whatcom County

GIS Path: G:\projects\ChlorAlkaliRAU_210368\Delivered\GPWest\PreRemedialDesign\03 Field Pilot Testing - Plan View 1 of 2.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/28/2022 || User: nkochie || Print Date: 7/28/2022

▢ Pile Cap

▢ Available benching area to access piles

▢ Temporary Stockpile Area

◎ Perimeter Air Monitoring Location

x — x — Fence

▢ Pilot Test Area

▢ Equipment and Water Management Area

▨ Former Cell Building

▨ Shop Slab

🟩 Paved Area (2017)

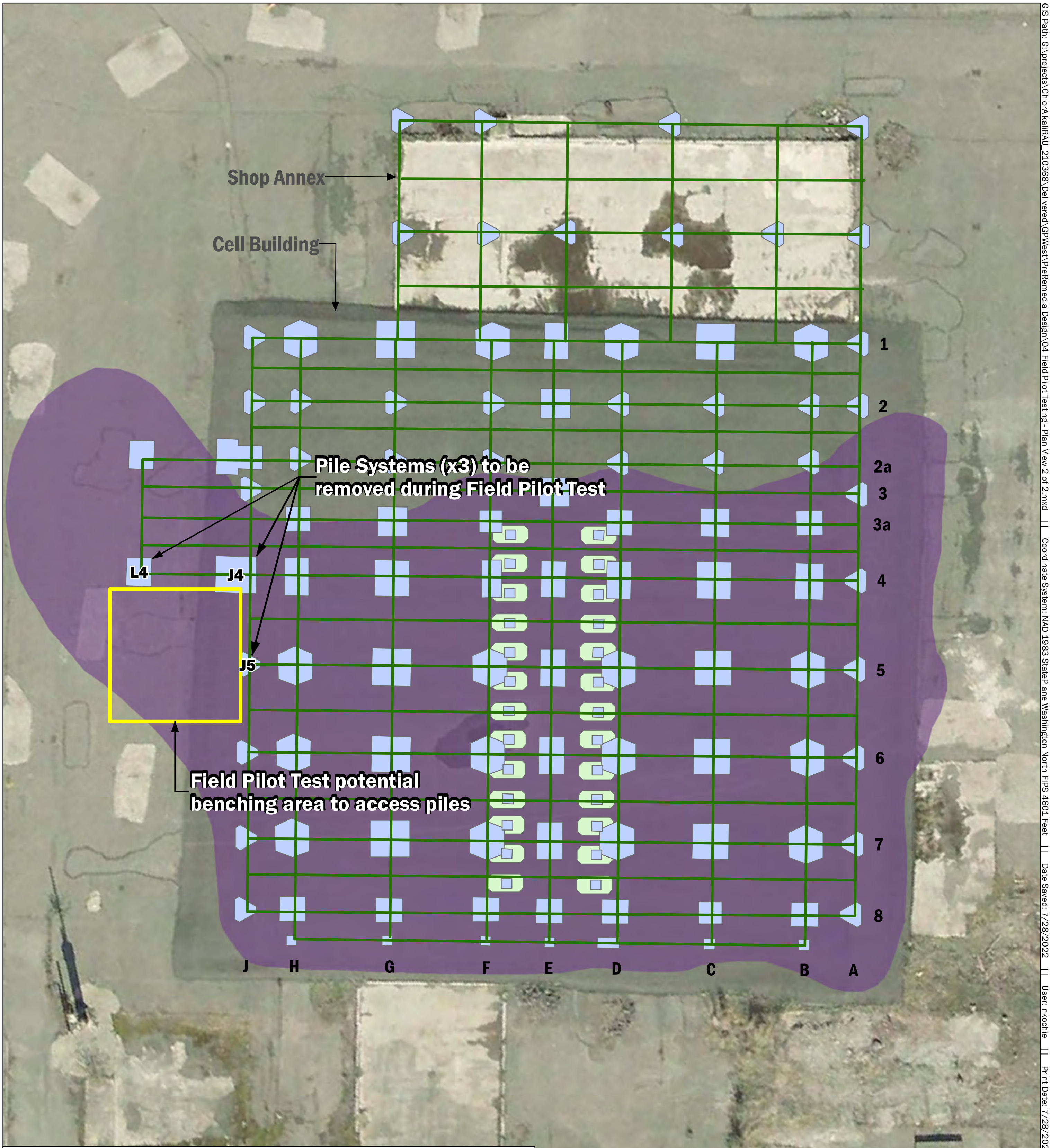
Field Pilot Testing - Plan View (1 of 2)

Pre-Remedial Design Investigation 2 Project Plan
Chlor-Alkali RAU - GP West Site
Bellingham, Washington

Aspect CONSULTING

JUL-2022	BY: MAV / HRL	FIGURE NO.
PROJECT NO. 210368	REVISED BY: DAH / RAP / NLK	3

Basemap Layer Credits || Whatcom County

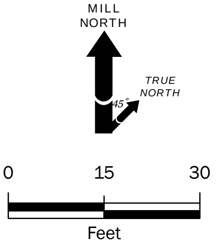


GIS Path: G:\projects\ChlorAlkaliRAU_210368\Delivered\GPWest\PreRemedialDesign\04 Field Pilot Testing - Plan View 2 of 2.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 7/28/2022 || User: nkochie || Print Date: 7/28/2022

▭	Field Pilot Test potential benching area to access piles
―	Grade Beam
▨	Pile Cap
▨	Pile-Supported Structure

Cell Building Area Cleanup Action

●	Aggressive Removal of Obstructions and In Situ Stabilization of Soils



Field Pilot Testing - Plan View (2 of 2)

Pre-Remedial Design Investigation 2 Project Plan
Chlor-Alkali RAU - GP West Site
Bellingham, Washington

Aspect CONSULTING	JUL-2022	BY: MAV / HRL	FIGURE NO.
	PROJECT NO. 210368	REVISED BY: DAH / RAP / NLK	4

Basemap Layer Credits || Whatcom County

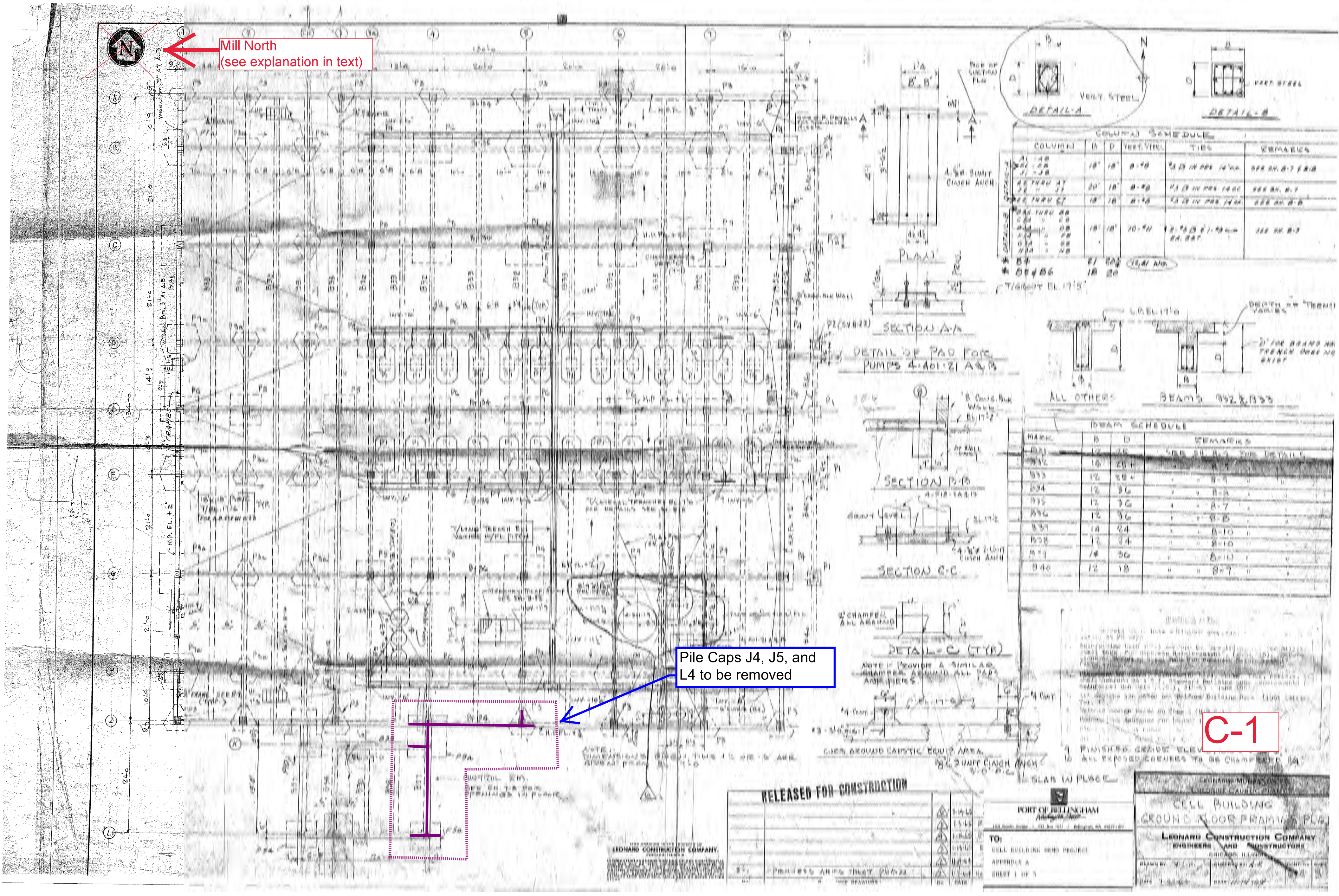
APPENDIX A As-Builts

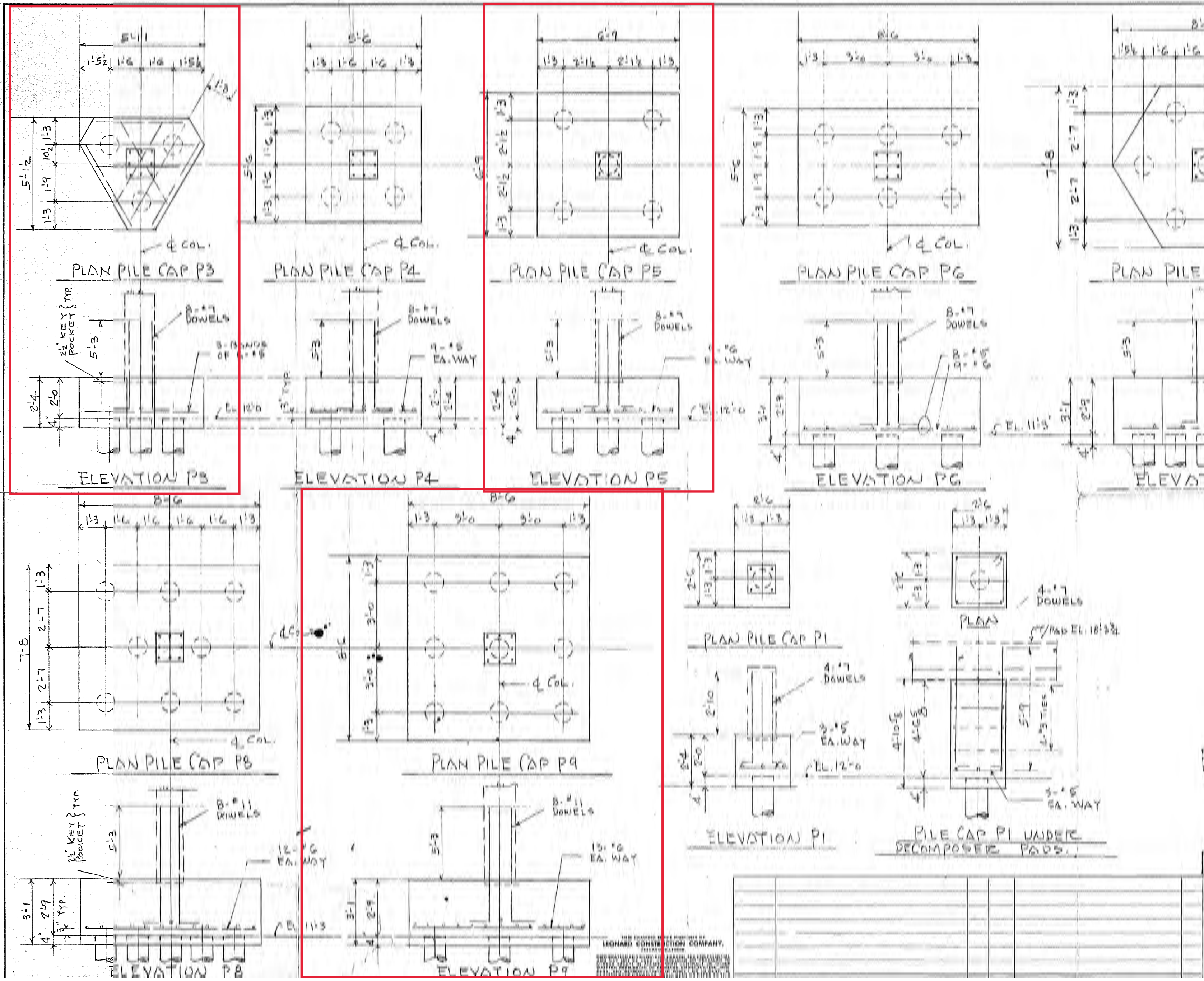
A-1 Cell Building Foundation As-Builts

A-2 Interim Action As-Builts

APPENDIX A

A-1 Cell Building Foundation As-Builts


Mill North
(see explanation in text)
Pile Caps J4, J5, and L4 to be removed
C-1
DETAIL-A
DETAIL-B
COLUMN SCHEDULE
SECTION A-A
DETAIL OF PAD FOR PUMPS 4-A01-Z1 A & B
ALL OTHERS
BEAMS B32 & B33
SECTION B-B
BEAM SCHEDULE
SECTION C-C
DETAIL-C (TYP)
RELEASED FOR CONSTRUCTION
PORT OF BELLINGHAM
CELL BUILDING DEMO PROJECT
APPENDIX A
SHEET 1 OF 5
CELL BUILDING
GROUND FLOOR FRAMING PLAN
LEONARD CONSTRUCTION COMPANY
ENGINEERS AND CONSTRUCTORS
CHICAGO, ILLINOIS



C-2

FOR GENERAL NOTES SEE SH. 8-8
FOR ORIENTATION & LOCATION OF
FOOTINGS SEE SH. 8-5

FOR INFORMATION

PRELIMINARY
8-12-64

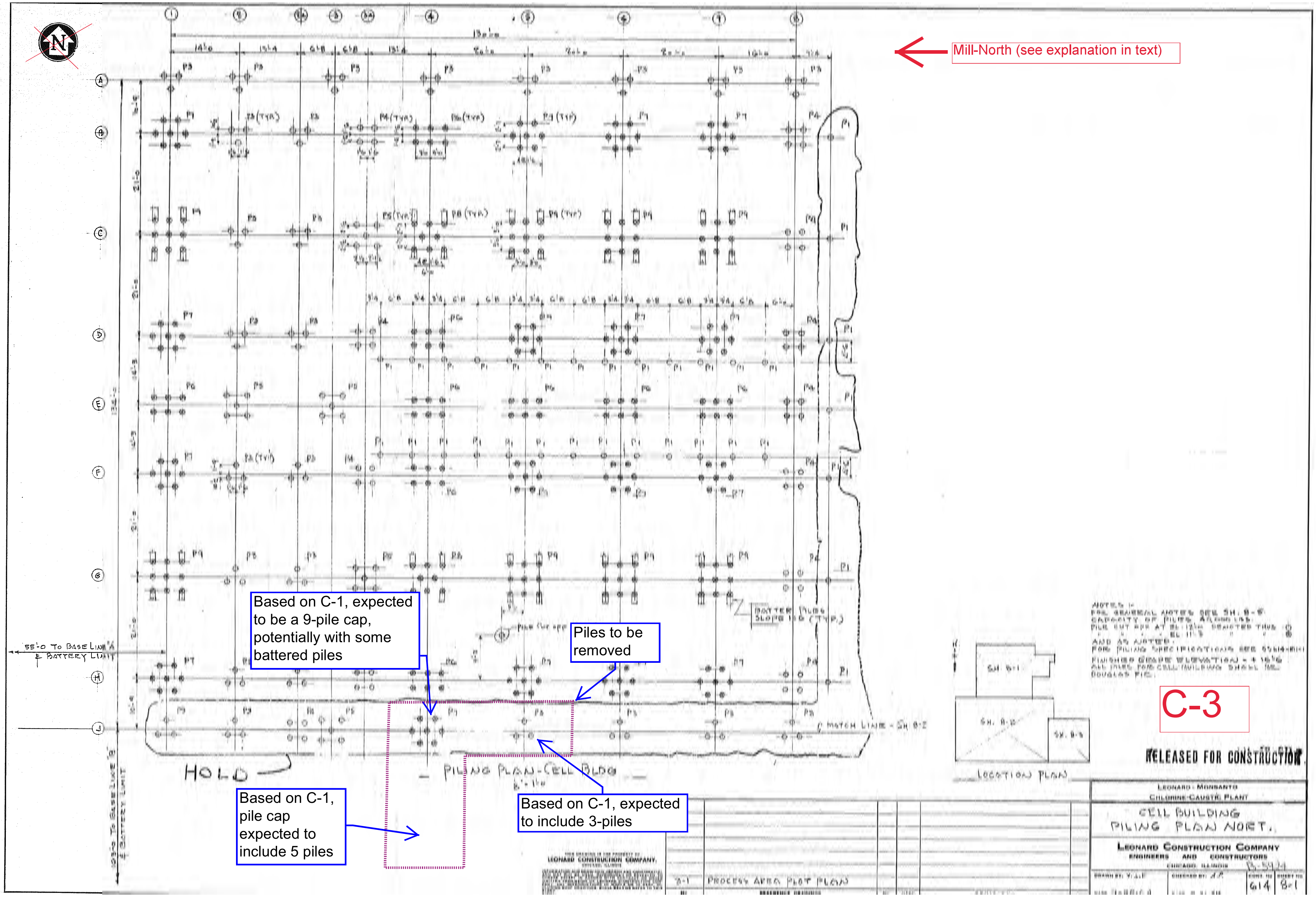
LEONARD - MONSANTO
CHLORINE-CAUSTIC PLANT

CELL BUILDING
PILE CAP DETAILS

LEONARD CONSTRUCTION COMPANY
ENGINEERS AND CONSTRUCTORS
CHICAGO, ILLINOIS

B-5923

DRAWN BY: V. J. F.	CHECKED BY:	CONT. NO. 614	SHEET NO. 8-4
DATE 8-11-64	DATE		



Mill-North (see explanation in text)

C-3

Based on C-1, expected to be a 9-pile cap, potentially with some battered piles

Piles to be removed

Based on C-1, pile cap expected to include 5 piles

Based on C-1, expected to include 3-piles

21

12

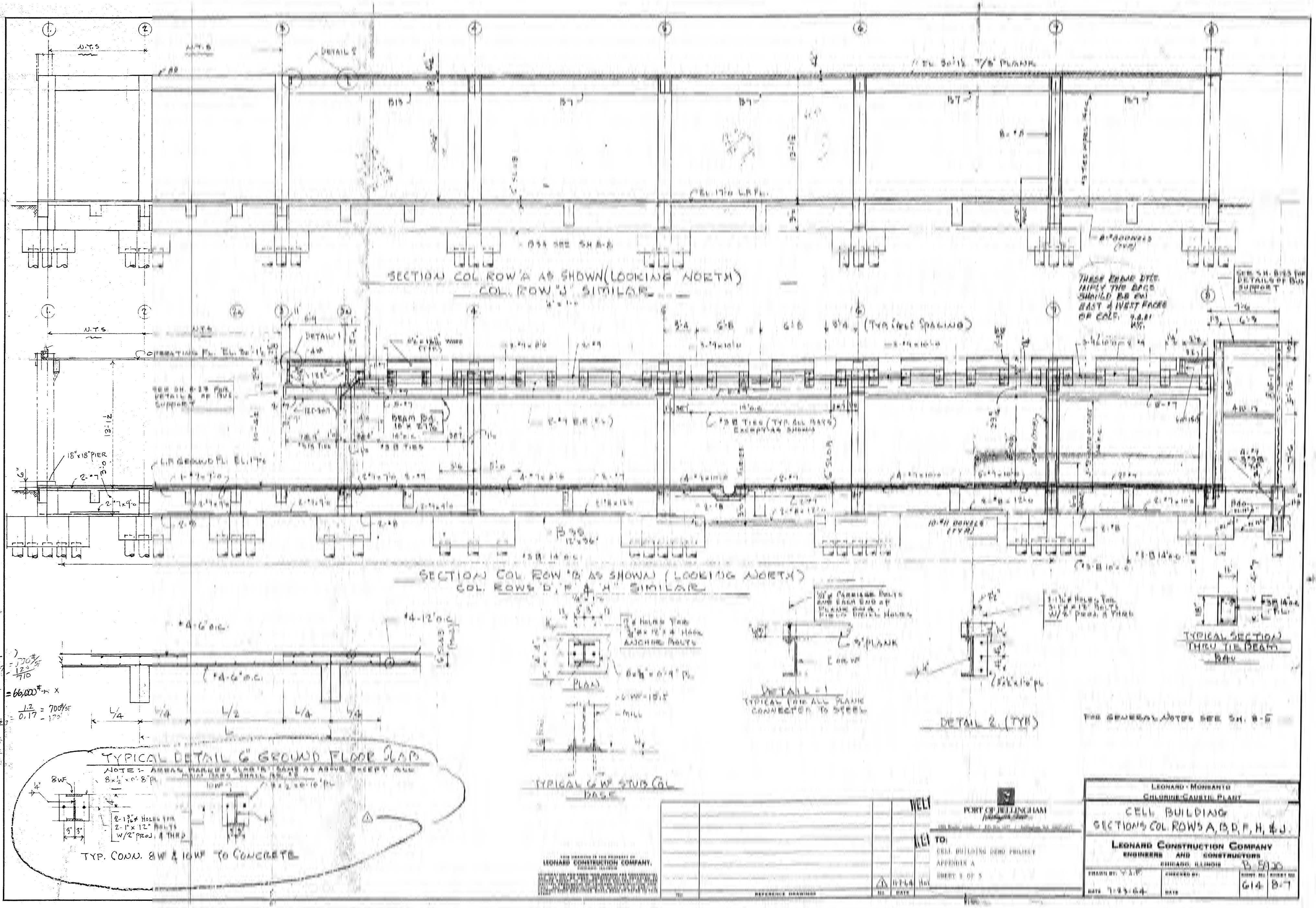
25

$\frac{120{,}000}{7\times21} = 14?$ = 770#/SF − 120 / 710

M = $100\times\frac{12}{8}\times21^2$ = 66,000#-in x

As = $\frac{66{,}000}{20{,}000\times0.85\times23}$ = $\frac{1.2}{0.17}$ = 700#/SF − 120

slab = 75#
beam 45#
120#



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PORT OF BELLINGHAM

TO:
CELL BUILDING DEMO PROJECT
APPENDIX A
SHEET 3 OF 5

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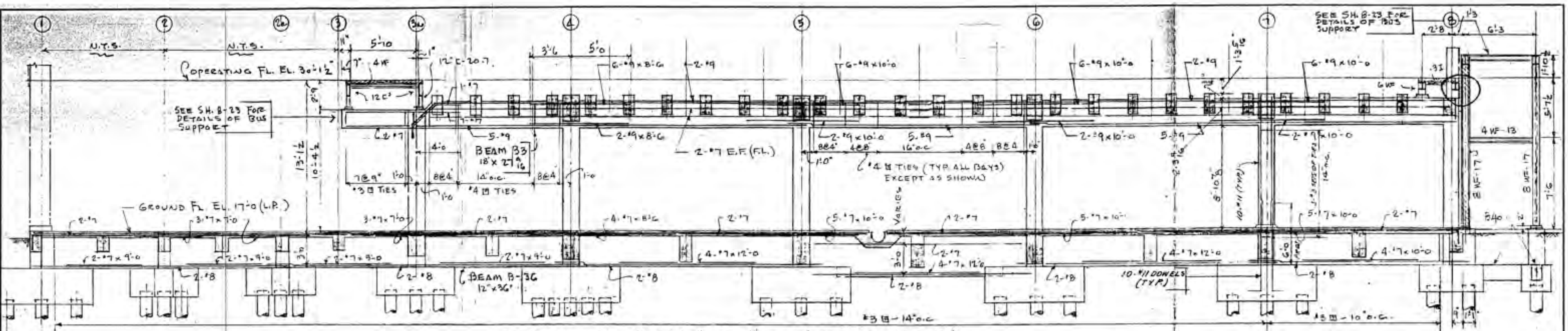
LEONARD - MONSANTO
CHLORINE-CAUSTIC PLANT

CELL BUILDING
SECTIONS COL. ROWS A, B, D, F, H, & J.

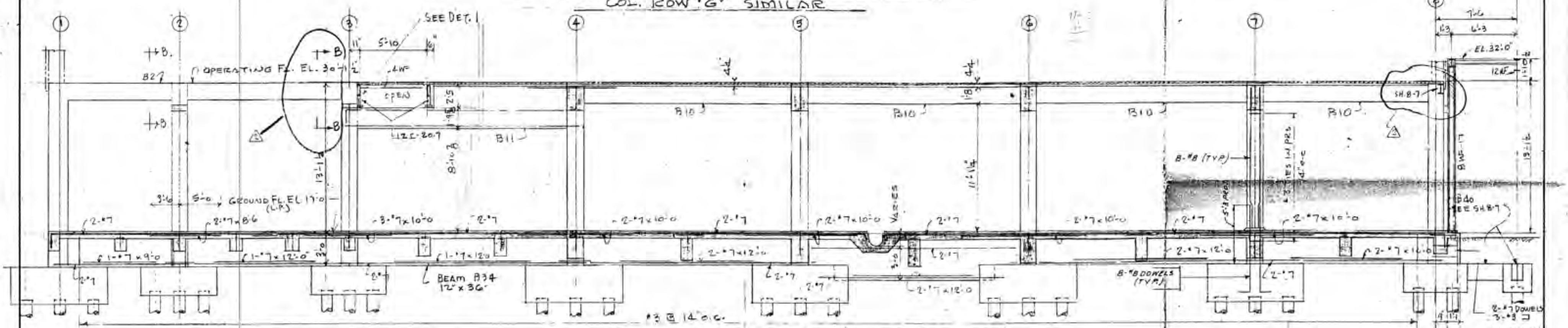
LEONARD CONSTRUCTION COMPANY
ENGINEERS AND CONSTRUCTORS
CHICAGO, ILLINOIS

B 5930

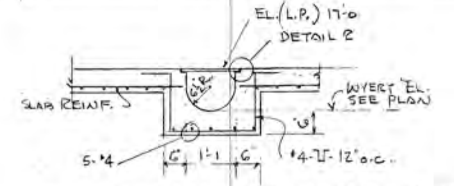
DRAWN BY:	CHECKED BY:	CONT. NO.	SHEET NO.
V.A.P. DATE 7-23-64	DATE	614	B-7



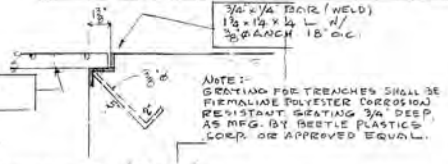
SECTION COL. ROW "C" AS SHOWN (LOOKING NORTH)
COL. ROW "G" SIMILAR



SECTION COL. ROW "E" (LOOKING NORTH)

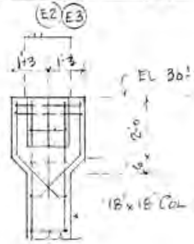


TYP. SECTION THRU LATERAL TRENCH (E. TO W.)

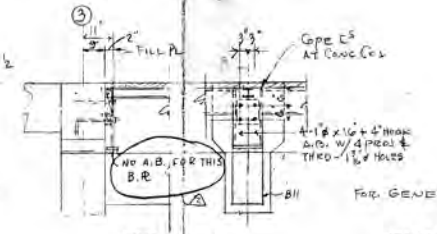


NOTE :- GRATING FOR TRENCHES SHALL BE FIRMALINE POLYESTER CORROSION RESISTANT GRATING 3/4" DEEP, AS MFG. BY BEETLE PLASTICS CORP. OR APPROVED EQUAL.

DETAIL 2 (TYP.)

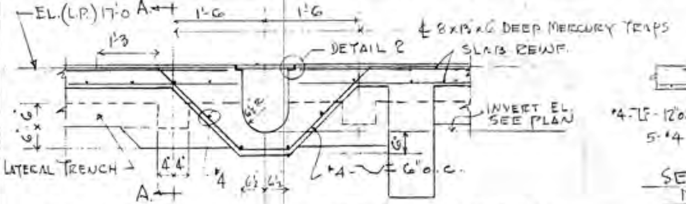


SECTION B-B



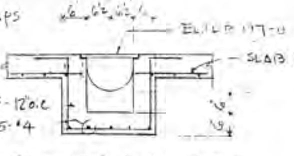
DETAIL - 1

FOR GENERAL NOTES SEE SH. 8-5



₤ 8 x 13 x 6 DEEP MERCURY TRAPS

TYP. SECTION THRU MAIN TRENCH (N. TO S.)



SECTION A-A THRU MERCURY TRAP

NOTE :- INSIDE OF ALL TRENCHES SHALL BE SMOOTH AND LINED WITH PHENOLINE 368 PRIMER AND PHENOLINE 368 FINISH, COLOR 707, IN TWO 5 MIL APPLICATIONS

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PORT OF BELLINGHAM
Washington State

TO:
CELL BUILDING DEMO PROJECT
APPENDIX A
SHEET 3 OF 5

LEONARD - MONSANTO
CHLORINE-CAUSTIC PLANT

CELL BUILDING
SECTIONS COL. ROWS C, E & G.

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CHICAGO, ILLINOIS
B-5922

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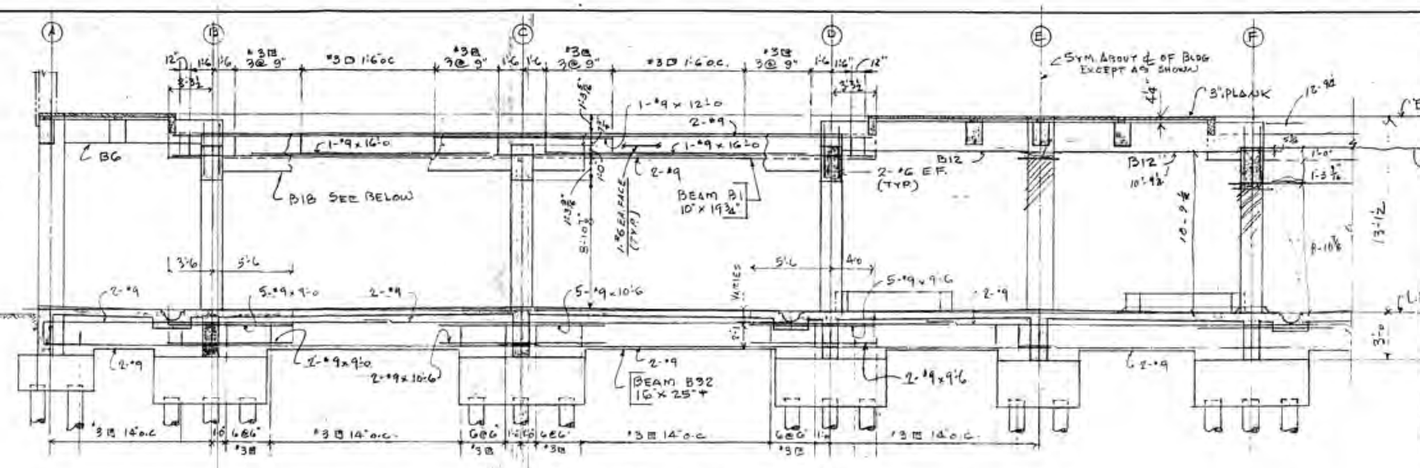
DATE 7-24-64	DATE 11-14-64	614	8-8



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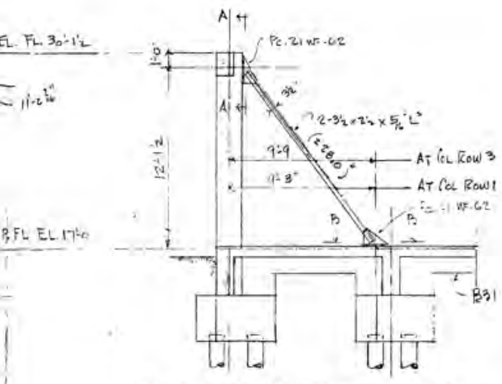
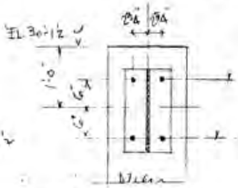
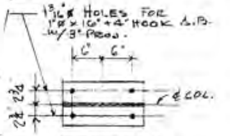
COL. ROWS "4", "5" & "6" SIMILAR



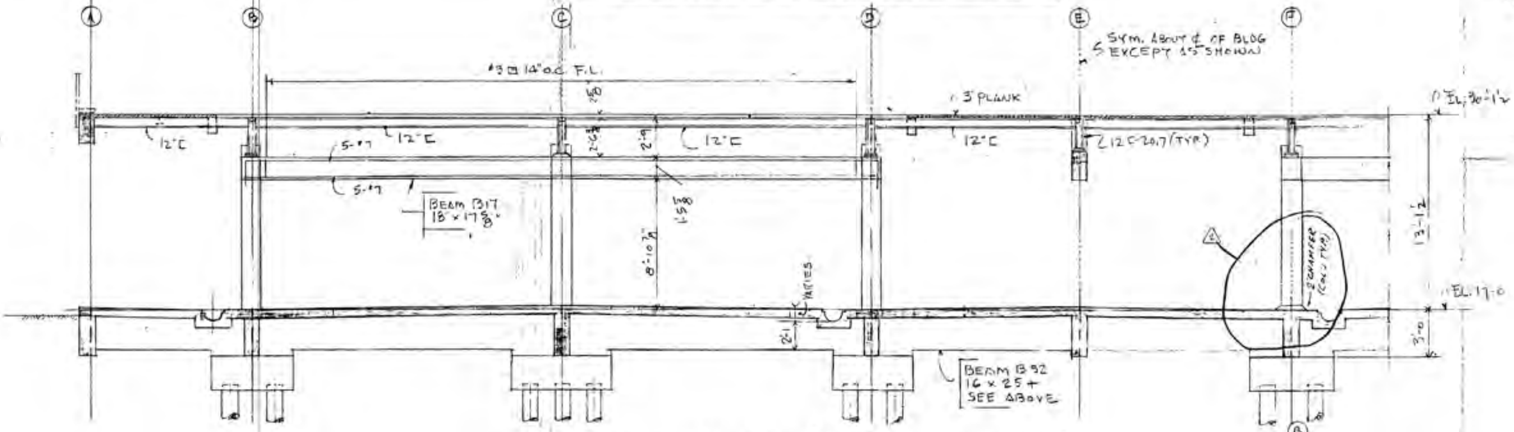
"A" FRAMES AT COLS. A1-A3-E1-J1-J3
(6-REQ'D)



SECTION A-A

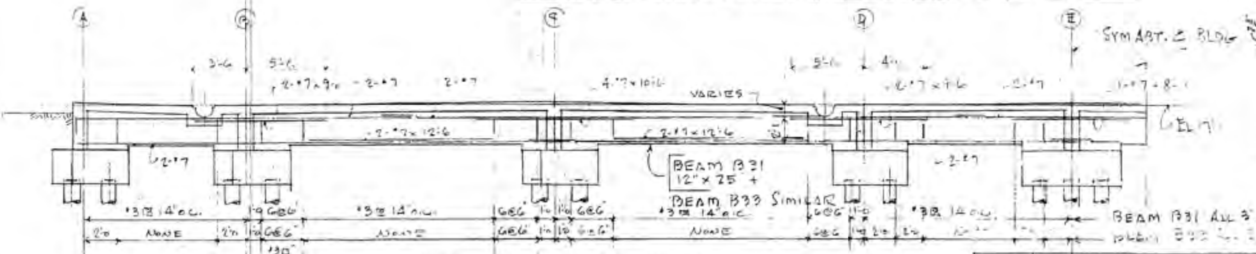


SECTION B-B

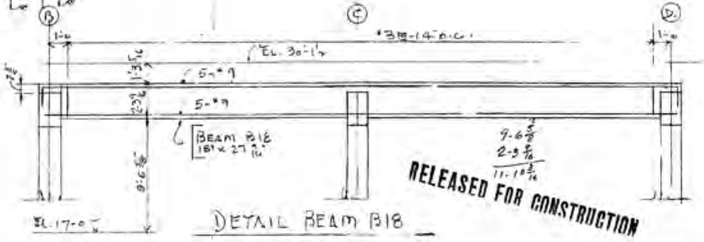


SECTION COL. ROW "3a" (LOOKING EAST)

13'-1½
4½
12'-9½



DETAIL BEAMS B31 & B33



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DETAIL BEAM B18

FOR GENERAL NOTES SEE SH. B-5

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PORT OF BELLINGHAM
Washington State

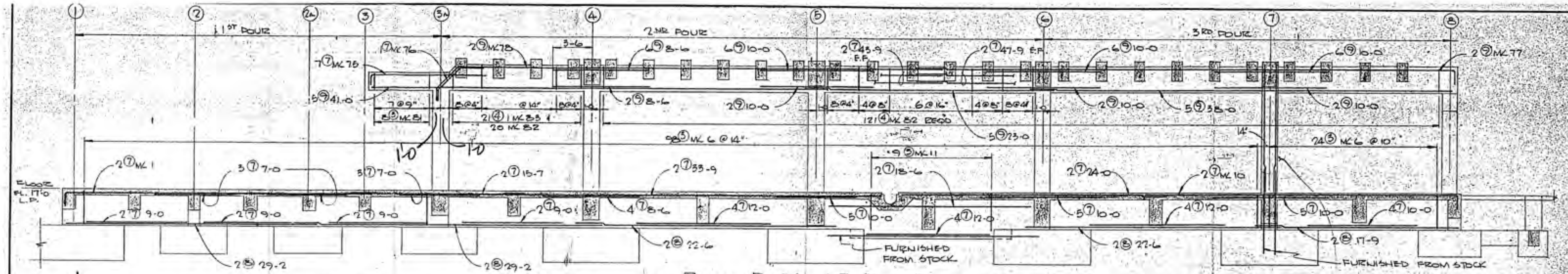
TO:
CELL BUILDING DEMO PROJECT
APPENDIX A
SHEET 1 OF 1

CELL BUILDING
SECTIONS COL. ROWS 3a, 4, 5, 6 & 7.

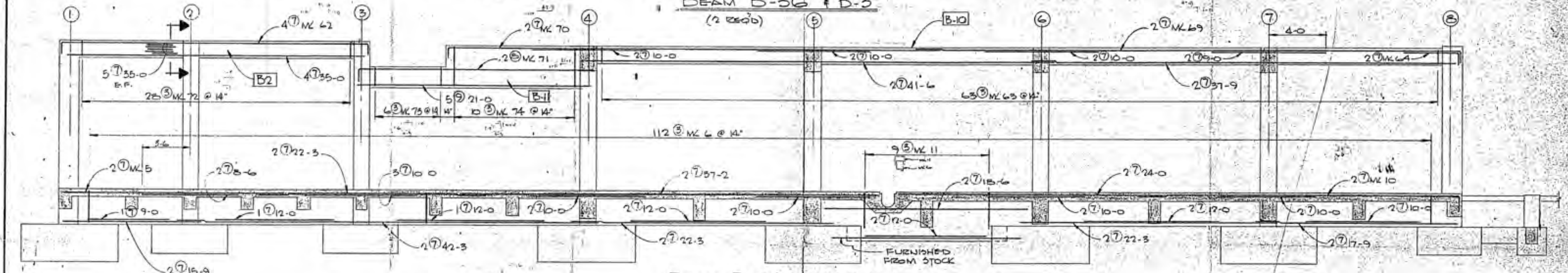
LEONARD CONSTRUCTION COMPANY
ENGINEERS AND CONSTRUCTORS
CHICAGO, ILLINOIS

B-5921

DRAWN BY: V.J.F.	CHECKED BY: A.P.	CONT. No.	SHEET No.
DATE 7-27-64	DATE 11-14-64	6:4	B-9



BEAM B-36 & B-3
(2 REQ'D)



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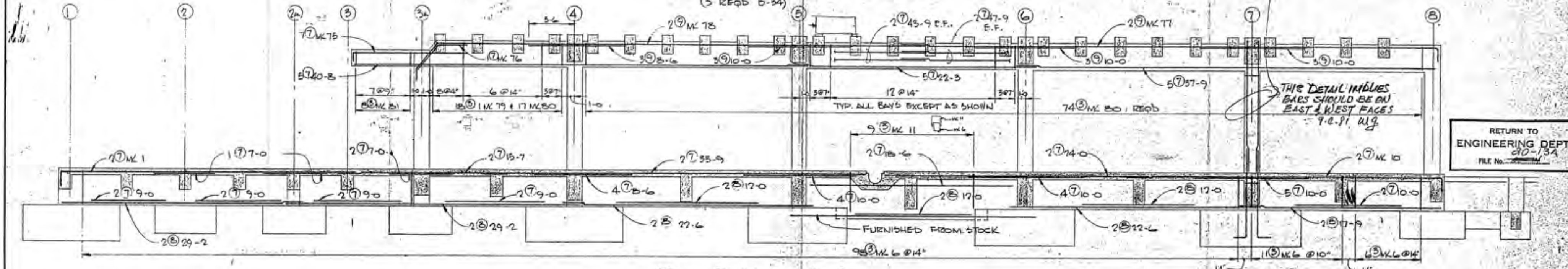
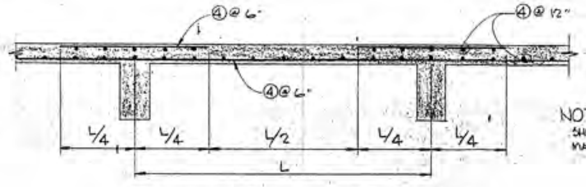
(3 REQ'D B-34)



THIS DETAIL IMPLIES BARS SHOULD BE ON EAST & WEST FACES
9-2-81 mg

RETURN TO
ENGINEERING DEPT.
FILE No. 20-134

BEAM B-35 & B-4
(4 REQ'D)



TYPICAL DETAIL 6" GROUND FLOOR SLAB (SEE SHEET 1)

NOTE: AREA'S MARKED SLAB "B" SHEET 1, SAME AS SHOWN EXCEPT MAIN REINF SHALL BE ⑤

APPR

NO R
OMIS
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ALL C
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LEON

By

PORT OF BELLINGHAM
Washington State

TO:
CELL BUILDING DEMO PROJECT
APPENDIX A
SHEET 3 OF 3

P023 C6/RK

NO.	DATE	REVISION
	11/15	ADDED OPERATING FLOOR BEAMS

SIZE DESIGNATION

SIZE	NO.	SIZE	NO.
¼ rd.	2	1 rd.	8
⅜ rd.	3	1 sq.	9
½ rd.	4	1⅛ sq.	10
⅝ rd.	5	1¼ sq.	11
¾ rd.	6	1½ sq.	14
⅞ rd.	7	2 sq.	18

MARKING CHART
START ALWAYS WITH BLACK MARK

CELL BUILDING
CUSTOMER: LEONARD CONST. CO.
REINFORCING STEEL PLACING PLAN
B-34, B-35, B-36 & TYP. 6" SLAB B-5919

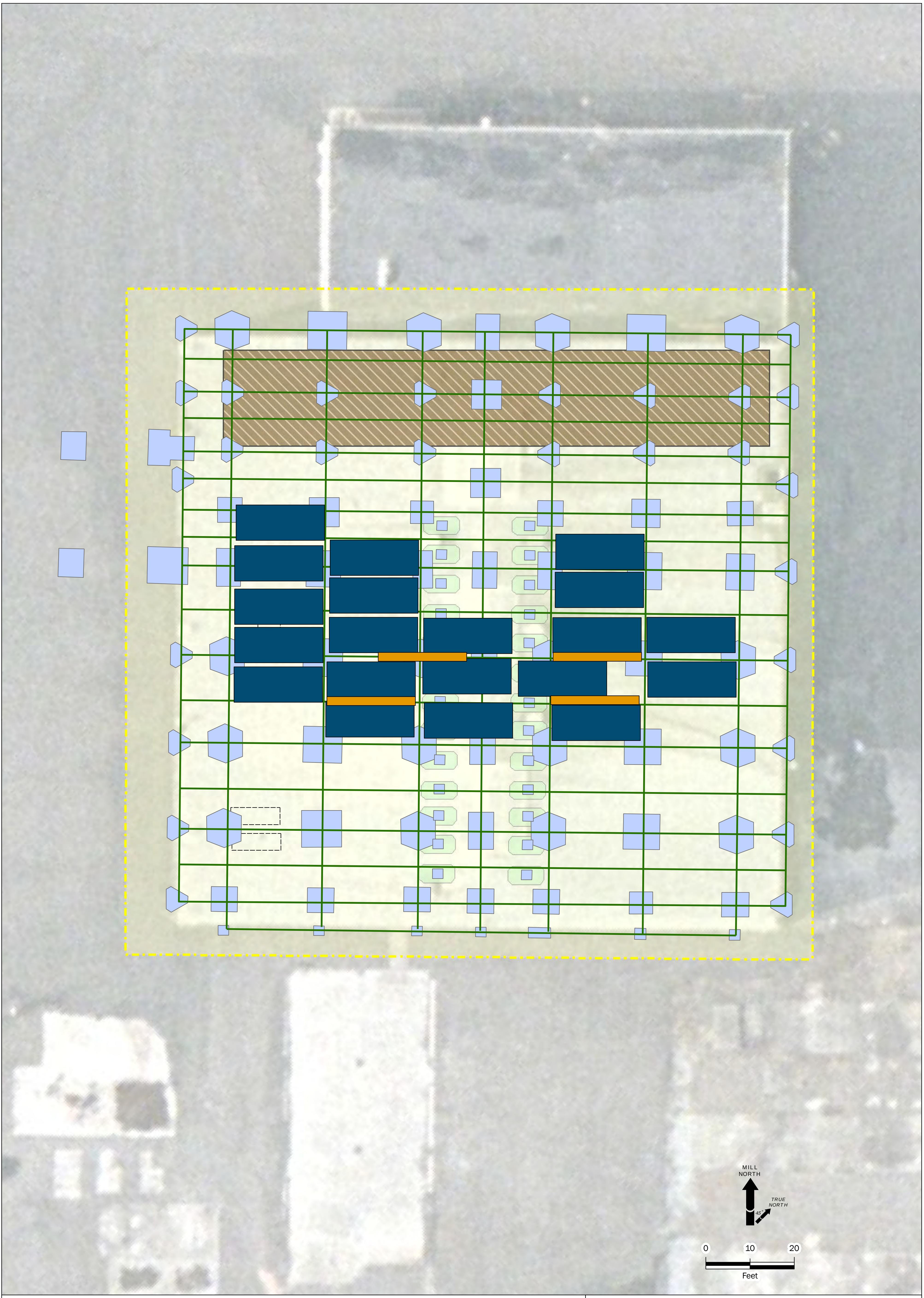
SCALE NONE
DATE
JOB NUMBER 544
DR. Ron W.
CH.
APP.
SHEET NUMBER 2

BETHLEHEM STEEL CO., BOX 3827, SEATTLE 24, WASH.

APPENDIX A

A-2 Interim Action As-Builts

GIS Path: T:\projects_8\Port_of_Bellingham\Delivered\CausticPlumeInterimAction\August2014\7 Excavation Area Cover.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/23/2014 || User: randrusyszyn || Print Date: 10/6/2014

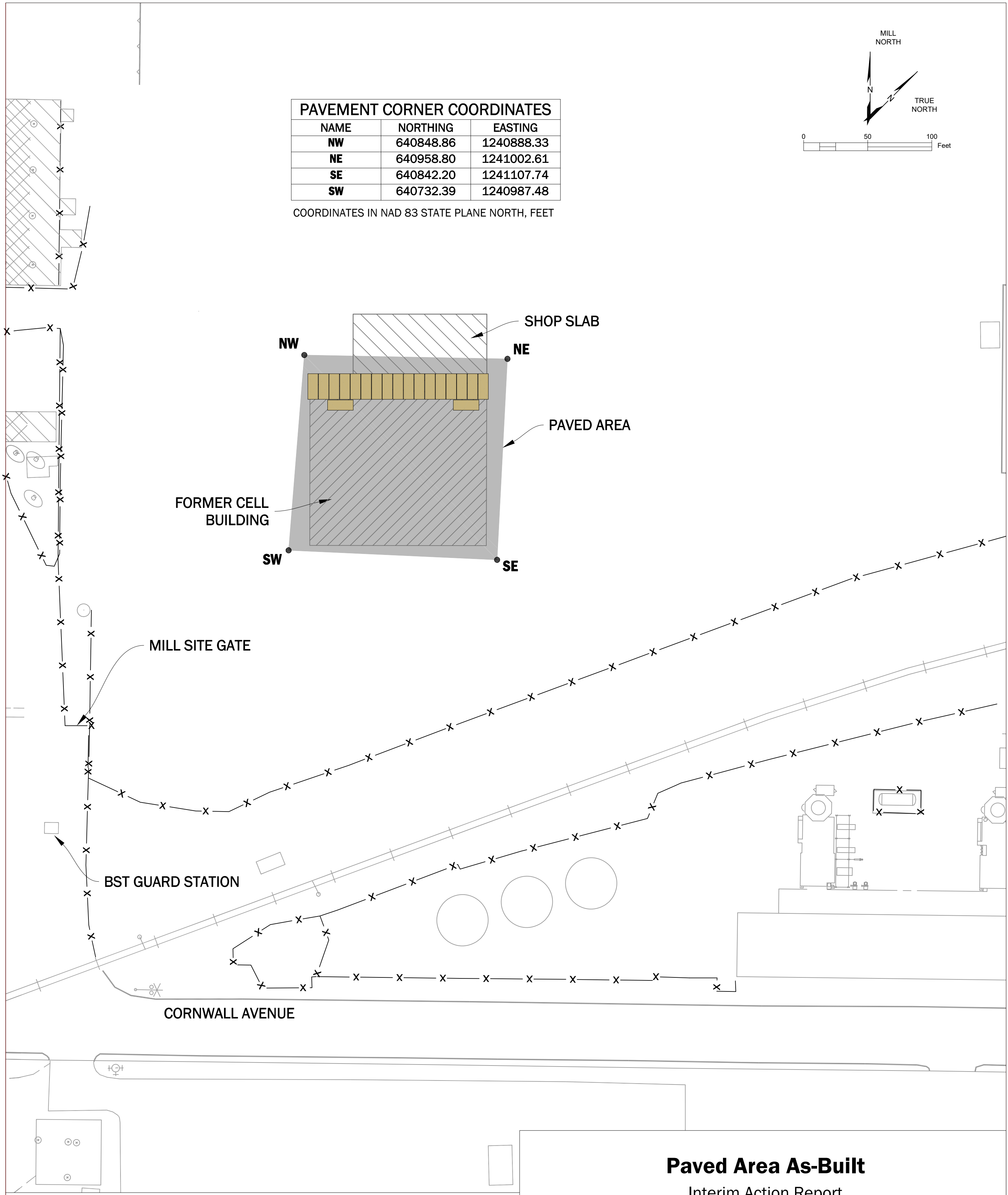


■	1-inch Steel Plate (approximate location)	▨	12mm Reinforced PE Cover
■	Timber Pole Support Beam (approximate location)	—	Grade Beam
▨	Soil Storage Area	■	Pile Caps
		■	Pile-Supported Structures

As-Built Diagram for Excavation Area Cover, Cell Building Area

Caustic Plume/Cell Building Interim Action Report
GP West Site, Bellingham, Washington

Aspect CONSULTING	SEP-2014	BY: MAV / RAA	FIGURE NO. 7
	PROJECT NO. 070188-018	REVISED BY: - - -	



PAVEMENT CORNER COORDINATES

NAME	NORTHING	EASTING
NW	640848.86	1240888.33
NE	640958.80	1241002.61
SE	640842.20	1241107.74
SW	640732.39	1240987.48

COORDINATES IN NAD 83 STATE PLANE NORTH, FEET

LEGEND

—x—	FENCE
🟫	STEEL ROAD PLATE BENEATH PAVEMENT AND CRUSHED SURFACING BASE COURSE

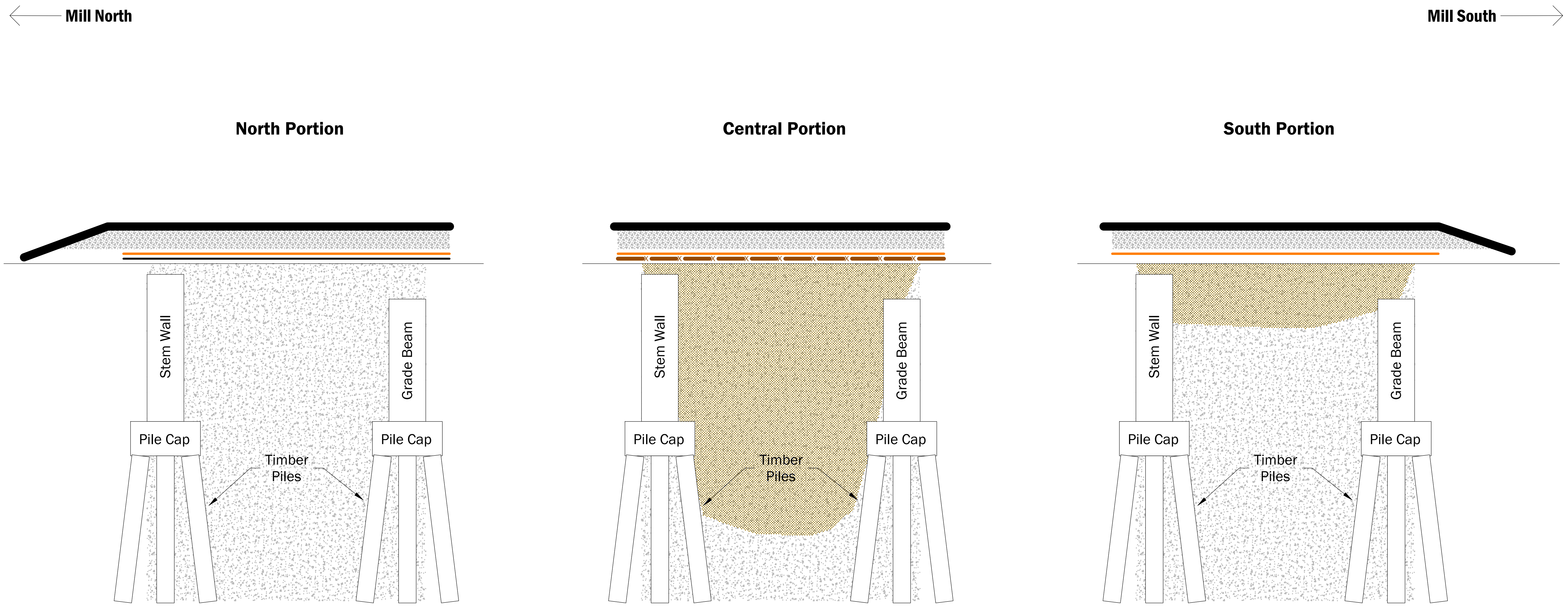
Paved Area As-Built

Interim Action Report
Mercury Soil Treatment and Disposal Project
Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Aspect CONSULTING

Jan-2018	BY: DAH/SCC	FIGURE NO.	3
PROJECT NO. 070188	REVISED BY: SCC		

CAD Path: Q:\Port of Bellingham\070188 Former GP Mill Property\2018-01 Hg Soil-Chlor-Alkali RAU-Interim Action Report\070188-02.dwg PAVED AREA AS-BUILT || Date Saved: Jan 09, 2018 10:12am || User: scudd



Not to Scale

▨ Soft, wet, silty, dredge-spoils fill

Placed (not compacted) during Interim Actions

— Crushed Brick

▨ Sandy, gravelly fill

Placed during 2017 Interim Action

— Hot Mix Asphalt (HMA) 3" Thickness

▨ Crushed Surfacing Base Course (CSBC) Variable Thickness

— Separation Geotextile

— 8' x 20' Steel Road Plate

Notes:

1. This figure is a schematic representation of subgrade conditions for the mill-northern, mill-central, and mill-southern portions of the Cell Building footprint. Subgrade conditions will vary from those shown, depending on location.
2. Subgrade conditions across the former Cell Building footprint are variable because, during the 2013-2014 interim action, some foundation elements (grade beams, pile caps) were removed and some contaminated dredge-spoils fill was excavated to variable depths. Some of the excavations were backfilled with imported gravel borrow and some were left open (voids) until backfilled with onsite stockpiled soil during the 2017 interim action. Also, note that the nature of the dredge-spoils fill is variable.

Schematic Cross Section of As-Built Pavement and Subgrade Conditions

Interim Action Report
Mercury Soil Treatment and Disposal Project
Chlor-Alkali RAU, GP West Site, Bellingham, Washington

Aspect CONSULTING	Jan-2018 PROJECT NO. 070188	BY: MAV/SCC REVISED BY: -	FIGURE NO. 4

CAD Path: Q:\Port of Bellingham\070188 Former GP Mill Property\2018-01 Hg Soil-Chlor-Alkali RAU-Interim Action Report\070188-03.dwg 11x17 Landscape || Date Saved: Jan 16, 2018 11:45am || User: scudd

APPENDIX B

Sampling and Analysis Plan

September 2022
Pre-Remedial Design Investigation 2 Project Plan

Sampling and Analysis Plan

Prepared for the Port of Bellingham

September 2022
Chlor-Alkali RAU, GP West Site

Sampling and Analysis Plan

Prepared for
Port of Bellingham

Prepared by
Anchor QEA, LLC
6720 SW Macadam Avenue, Suite 125
Portland, Oregon 97219

Aspect Consulting
103 E Holly Street, Suite 320
Bellingham, Washington 98225

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1.3.2 EGL Chemical Hygiene Plan 3
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APPENDICES

Appendix A	Quality Assurance Project Plan
Appendix B	EGL Chemical Hygeine Plan
Appendix C	Standard Operating Procedures

ABBREVIATIONS

Apex	Apex Laboratories
ASTM	ASTM International
Budinger	Budinger and Associates
CAP	Cleanup Actin Plan
CHP	Chemical Hygiene Plan
COC	chain of custody
EGL	Environmental Geochemistry Laboratory
IDW	investigation-derived waste
ISS	in situ solidification/stabilization
LEAF	Leaching Environmental Assessment Framework
MS/MSD	matrix spike/matrix spike duplicate
ORP	oxidation-reduction potential
Pilot Test	Field Pilot Test
PRDI	Pre-Remedial Design Investigation
PRDI Plan	Pre-Remedial Design Investigation 2 Project Plan Chlor-Alkali RAU, GP West Site, Bellingham, Washington
QA	quality assurance
QAPP	*Quality Assurance Project Plan*
QC	quality control
SAP	Sampling and Analysis Plan
Site	GP West Site
SOP	standard operating procedure
UCS	unconfined compressive strength

1 Introduction

This *Sampling and Analysis Plan* (SAP) outlines the scope for treatability studies as described in the Pre-Remedial Design Investigation (PRDI) 2 Project Plan Chlor-Alkali Remedial Action Unit, GP West Site (the site), Bellingham, Washington (PRDI Plan). Figure 1 of the PRDI Plan shows the site location and Figure 3 shows a plan view of the Field Pilot Test area.

The cleanup action selected in the Chlor-Alkali RAU Cleanup Action Plan (CAP) includes removal of obstructions and in situ solidification/stabilization (ISS) treatment of soils containing visible elemental mercury (Hg) in the Chlorine Plant Area. The goal of the work described in this SAP is to evaluate ISS treatments for the site. During the Field Pilot Test (Pilot Test), soil samples will be collected for a laboratory study. Two representative site soils will be collected and submitted to the Anchor QEA Environmental Geochemistry Laboratory (EGL) for treatability testing.

The following documents are supporting plans to this SAP:

- *Quality Assurance Project Plan* (QAPP; Appendix A)
- *EGL Chemical Hygiene Plan* (CHP; Appendix B)

1.1 Sampling and Analysis Plan Organization

This SAP is organized into the following sections:

- Section 1 – Background and objectives
- Section 2 – Project organization, roles, and responsibilities
- Section 3 – Pilot Test sample collection
- Sections 4 through 8 – Overview of laboratory treatability
- Section 9 – Quality assurance (QA) and quality control (QC) procedures
- Section 10 – Documentation and sample management
- Section 11 – Investigation-derived waste (IDW)
- Section 12 – References

1.2 Overview

This SAP details laboratory treatability testing to support the remedial design for the ISS of soils containing visible elemental mercury in the Chlorine Plant Area.

1.2.1 Pilot Test

The Pilot Test will be conducted within a portion of the Cell Building footprint to evaluate means and methods of obstruction removal. The Pilot Test will target removal of the wooden pilings down to the Fill Unit/aquitard interface (approximately 15 feet deep). The Pilot Test will be performed as described in the PRDI Plan. The samples for this treatability testing will be collected during the Pilot Test.

1.2.2 *Treatability Testing*

Site soils and groundwater will be collected during the Pilot Test for the laboratory treatability testing. Laboratory treatability testing will be conducted to evaluate ISS treatment objectives by creating laboratory-scale monoliths of site soil with a range of mix designs, on two representative soil homogenates. The monoliths will be evaluated using strength, permeability, and leachability performance criteria established in Section 4.1 of the PRDI Plan. The laboratory treatability testing will be conducted at the Anchor QEA EGL in Portland, Oregon. Budinger and Associates (Budinger) will be subcontracted by Aspect Consulting for geotechnical testing (unconfined compressive strength and hydraulic conductivity of select samples), and Apex Laboratories (Apex) will be subcontracted for chemical analyses.

An overview of the planned treatability testing is as follows:

- **Soil characterization:** The physical and chemical nature of the two Site soils for treatability testing will be characterized.
- **ISS Mix Designs:** Eleven different ISS mix designs will be tested on the two site soils. The amended soils will be cured as laboratory scale monoliths (test cylinders).
- **Characterization of Test Mixes:** The strength (by pocket penetrometer), slump, pH, and moisture content will be determined for each test mixture.
- **Geotechnical Characterization of Test Mixes:** A subset of the cured test mixtures will be submitted for determination of hydraulic conductivity and unconfined compressive strength.
- **Leachability Testing:** Cured test cylinders of the selected amendment mixture for each soil will be subjected to leach testing by the EGL.

A summary of the sampling and data collection program is provided in Sections 3 through 8 of this SAP.

1.3 Health and Safety

This section provides an overview of the health and safety requirements for the laboratory study.

1.3.1 *Compliance with Health and Safety Requirements*

All laboratory activities proposed will be performed in accordance with the EGL CHP provided in Appendix B to this SAP.

1.3.2 EGL Chemical Hygiene Plan

All laboratory work in the EGL will be performed in accordance with the (Appendix B) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the Laboratory Manager, as specified in the CHP.

1.4 Quality Assurance

This section provides an overview of the standard operating procedures (SOPs) and equipment calibration and decontamination requirements for the laboratory study to ensure activities adhere to specific standards and procedures.

1.4.1 Standard Operating Procedures

SOPs ensure consistency and quality in the implementation of laboratory work. Detailed SOPs for specific project tasks are referenced in the appropriate sections of this SAP and provided in Appendix C.

1.4.2 Maintenance, Calibration, and Decontamination of Instruments

Instruments used for laboratory measurements will be maintained and calibrated per the manufacturer's specifications and applicable SOPs. Instruments will be inspected daily for possible problems. Instruments will be calibrated before and checked after each laboratory use and as needed to produce accurate and reproducible data.

2 Organization and Responsibilities

Executing the work described in this SAP requires coordination between Aspect Consulting, Anchor QEA, and the subcontract laboratories. Lines of communication will be maintained among project personnel and managers. Regular communication will also be maintained between Aspect Consulting and Anchor QEA.

2.1 Project and Task Management

Aspect Consulting and Anchor QEA are the Technical Consultants performing the field and laboratory work on behalf of the Port of Bellingham. Aspect Consulting will be responsible for overall project management and field activities. Anchor QEA will perform laboratory testing to support the overall PRDI Plan objectives under subcontract to Aspect Consulting.

2.2 Subcontractors

Aspect Consulting will oversee subcontractors including analytical chemistry and geotechnical laboratories.

3 Pilot Test Sample Collection

The Pilot Test will be performed as described in the PRDI Plan. Soil and groundwater required for the laboratory treatability testing will be collected during the Pilot Test.

3.1 Soil and Groundwater Sampling

3.1.1 Objectives

The objective of field sampling is to collect representative site soils and groundwater for use in the laboratory treatability testing.

3.1.2 Summary of Work to Be Performed

Two representative soils will be collected during the Pilot Test. Each sample will represent the full depth of the soil column. Soil #1 will represent the mercury-impacted soils present within the footprint of the Chlorine Plant. Soil # 2 will represent low-mercury concentration soils anticipated at the edges of the area targeted for ISS.

Site groundwater will be used to generate the test mixtures and will be collected from monitoring well EMW-4S during the Pilot Test.

Tap water will also be used to generate the test mixtures and will be collected during the Pilot Test.

3.1.3 Procedures

Soil samples will be collected from the selected pit face (professional judgement in the field) to capture a relatively uniform sample from ground surface to the surface of the aquitard. The collected soil will be field homogenized by mechanical mixing. Three 5-gallon buckets will be collected for Soil #1 and two 5-gallon buckets will be collected for Soil #2. As mercury droplets may density separate during mixing, the homogenized material will be split vertically such that each subsample retains an equivalent mass of soil through the full depth of the homogenized sample.

The two representative soil samples will be field homogenized and submitted to the EGL in 5-gallon buckets.

Groundwater will be collected from well EMW-4S in accordance with routine groundwater monitoring sample collection procedures. The well will be purged prior to groundwater collection until water quality parameters (pH, oxidation-reduction potential [ORP], temperature, and specific conductance) stabilize[1]. Five gallons of groundwater will be transported to the EGL in 1-gallon cubitainers on ice.

---

[1] Stabilize = three successive measurements within 10% of the prior measurement

Five gallons of site tap water will also be collected and transported to the in 1-gallon cubitainers EGL on ice.

4 Soil Characterization

Characterization of the two soil samples performed by the EGL will include the parameters listed in Table 1. These analyses will be performed in accordance with the EGL Standard Operating Procedures (Appendix C). Each bucket of soil will be re-homogenized by mechanical mixing prior to sub-sampling.

Table 1
Characterization Parameters and Sample Count (EGL)

Parameter	Soil #1	Soil #2
Moisture Content EGL SOP/ ASTM D2216	2	1
Grain Size Analysis (with hydrometer) EGL SOP/ ASTM D422	2	1
Atterberg Limits EGL SOP/ ASTM 4318	2	1
Specific Gravity EGL SOP/ ASTM D854	2	1
pH EGL SOP/ ASTM D4972	2	1
Modified SPLP* EGL SOP/EPA Method 1312	2	2

Note:
*SPLP to be performed with Site groundwater.
ASTM: ASTM International

The soil samples will also be submitted to Apex Laboratories for analysis of total mercury and total organic carbon (Table 2). A duplicate analysis will be performed on one soil sample. These analyses will be performed in accordance with the QAPP (Appendix A).

Table 2
Characterization Parameters and Sample Count (Apex)

Parameter	Soil #1	Soil #2
Organic Content by ASTM D2974	2	1
Mercury (Total)	2	2

The following EGL SOPs are applicable to this activity and are included in Appendix C:

- Grain Size
- Moisture Content

- Atterberg Limits
- Specific Gravity
- Soil pH
- SPLP

5 Solidification/Stabilization Test Mixes

Laboratory treatability testing will be conducted to evaluate ISS performance criteria by creating laboratory-scale monoliths of site soil with a range of mix designs for both soil homogenates. Eleven amendment or amendment mixtures consisting of MaxCem, Terraflow, NewCem, Portland cement will be tested for each soil.

Test cylinders of the various treatment mixtures will be created for evaluation of the geotechnical characteristics, and determination of leachability reduction for selected amendment mixtures. The 11 test mixes in each soil will be subjected to strength testing, hydraulic conductivity testing, and leachability testing. The testing will proceed in a stepwise manner, such that only test mixtures with desirable strength properties are retained for further testing.

5.1 Summary of Work to Be Performed

Test mixtures will be generated for both soils with the amendment mixtures specified in the PRDI Plan. The soil samples will be re-homogenized by mechanical mixing prior to sub-sampling. After homogenization, the sub-samples will be split vertically within the container to account for any settling of liquid mercury. The soil will be combined with the indicated amendment mixtures on a dry-weight basis. Water will be added to the soil prior to amendment. The final moisture content will be determined in the laboratory, with a targeted mixture that generates 4 to 7 inches of slump as specified in the PRDI Plan. The water used in the test mixes will be a 1:1 mixture of site groundwater from well EMW-4S and site tap water. The amendments, soil, groundwater, and tap water will be combined and homogenized by mechanical mixing with a hand-held cement/paint mixer. The treatability test mix designs are included in Table 2 of the PRDI Plan.

Each mixture will be subsampled to generate 2-inch by 4-inch test cylinders to cure in plastic molds, as well as to reserve material for determination of pH, slump, and strength by pocket penetrometer. A total of nine test cylinders will be generated for each amendment mixtures with Soil #1, and six test cylinders will be generated for each mixture with Soil #2. The test cylinders will be allowed to cure in an undisturbed location at ambient (room) temperature.

6 Characterization of Test Mixes

The 11 test mixes in each soil will be characterized at the EGL for initial strength, mix cohesiveness (slump), pH, initial temperature, and water content.

6.1 Summary of Work to Be Performed

The 11 test mixtures for each soil will be analyzed for mix temperature, slump, pH, and strength (by pocket penetrometer) as summarized in Table 3 of the PRDI Plan.

The characterization of test mixes will be communicated to Aspect Consulting prior to submission of geotechnical samples described in Section 8.

The following SOPs apply to this activity and are included in Appendix C:

- Slump
- Strength by Pocket Penetrometer
- Soil pH

7 Geotechnical Characterization of Test Mixtures

The 11 test mixes for Soil #1 will be submitted to Budinger for determination of the unconfined compressive strength after 7 days of cure time. The unconfined compressive strength will be determined after 14, 28, and 49 days of curing for select mixtures, and for select mixtures with Soil #2. Geotechnical testing is summarized in Table 3 of the PRDI Plan. Hydraulic conductivity will be determined on two mixtures selected from the results of the strength testing.

7.1 Summary of Work to Be Performed

Selected test mixtures will be submitted to Budinger for analysis of unconfined compressive strength by ASTM D2166, hydraulic conductivity by ASTM D5084 after 7, 14, 28, or 49 days of cure time. The cured test cylinders will be submitted to the geotechnical laboratory in the plastic molds and shipped to arrive the day prior to anticipated strength testing.

The unconfined compressive strength (UCS) results for day 7, 14, 28, and 49 will be reported directly to Aspect Consulting, who will inform the EGL which sample mixes are selected for the next round of geotechnical testing.

8 Leachability Testing

The mercury leachability of the preferred test mixture will be determined by Leaching Environmental Assessment Framework Method 1315 (LEAF) testing for a single test mix for each soil. The test mixture will be selected based on the initial characterization and unconfined compressive strength for each mix in Soil #1. The ISS mix design to be LEAF tested will be selected by Aspect Consulting.

8.1 Summary of Work to Be Performed

The cured test cylinders will be removed from the plastic mold and immersed in reagent water (or site groundwater) as specified in the LEAF method and EGL SOP. The LEAF testing may be modified such that the leaching solution is exchanged less frequently than specified in the method in order to evaluate equilibrium leaching. The leaching solution will be tested for dissolved mercury.

The following SOPs are applicable to this activity and are included in Appendix C:

- LEAF Monolith Testing

9 Quality Assurance/Quality Control

This section summarizes quality assurance procedures. Chemistry QC samples will include duplicates and analytical laboratory matrix spike/matrix spike duplicate (MS/MSD) analyses. Analytical laboratory analysis of duplicates will be used to evaluate the precision and accuracy of protocols. QC samples will be collected and analyzed as outlined in the QAPP (Appendix A).

The QC procedures for measuring direct-read parameters will include the initial calibration of the instruments and daily calibrations to a reference standard before and after each event.

10 Documentation and Sample Management

This section describes how data and documents will be archived and how samples will be named and handled. Laboratory documentation procedures are described in the QAPP (Appendix A).

10.1 Sample Management

This section describes how samples will be named and handled during the field and laboratory program and addresses the sampling program requirements for sample nomenclature, IDW management, sample custody, and sample shipping requirements.

10.1.1 Sample Nomenclature

Each sample name will specify Soil #1/Soil #2, amendment mixture, and number of days cured, as appropriate.

10.1.2 Sample Custody and Shipping Requirements

Samples are in one's custody if they are in the custodian's possession or view, in a secured location (under lock) with restricted access, or in a container that is secured with official seals such that the sample cannot be reached without breaking the seals.

Chain-of-custody (COC) procedures will be followed for all samples throughout the collection, handling, and analytical process. The principal document used to track possession and transfer of samples is the COC form. Each sample identifier will be listed on an electronic or handwritten COC form the day it is collected. All handwritten data entries will be made using an indelible-ink pen. Corrections will be made by drawing a single line through the error, writing in the correct information, and then dating and initialing the change. Blank lines and spaces on the COC form will be lined out, dated, and initialed by the individual maintaining custody.

A COC form will accompany each shipment of samples to the analytical laboratory. Each person who has custody of the samples will ensure that the samples are not left unattended unless properly secured. Copies of all COC forms will be retained in the project files.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the COC form. Upon receipt of samples at the laboratory, the person receiving the sample will sign the COC form. The shipping container seals will be broken (if applicable), and the receiver will record the condition of the samples on a sample receipt form. COC forms will be used internally in the laboratory to track sample handling and final disposition.

11 Investigation-Derived Waste Management

Upon completion of the project, any untreated site soil or groundwater will be returned to the site for appropriate disposal.

Appendix A

Quality Assurance Project Plan

September 2022
GP West Site Pre-Remedial Design Investigation

Quality Assurance Project Plan

Prepared for the Port of Bellingham

September 2022
GP West Site

Quality Assurance Project Plan

Prepared for
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ABBREVIATIONS

ASTM	ASTM International
CAP	Cleanup Action Plan
CCV	continuing calibration verification
DQO	data quality objective
Ecology	Washington State Department of Ecology
EGL	Environmental Geochemistry Laboratory
EPA	U.S. Environmental Protection Agency
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MD	matrix duplicate
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
Order	Agreed Order No. DE 6834
Plan	PRDI 2 Project Plan
Port	Port of Bellingham
PRDI	Pre-Remedial Design Investigation
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R	recovery
RAU	Remedial Action Unit
RL	reporting limit
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SDG	sample delivery group
Site	GP West site
SOP	standard operating procedures

1 Introduction and Background

This Quality Assurance Project Plan (QAPP) outlines the quality assurance and quality control (QA/QC) procedures associated with the Pre-Remedial Design Investigation (PRDI) 2 Project Plan (Plan) for the Chlor-Alkali Remedial Action Unit (RAU) cleanup at the GP West Site (Site). This QAPP was prepared in conjunction with the *Sampling and Analysis Plan* (SAP; Anchor QEA, LLC, and Aspect Consulting 2022). Sampling and treatability study QA/QC procedures are described in the SAP.

2 Data Quality Objectives and Criteria

The data quality objectives (DQOs) for this project will ensure that data collected are of known and acceptable quality so that the project objectives described in this QAPP are achieved. The quality of laboratory data is assessed by precision, accuracy, representativeness, comparability, completeness, and sensitivity (the "PARCCS" parameters). Definitions of these parameters and the applicable QC procedures are described in the following subsections. Applicable quantitative goals for these data quality parameters are listed or referenced in Table 1.

Table 1
Quantitative Goals for Analytical Data

	Replicate and MS/MSD Precision[1]	LCS/LCSD and/or MS/MSD Accuracy[1,2]	Completeness
Water			
Mercury	± 20% RPD	70% to 130% R	95%
Soil			
Mercury	± 30% RPD	70% to 130% R	95%
Organic Carbon	± 30% RPD	70% to 130% R	95%

Note:
1. Precision or accuracy control limits may vary dependent on revisions to laboratory control charts.
2. LCS/LCSD recovery may be used in place of MS/MSD to assess accuracy.
LCS: laboratory control sample
LCSD: laboratory control sample duplicate
MS/MSD: matrix spike/matrix spike duplicate
N/A: not applicable
R: recovery
RPD: relative percent difference

2.1 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling, and laboratory analyses. ASTM International (ASTM) recognizes the following two levels of precision (ASTM 2002):

1. Repeatability: the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory with the same apparatus under constant operating conditions
2. Reproducibility: the random error associated with measurements made by different test operators in different laboratories using the same method but different equipment to analyze identical samples of test material

In the laboratory, "within-batch" precision is measured using duplicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analyses of standard solutions or laboratory control samples from multiple analytical batches.

Precision will be evaluated by collecting duplicates for chemistry samples at a frequency of 1 in 20 samples. Duplicate precision will be screened against an RPD of 35% for waters and 50% for soils. However, data may not be qualified based solely on field homogenization duplicate precision but will be left to the discretion of the validator. Laboratory precision control limits are listed in Table 1 for each analysis. The RPD equation used to express precision is shown in Equation 1.

Equation 1

$$RPD = \frac{(C_1 - C_2) x\, 100\%}{(C_1 + C_2)/2}$$

where:

RPD = relative percent difference
C_1 = larger of the two observed values
C_2 = smaller of the two observed values

Precision measurements can be affected by the nearness of a chemical concentration to the reporting limit (RL), where the percent error (expressed as RPD) increases. Duplicate results that are less than five times the RL will be evaluated by using the difference between the results using a control limit of plus or minus the RL for waters and a control limit of plus or minus two times the RL for soils.

2.2 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the value of results from analyses of laboratory control samples, standard reference materials, and standard solutions. In addition, matrix-spiked (MS) samples are also measured, which indicate the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery of the measured value, relative to the true or expected value. If a measurement process produces results that are not the true or expected values, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination). Analytical laboratories use several QC measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples, and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

Laboratory accuracy will be evaluated using quantitative laboratory control sample, MS, and standard reference material recoveries compared with method-specified performance criteria or criteria listed in Table 1. Accuracy can be expressed as a concentration compared to the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is shown in Equation 2.

Equation 2

$$\%R = 100\% \, x \, (S - U)/Csa$$

where:

$\%R$ = percent recovery
S = measured concentration in the spiked aliquot
U = measured concentration in the unspiked aliquot
Csa = actual concentration of spike added

Accuracy will be ensured by adhering to sample collection procedures outlined in the SAP (Anchor QEA and Aspect Consulting 2022).

2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. Sample collection and handling procedures described in the SAP (Anchor QEA and Aspect Consulting 2022) will be followed to ensure samples represent Site conditions.

2.4 Comparability

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. For this program, comparability of data will be established by using standard analytical methodologies and reporting formats and through common traceable calibration standards and reference materials.

2.5 Completeness

Completeness is a measure of the amount of data determined to be valid in proportion to the amount of data collected. Completeness will be calculated as shown in Equation 3.

Equation 3

$$C = \frac{(Number\ of\ acceptable\ data\ points)x\ 100}{Total\ number\ of\ data\ points}$$

where:

C = completeness

The DQO for completeness for all components of this project is 95%. Data that are qualified as estimated because QC criteria are not met will be considered valid for the purposes of assessing completeness. Data that are rejected will not be considered valid for the purposes of assessing completeness.

2.6 Sensitivity

Sensitivity is a measure of analytical detection and RLs. In general, the lowest method detection limits (MDLs) and RLs achievable by the specified method will be targeted for this project.

The MDL is defined as the minimum concentration at which a given target analyte can be measured and reported with 99% confidence that the analyte concentration is greater than zero. Laboratory RLs are defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. Laboratory MDLs and RLs will be used to evaluate the method sensitivity and applicability prior to the acceptance of a method for this program. Method blanks will be analyzed to ensure target analytes are not introduced during sample preparation or analysis that would affect the analytical sensitivities.

The sample-specific MDLs and RLs will be reported by the laboratory and will account for any factors relating to the sample analysis that might decrease or increase these limits (e.g., dilution factor, percent moisture, and analytical mass/volume). If MDLs and RLs are elevated due to matrix interferences and subsequent dilutions or reductions in sample aliquots, then data will be evaluated to determine if an alternative course of action is required. The sample-specific MDLs and RLs will be included in the data transmittal.

3 Documentation and Records

Environmental Geochemistry Laboratory (EGL) documentation and analytical data will be stored electronically in a designated directory at Anchor QEA.

3.1 Analytical Records

Additionally, Anchor QEA and Aspect Consulting will retain copies of analytical data in the central project files. Data reporting requirements will include those items necessary to complete data validation. Analytical and geotechnical laboratories will be required to maintain records relevant to project sample analyses for a minimum of 5 years. Data validation reports will be maintained in the central project files with the analytical data reports.

3.2 Data Reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample mass or volume analyzed, sample moisture content, and/or dilutions required, be considered in the final result. It is the laboratory analyst’s responsibility to reduce data.

4 Analytical Methods

This section summarizes the target physical and chemical analyses that will be conducted on the samples collected. Sample analyses will be conducted in accordance with ASTM or U.S. Environmental Protection Agency (EPA)-approved methods, other commonly acceptable methods, or as described in the laboratory standard operating procedures (SOPs), as well as this QAPP. Prior to analyses, all samples will be maintained according to the appropriate holding times and temperatures for each analysis, as listed in Table 2.

Table 2
Guidelines for Sample Handling and Storage

Parameter	Sample Size	Container Type	Holding Time	Preservative
Aqueous Samples				
Mercury	250 mL	Glass	28 days	Nitric acid
Soil Samples				
Mercury	4 oz	Glass	28 days	<6°C
Organic Carbon	4 oz	Glass	14 days	<6°C

Note:
mL: milliliters
oz: ounce
C: Celsius

Analytes, analytical methods, and target detection limits for chemical and physical testing are presented in Table 3.

Table 3
Parameters for Analysis, Methods, and Target Quantitation Limits

Parameter	Method	Laboratory Detection Limit
Water Parameters		
Mercury	EPA Method 6020A, 7470A	1 µg/L
Soil Parameters		
Mercury	EPA 7471B	0.03 mg/kg
TOC	EPA Method 9060	0.1%

Note:
µg/L: micrograms per liter
mg/kg: milligrams per kilogram
%: percent

The laboratories will prepare reports in accordance with this QAPP. Prior to the analyses of the samples, the analytical laboratories will calculate MDLs and establish RLs for each analyte of interest, where applicable. RLs will be at or below the values specified in Table 3, if technically feasible.

Chemistry testing will be conducted at Apex Laboratories, which is accredited under the National Environmental Laboratories Accreditation Program. All physical and chemical testing will adhere to the most recent EPA QA/QC procedures outlined in the approved analytical methods, the laboratory SOPs, and this QAPP.

Geotechnical testing will be conducted at Budinger and Associates. All testing will adhere to the procedures outlined in the approved analytical methods, the laboratory SOPs, and this QAPP.

In completing chemical analyses for this project, the analytical and geotechnical laboratory subcontractors are expected to meet the following minimum requirements:

- Adhere to the methods outlined in this QAPP, including methods referenced for each analytical procedure (Table 3).
- Deliver electronic data as specified.
- Meet reporting requirements for deliverables.
- Meet turnaround times for deliverables.
- Implement QA/QC procedures discussed in this QAPP, including following DQOs, laboratory QC requirements, and performance evaluation testing requirements.
- Notify the project contact of any QA/QC problems when they are identified to allow for quick resolution.
- Allow laboratory and data audits to be performed, if deemed necessary.

5 Quality Assurance and Quality Control

Field and EGL activities will be conducted in such a manner that the results meet specified quality objectives and are fully defensible. Guidance for QA/QC is derived from the protocols developed for EPA SW846 (EPA 1986), the EPA National Functional Guidelines (EPA 2020), the laboratory SOPs, and the cited methods.

5.1 Quality Control

Field and EGL personnel will label samples in a consistent manner to ensure that field samples are traceable. Labels should be used in conjunction with the chain-of-custody form, the SAP (Anchor QEA and Aspect Consulting 2022), and this QAPP to provide all information necessary for the analytical laboratory to conduct required analyses properly. QC samples will be collected in the field to ensure project DQOs are met. Samples will be placed in appropriate containers and preserved for shipment to the laboratory in accordance with the requirements presented in Table 2.

5.2 Quality Assurance Sampling

QC samples are useful in identifying possible problems resulting from sample collection or sample processing. Chemistry sample blanks will be collected at a minimum frequency of one per sampling event per matrix. Duplicates for chemistry samples will be collected at a minimum frequency of one per sampling event per matrix, provided sufficient sample volume can be collected.

QC samples will also include the collection of additional sample volume as required to ensure that the analytical laboratory has sufficient sample volume to run the matrix-specified analytical QA/QC (matrix duplicate [MD]/MS) samples for analyses. Additional volume to meet this requirement will be collected at a frequency of one per matrix per sampling event or 1 per matrix per 20 samples collected, whichever is more frequent. The samples designated for MD/MS analyses will be clearly marked on the chain-of-custody form.

5.2.1 Sample Containers, Filtering, and Preservation

Sample containers and preservatives will be provided by the analytical laboratory. Container, filtration, and preservative requirements are listed in Table 2. Water samples that require filtration (Table 2) will be filtered using 0.45 micron polyethersulfone membrane filters. Chemistry samples will be stored and transported at 4°C.

5.2.2 Sample Identification and Labels

Each sample will be labeled at the time of collection with an adhesive plastic or waterproof paper label affixed to the container. The following information will be recorded on the container label:

- Project name

- Sample identification
- Date and time of sample collection
- Preservative type (if applicable)
- Analysis to be performed

5.3 Analytical Laboratory Quality Control

Analytical laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials, laboratory control samples, matrix replicates, MS samples, and method blanks. A summary of the DQOs is provided in Table 1.

The analyst will review the results of the QC samples from each sample group immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the QA/Data Validation Lead will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

5.3.1 Analytical Laboratory Instrument Calibration and Frequency

An initial calibration will be performed on each laboratory instrument to be used prior to the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet method control criteria. An initial calibration verification will be analyzed following each initial calibration and will meet method criteria prior to analyses of samples. Continuing calibration verifications (CCV) will be analyzed at method-required frequencies to track instrument performance. CCVs will be analyzed at a frequency of 1 for every 10 field samples analyzed and at the end of each run, as applicable. If the continuing calibration is out of control, the analysis will be terminated until the source of the control failure is eliminated or reduced to meet control specifications, which may include analyzing a new initial calibration. Any project samples analyzed while the instrument calibration was out of control will be reanalyzed.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to or immediately following continuing calibration verification at the instrument for each type of applicable analysis.

5.3.2 Analytical Laboratory Duplicates/Replicates

Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates and replicates are subsamples of the original sample that are prepared and analyzed as a separate sample.

5.3.3 Matrix Spikes

Analyses of MS samples provide information on the extraction efficiency of the method on the sample matrix as well as any interferences introduced by the sample matrix.

5.3.4 Method Blanks

Method blanks are prepared and analyzed in the same manner as project samples to assess possible laboratory contamination at all stages of sample preparation and analysis. The method blank for all analyses must be less than the method reporting limit of any single target analyte. If a laboratory method blank exceeds this criterion for any analyte, and the concentration of the analyte in any of the samples is less than five times the concentration found in the blank, analyses must stop and the source of contamination must be eliminated or reduced. Affected samples should be re-prepared and reanalyzed, if possible.

5.3.5 Analytical Laboratory Control Samples

Laboratory control samples are analyzed to assess possible laboratory bias at all stages of sample preparation and analysis. The laboratory control sample is a matrix-dependent spiked sample prepared at the time of sample extraction, along with the preparation of the sample, MD, MS, and method blank. The laboratory control sample will provide information on the accuracy of the analytical process and, when analyzed in duplicate, will provide precision information as well.

5.3.6 Analytical Laboratory Deliverables

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present. The analytical laboratory will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will include a discussion of any problems encountered during analyses. This summary should include (but not be limited to) QA/QC, sample receipt, sample storage, and analytical difficulties. Any problems encountered and their resolutions will be documented in as much detail as appropriate.
- **Chain-of-Custody Records.** Legible copies of the chain-of-custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of the samples received by the laboratory.
- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:
  - Sample identification and the corresponding laboratory identification code
  - Sample matrix
  - Date of sample preparation/extraction
  - Date and time of analysis

    - Mass or volume used for preparation and analysis
    - Final dilution or concentration factors for the sample
    - Identification of the instrument used for analysis
    - MDLs and method RLs accounting for sample-specific factors (e.g., dilution and total solids)
    - Analytical results with reporting units identified
    - Data qualifiers and their definitions
- **QA/QC Summaries.** This section will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results. No recovery or blank corrections will be made by the laboratory. The required summaries are as follows (additional information may be requested):
    - **Method Blank Analysis.** The method blank analysis associated with each sample and the concentration of all target analytes identified in these blanks will be reported.
    - **MS Recovery.** MS recovery data for all applicable analyses will be reported. The names and concentrations of analytes added, percent recoveries, and range of acceptable recoveries will be listed. The percent recoveries and RPD values for matrix spike duplicate analyses will be reported.
    - **MDs.** The RPD values for MD analyses will be reported.
    - **Laboratory Control Sample.** Laboratory control sample recovery data will be reported. The names and concentrations of analytes added, percent recoveries, and range of acceptable recoveries will be included. The percent recoveries and RPD values for laboratory control sample duplicate analyses will be included.
    - **Instrument Calibration Verification Standard Recoveries and Blanks.** Instrument calibration verification standard recoveries and blanks will be re-reported to verify that the instrument's probe maintained adequate calibration for the entire analytical sequence.
- **Electronic Data Deliverable.** An electronic data deliverable will be prepared.

5.4 Instrument/Equipment Maintenance and Records

This section describes procedures for testing, inspection, and maintenance of EGL equipment. The EGL Laboratory Manager will be responsible for ensuring that the laboratory instrumentation is calibrated in accordance with specifications. Recognized procedures (EPA, ASTM, or manufacturer's instructions) will be used when available. EGL data sheets will be checked for completeness and accuracy. EGL documentation will be filed in the main project folder after data entry and verification are complete.

6 Assessments and Response Actions

Once data are received from the laboratory, several QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

6.1 Response and Corrective Actions

The following sections identify the responsibilities of key project team members and actions to be taken in the event of an error, problem, or non-conformance of protocols identified in this document.

6.1.1 EGL Activities

EGL activities will comply with SOPs, the SAP, and this QAPP. The EGL Laboratory Manager will be responsible for correcting situations that may result in non-compliance with this QAPP. All EGL personnel will be responsible for reporting problems that may compromise the quality of the data. Any corrective measures that are taken will be immediately documented.

6.1.2 Analytical Laboratory

The analytical laboratory is required to comply with its SOPs. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

6.1.3 Reports to Management

QA reports to management may include verbal status reports, data validation reports, and final project reports.

7 Data Validation, Usability, and Reporting

This section describes the processes that will be used to review project data quality.

Analytical Laboratory data will be provided as a report and electronic data deliverable. Laboratory data that is electronically provided and loaded into a database will undergo a check against the laboratory hard copy data. Data will be validated or reviewed manually, and qualifiers, if assigned, will be entered manually. The accuracy of all manually entered data will be verified. Data tables and reports will be exported from EQuIS to Microsoft Excel tables.

7.1 Data Review and Verification

Analytical data will be evaluated for project, method, and laboratory QC compliance, and their validity and applicability for program purposes will be determined. Based on the findings of the validation process, data validation qualifiers may be assigned.

7.2 Validation and Verification Methods

Data validation includes signed entries by the field and laboratory technicians on field data sheets and laboratory datasheets, respectively; review for completeness and accuracy by the Field Leads and Laboratory Project Managers; review by the QA/Data Validation Lead for outliers and omissions; and the use of QC criteria to accept or reject specific data. If errors are found, further verification will be performed to ensure that all data are accurate. Any errors found will be corrected, and the laboratory will be notified of the errors. Laboratory data will be reviewed and verified to determine whether DQOs have been met and that appropriate corrective actions have been taken, when necessary. The laboratory manager will be responsible for the final review of data generated from analyses of samples.

Data packages will be checked for completeness immediately upon receipt from the laboratory to ensure that data and QA/QC information requested are present.

7.3 Data Reporting

Data will be included in the final report. This will include:

- Sample location coordinates where relevant
- Chemical and physical results data tables
- Copies of complete laboratory data packages as appendices or attachments
- Copies of applicable sections of the field logs as appendices or attachments
- Copies of validation reports and findings

8 References

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Appendix B

Environmental Geochemistry Laboratory Chemical Hygiene Plan

February 2022

Environmental Geochemistry Laboratory Chemical Hygiene Plan

February 2022

Environmental Geochemistry Laboratory Chemical Hygiene Plan

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APPENDICES

Appendix A Glove Chemical Resistance Guide
Appendix B Chemical Inventory List
Appendix C Chemical Compatibility Chart (EPA-600/2-80-076)

ABBREVIATIONS

CL	ceiling limit
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CHSD	Corporate Health and Safety Director
CHSP	Corporate Health and Safety Program
EDTA	ethylenediaminetetraacetic acid tetrasodium salt
HASP	health and safety plan
Laboratory	Environmental Geochemistry Laboratory
LD	Laboratory Director
mg/m^3	milligrams per cubic meter
OAR	Oregon Administrative Rule
PAH	polycyclic aromatic hydrocarbon
PEL	permissible exposure limit
PPE	personal protective equipment
ppm	parts per million
SDS	safety data sheet
SPME	solid-phase microextraction
STEL	short-term exposure limit
TWA	time-weighted average
VOC	volatile organic compound
XRF	x-ray fluorescence

1 Purpose

The purpose of this Chemical Hygiene Plan (CHP) is to prevent chemically related accidents in the Environmental Geochemistry Laboratory (EGL) and to ensure employee chemical exposure levels are kept as low as reasonably attainable. This plan is also intended to establish hazard communication protocols for providing information pertaining to chemical hazards to EGL staff. This plan is intended to comply with **OSHA 29 CFR 1910.1450 – Occupational Exposure to Hazardous Chemicals in Laboratories**. This plan is also intended to comply with **OSHA 29 CFR 1910.1200 – Hazard Communication** as adopted by the Oregon Occupational Safety and Health Administration (OSHA). The Anchor QEA Corporate Health and Safety Program (CHSP) is the overarching program applicable to employees working in the EGL. This CHP will be readily available to workers involved in laboratory activities.

2 Scope

This plan applies to all EGL personnel and to other personnel who enter the EGL.

Please note not all chemicals listed in this document may be present in the EGL but are included in the event that a listed chemical may be encountered.

3 Responsibility

3.1 Corporate Health and Safety Director

The Corporate Health and Safety Director (CHSD), David Templeton, has the following responsibilities:

- Maintaining the CHSP, the overarching program that includes this Chemical Hygiene Plan (CHP).
- Ensuring consistency between the CHP and the CHSP.
- Supporting, along with the Laboratory Director (LD), the shared goal of keeping the EGL in compliance with all applicable federal, state, and local codes and regulations, as well as company policies

3.2 Laboratory Director

The LD, Dimitri Vlassopoulos, has the following responsibilities:

- Assuming responsibility for personnel engaged in the laboratory, including employee use of hazardous chemicals.
- Providing the Chemical Hygiene Officer (CHO) with the support necessary to implement and maintain the CHP.
- Ensuring timely actions to protect trained laboratory personnel and facilities and to keep the EGL in compliance with all applicable federal, state, and local codes and regulations, as well as company policies.
- Providing budgetary arrangements to ensure the health and safety of departmental personnel, visitors, and students.

3.3 Chemical Hygiene Officer

The CHO, Grace Weatherford, has the following responsibilities:

- Establishing, maintaining, and revising the CHP.
- Creating and revising CHP content based on applicable safety rules and regulations.
- Monitoring procurement, use, storage, and disposal of chemicals.
- In coordination with CHSP, conducting regular reviews of the EGL, preparation rooms, and chemical storage rooms, and providing summarized information to the Laboratory Manager for resolution.
- Assisting Laboratory Manager in developing and maintaining adequate facilities.
- Seeking ways to improve the CHP.

3.4 Laboratory Manager

The Laboratory Manager, Jessica Goin has overall responsibility for chemical hygiene in the EGL, including the following responsibilities:

- Ensuring EGL personnel comply with the CHP and do not operate equipment or handle hazardous chemicals without proper training and authorization.
- Always wearing personal protective equipment (PPE) that is compatible with the relevant chemical's degree of hazard.
- Following all pertinent safety rules when working in the EGL to set an example.
- Reviewing laboratory procedures for potential safety problems before assigning to other EGL personnel.
- Ensuring visitors follow EGL rules and assuming responsibility for EGL visitors.
- Ensuring PPE is available and properly used by each EGL employee and visitor.
- Maintaining and implementing safe laboratory practices.
- Providing regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment.
- Monitoring the facilities and chemical fume hoods to ensure they are maintained and function properly. Contacting the CHO to report problems with the facilities or chemical fume hoods.
- Conducting regular inspections of the EGL, preparation rooms, and chemical storage rooms, and submit detailed laboratory inspection reports to the CHO. Addressing issues identified by the CHO.
- Maintaining inspection, personnel training, and inventory records.
- Reviewing accident reports and make appropriate recommendations to the CHSD, LD, and CHO, as appropriate, regarding proposed changes in laboratory procedures.

3.5 Laboratory Personnel

EGL personnel have the following responsibilities:

- Reading, understanding, and following all safety rules contained in the CHP.
- Planning and conducting each operation in accordance with the CHP, EGL standard operating procedures, and assigned work specifics.
- Promoting and following good housekeeping practices in the EGL. A job is never complete in the EGL until the workstation is completely cleared and cleaned, and equipment and glassware is properly returned. Do not leave work for others without advanced communication.
- Notifying the Laboratory Manager of any hazardous conditions or unsafe work practices in the work area.
- Reporting accidents or near accidents (i.e., near misses) that result in or might involve personal injury to the Laboratory Manager and CHO immediately.

- Reporting any near miss through the company’s near miss program.
- Using PPE as appropriate for each procedure that involves hazardous chemicals.

4 Standard Practices for a Safe Laboratory

In addition to the previously mentioned responsibilities, it is the responsibility of all EGL personnel to ensure that the following safe work practices are observed:

- The following type of footwear is required while performing laboratory tasks: work shoes that are closed at the toe and have minimal ventilation or decorative holes and a heel not more than 1-inch high. Additional footwear requirements may be necessary depending on the safety data sheet (SDS) recommendations for the chemical being handled.
- Working with chemicals without a clear understanding of the hazards and required safety procedures and equipment is not permitted. Review the SDS prior to working with any chemical.
- Hazardous operations should not be left unattended.
- Running and horseplay are not permitted in the EGL.
- Accidents or near accidents (i.e., "near misses") that result in or might involve personal injury are to be reported to the Laboratory Manager and CHO immediately as well as the company's near miss program.
- Hands must be properly washed prior to leaving the EGL.
- Laboratory coats and other PPE must be removed prior to leaving the EGL.
- Eating and drinking are not permitted in the EGL.
- All chemical and sample containers must be clearly labeled prior to receiving for storage, transport, or processing.
- When mixing acid with water, follow the AAA rule: Always Add Acid to water. Adding water to acid can produce a violent reaction. The same rule applies when mixing bases with water (AAB).
- Compressed gas cylinders must be properly stored and secured at all times.
- Maintaining compliance with standard housekeeping procedures helps ensure smooth laboratory operations and minimizes accidental exposure to chemical hazards. All work areas must be kept clean, neat, orderly, and free of contamination. When a laboratory task is completed, all chemicals must be returned to the appropriate storage location, bench tops cleaned, and dishware washed and returned to appropriate storage location. All personnel should plan for the required cleanup when scheduling laboratory tasks. Laboratory tasks will not be considered complete until appropriate cleanup has occurred. Do not leave cleanup for others.
- SDS for all chemicals stored or used in the EGL will be kept in a readily accessible binder in the EGL. If a new chemical is ordered, the CHO must be notified in advance.
- Working in the EGL alone with hazardous chemicals should be avoided.
- Loose or dangling jewelry should be removed and long hair must be tied back to prevent accidental contact with chemicals.

5 Personal Protective Equipment

Appropriate PPE will be available in the EGL. If a chemical is ordered for a project, the CHO must confirm the EGL is in possession of PPE required for its use, and corresponding PPE training for EGL staff must be provided prior to the use of the chemical.

5.1 Gloves

Disposable gloves will be worn during any activity with potential chemical exposure to the hands. The type of glove chosen should be compatible with the chemical or chemicals being used. Glove type should be selected based on chemical compatibility and breakthrough times, available from the glove manufacturer. Glove selection is discussed further in the Section 6 and Appendix A.

Double gloves should be worn when working with chemicals that may penetrate gloves, such as strong acids, and gloves should be changed frequently. If contact with chemicals occurs while wearing gloves, the gloves should be immediately removed and replaced. When removing gloves, care must be taken to avoid touching the outside of the glove with bare hands. Always dispose of gloves and wash hands before leaving the EGL. Laboratory orientation will include review and demonstration of proper glove removal and disposal procedures.

5.2 Eye Protection

Safety glasses must be worn at all times in the EGL when working with chemicals or during any other activities that involve potential eye hazards. Some chemicals may require safety glasses be replaced by or supplemented with chemical goggles, face shields, or other eye protection as required by the SDS. Employees in the EGL will post signage indicating the elevated PPE requirements when eye protection beyond safety glasses is necessary.

Safety glasses, chemical goggles, and face shields will always be kept clean and properly stored. Chemical contamination can cloud eye protection and obscure vision, creating a potentially hazardous situation. If eye protection becomes damaged and restricts vision, it should be replaced immediately.

5.3 Aprons and Laboratory Coats

An approved chemical resistant apron or laboratory coat will be worn for activities where exposure from chemical splashing is possible. Ensure the apron provides enough coverage for the task at hand. When working with strong oxidants, acids, or bases, chemical resistant sleeve covers should be worn in addition to a laboratory coat. Activities that may result in chemical splashing should be contained by glass or plastic shielding. Aprons and laboratory coats may not be removed from the EGL without appropriate decontamination or storage.

6 Common Chemical and Material Handling

6.1 Handling Acids, Bases, and Oxidizers

Acids and bases are corrosive and can irritate or even burn the eyes, irritate the skin, and cause respiratory distress. The risk is higher when they are concentrated, but even when diluted, they can be hazardous. Always add acid to water when diluting an acid to avoid a vigorous exothermic reaction. When water is added to acid, the water will boil, and the acid may violently splatter.

Appropriate gloves, eye protection, and a chemical apron will be used when handling corrosive materials (such as nitric acid, potassium hydroxide, sodium hydroxide, ammonia, and sulfuric acid). All work with volatile corrosive chemicals will be done in a fume hood.

Laboratory activities that involve handling acids, bases, and oxidizers require use of the PPE indicated in Tables 1a through 1c.

Table 1a
Corrosives in the Laboratory: Acids

Chemical	PPE
Hydrochloric acid	Handling strong acid solutions requires double nitrile gloves, a rubber apron, Tyvek sleeves over a laboratory coat, and chemical goggles; keep open solutions contained in the fume hood. If concentrated acid comes into contact with gloves, gloves must be removed immediately (be alert for discoloration).
Nitric acid	
Sulfuric acid	
Sulfuric acid (50% or higher)	Vinyl gloves in addition to the above PPE
Acetic acid	Chemical goggles, double gloves, and laboratory coat; keep open solutions contained in the fume hood
Oxalic acid dihydrate	
Aluminum sulfate	Safety glasses, gloves, and laboratory coat
Ferric chloride	

Note:
Reagent kits include trace amounts of sulfamic acid (Hach EZ Arsenic) and sodium metabisulfite (FerroVer reagent).

Table 1b
Corrosives in the Laboratory: Bases

Chemical	PPE
Calcium hydroxide	Handling concentrated bases requires double nitrile gloves, chemical goggles, and a Tyvek laboratory coat or rubber apron. Work should be performed in the fume hood.
Potassium hydroxide	
Sodium hydroxide	
Ammonium hydroxide	Eye protection, gloves, and laboratory coat. Work should be performed in the fume hood.

Chemical	PPE
Calcium oxide (quicklime)	Calcium oxide solids will react explosively with water or acid, and a splash guard may be needed in addition to chemical goggles.
Portland cement	Warms when cured; work in the fume hood if volatile contaminants are present in the material.

Note:
Buffer solutions at pH 10 or pH 12.45 are also bases and need to be handled appropriately.

Table 1c
Oxidizers in the Laboratory

Chemical	PPE
Hydrogen peroxide	Concentrated hydrogen peroxide requires a Tyvek laboratory coat, double nitrile gloves, chemical goggles, and a plastic work surface (contact with cotton or paper may cause fire). Work in the fume hood with a splash shield.
Potassium bromate	Strong oxidants may cause combustion in contact with cotton or paper. Work in the fume hood and wear a Tyvek laboratory coat or Tyvek sleeves, in addition to gloves and chemical goggles.
Potassium permanganate	
Sodium sulfide nonahydrate	

Note:
Nitric acid is an oxidizer as well as a strong acid.

Note that various types and strengths of acid can cause quicker degradation of gloves. Always review chemical concentrations relative to the glove’s chemical resistance. Always check gloves for damage before use. Double gloves should be worn when working with strong acids and bases. When chemical contact occurs, gloves should be immediately replaced.

6.2 Handling and Pouring Solvents/Hydrocarbons/Volatile Organic Compounds

Solvents/hydrocarbons/volatile organic compounds (VOCs) can irritate the skin. When these compounds encounter the skin, they readily defat dermal lipids causing drying and irritation, which can lead to contact dermatitis. Used in a confined space, they can cause asphyxiation. Laboratory activities that involve the handling and pouring of solvents/hydrocarbons/VOCs require use of the PPE noted in Table 2.

Table 2
Solvents/Hydrocarbons/Volatile Organic Compounds in the Laboratory

Chemical	PPE
Hexane	Double nitrile gloves, Tyvek laboratory coat or rubber apron, and chemical goggles. Open solutions in the fume hood only.
Ethanol	

Chemical	PPE
Methanol	Nitrile gloves, safety glasses, and laboratory coat. Open solutions in the fume hood where possible; ensure good airflow and minimize exposure.
Acetone	Nitrile gloves have poor chemical resistance to acetone, and latex gloves may be required.
Propanol	
Ethyl, methyl, isopropyl alcohol mixture	Eye protection, gloves, and laboratory coat. When using cleaning alcohol, work in the fume hood if possible; ensure good airflow and minimize exposure.

6.3 Extremely Hazardous Materials

Chemicals that are suspected or known human carcinogens, teratogens, mutagens, or materials that are highly toxic (as defined in Appendix A of OSHA 29 CFR 1910.1200) will only be approved for use after all possible substitutions have been investigated. A chemical-specific risk assessment will be performed prior to the use of any extremely hazardous substance. Work with these materials will be done in a fume hood. The chemicals will be handled using appropriate gloves, eye protection, and a chemical apron, at a minimum.

If employees in the work area will be potentially exposed to concentrations above action levels, signs will be posted outside work areas on storage cabinets and fume hoods describing the use of and precautions regarding these materials. Access to the EGL will be restricted to employees who have been trained on the chemical’s hazards and emergency measures.

The CHO will maintain a current list of employees who are trained to work with these substances. If any changes in procedures or processes have the potential to increase employee exposure of an extremely hazardous material, the CHO will notify the CHSD and LD to determine mitigation measures prior to the potential exposure increase.

6.4 Handling Toxic Chemicals

When a toxic chemical will be handled in the EGL, a specific health and safety meeting must occur with all EGL staff. The Laboratory Manager will consult the project health and safety plan (HASP) to determine what PPE should be used and what handling procedures should be followed. If information is not available, the CHO will be contacted. If necessary, the Laboratory Manager and LD will be consulted for recommendations and direction. Toxic materials with a permissible exposure limit (PEL)[1] less than 50 parts per million (ppm) will be used or handled in a fume hood.

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[1] The PEL is the regulatory limit on the amount of concentration in air based on an 8-hour time-weighted average (TWA) or short-term exposure limit (STEL). The TWA is the concentration of exposure to a contaminant over a workday (usually 8 hours long). The STEL is a concentration that is calculated over a 15-minute duration.

The following known toxics are sometimes handled in the EGL:

- **Arsenic**. Arsenic poisoning can cause abdominal pain, neurological effects, heart disease, and cancer. Arsenic is often present in soil, sediment, and groundwater samples in the EGL. Arsenic is hazardous if ingested, particularly with repeated exposure. Ensure that arsenic containing materials are not transferred away from the work area on clothes or gloves. Arsenic may be encountered in contaminated soils and sediments and is a component of some reagents.
- **Hydroxylamine hydrochloride**. Hydroxylamine hydrochloride ingestion or inhalation can cause respiratory distress and cardiac arrest, and may be fatal. Hydroxylamine hydrochloride is toxic in very small amounts; use extreme caution to avoid residue on laboratory implements and surfaces. Hydroxylamine hydrochloride is typically used as a reagent in sequential extraction procedures.
- **Mercury**. Mercury is a serious chronic health hazard. It is not readily absorbed through the skin; its greatest health hazard is due to inhalation of its vapors. Mercury compounds (e.g., alkyl mercury) are extremely toxic and must be handled with extreme care. Mercury can be present in project work including former chloralkali processes, mining sites, and fluorescent bulb manufacturing plants. Mercury is also present in the EGL in poisonous reagents including mercuric chloride, methyl mercury chloride, and mercury nitrate solution.,
- **Potassium bromate**. Potassium bromate, a chemical tracer, is dangerous if ingested. Bromate poisoning is characterized by severe gastrointestinal symptoms, followed by renal failure. If working with bromate salts, ensure that no material is carried away on gloves or clothing.
- **Sodium azide**. Sodium azide is extremely toxic if ingested. When mixed with water, it releases a toxic vapor. Sodium azide disrupts respiration at the cellular level. Ingestion or inhalation of vapors will lead to dizziness, headache, and weakness as the heart and brain are deprived of oxygen. Sodium azide is toxic in very small amounts; use extreme caution to avoid residue on laboratory implements and surfaces. Sodium azide is used to disrupt microbial metabolism in laboratory samples.

Very small quantities of highly toxic materials are also present in the EGL in test kits and as standards. This includes mercury nitrate solution and polycyclic aromatic hydrocarbon standards.

6.5 Other Human Health Dangers

In addition to those chemicals listed previously that have acute toxicity (as noted by a skull-and-crossbones pictogram on the container label), a number of laboratory reagents are human carcinogens or teratogenic (as noted by a health hazard pictogram).

Potential human carcinogens in the EGL include ethylenediaminetetraacetic acid tetrasodium salt (EDTA) and potassium bromate. Very small quantities of potential human carcinogens present in the EGL in test kits and as standards include dichloromethane, dioxin/furan standards, and bromcresol green–methyl red indicator. Extra care should be taken to avoid exposure and particularly to prevent repeated exposure to potential human carcinogens.

Potential human teratogens in the EGL include hexane and mercuric chloride. Very small quantities of potential teratogens present in the EGL in test kits or as standards include polycyclic aromatic hydrocarbon standards, bromate, and lead acetate. Special care should be taken to avoid exposure to potential human teratogens by all employees of reproductive age. Exposure should be avoided completely by any employee who may be pregnant.

Many chemicals are dermal, respiratory, or eye irritants. When working with any chemical, wear gloves, a laboratory coat, and eye protection unless additional PPE is indicated. Chemicals commonly used in the EGL that are irritants include calcium chloride, ferrous sulfate, manganese dioxide, potassium chloride, and sulfur. Chemicals that are corrosive (acids, bases, and oxidizers) with significant exposure are very likely to be dermal, respiratory, or eye irritants with lesser exposure.

6.6 Handling Biologically Hazardous Materials

Human pathogens may be present in soil, sediment, or groundwater samples in the EGL. Materials associated with landfill sites or sediment from urban waterways with potential human sewage impacts are of concern for potential pathogens. A potentially life-threatening bacterium, Vibrio vulnificus, occurs naturally in estuarine and sea waters and in filter-feeding shellfish. Potential parasitic hazards may be present in surface waters, sediment, and soil. These include (but are not limited to) roundworm, whipworm, and hookworm. Laboratory work that involves samples with potential pathogens and parasites may require increased medical monitoring, vaccination against a particular pathogen, and PPE such as disposable coveralls, particulate masks, or face shields.

Pathogens in samples also require additional precautions for personnel, including removal of all PPE, washing and sanitizing hands prior to leaving the EGL , and extreme care to prevent transfer of material on clothing or personal items. Work with such samples also requires transfer of all waste and sample materials to sealed and labeled containers and disinfection of all laboratory surfaces.

Samples from Newtown Creek may contain materials that have come into contact with untreated sewage or contain pathogenic organisms. The most common pathogenic organisms found in untreated sewage include bacteria (such as *Clostridium*), viruses, and parasitic protozoa. Common protozoan diseases include cryptosporidiosis and giardiasis.

Ingestion and direct contact are the primary methods of disease transmission in humans. Infection generally results from bacterial penetration of the skin in scratched or abraded areas. Bacterial infection causes varying degrees of gastrointestinal disease and may be accompanied by fever, headache, and chills. Waterborne microbes also can cause eye and ear infections, as well as more serious diseases such as Hepatitis A, which is a viral inflammation of the liver that causes flu-like symptoms, jaundice, and gastrointestinal discomfort.

It is likely that the samples coming from Newtown Creek will have been contaminated by sewage during field efforts. As such, the following precautions will be followed when handling field samples with creek water and sediments:

- If a worker has skin lesions or abraded skin areas that are particularly susceptible to infection (i.e., deep cuts, burns, or existing dermatitis such as poison ivy), the employee will be reassigned to another task that does not pose a potential exposure to bacterial hazards.
- Anti-bacterial wipes (e.g., Germ-X®, Wet-Ones®) will be kept in the lab. Workers that may have contacted creek water or sediment must wash their face, hands, and any other relevant part of their body as soon as possible.
- If a worker suffers a minor laceration (i.e., needing only first aid), the affected area will be immediately disinfected and a bandage will be applied.

All laboratory workers that may contact untreated sewage will be required to participate in a Hepatitis A, Hepatitis B, and tetanus booster vaccination program.

6.7 Other Hazards

Sodium azide is highly unstable and can cause undergo violent decomposition in response to a physical shock. Handle sodium azide with extreme care, and always work behind a shield. Sodium azide forms explosive compounds in contact with lead, copper, brass, or other metals. These highly reactive metal azides can accumulate in pipes over time; therefore, no trace of sodium azide may enter the plumbing system at any dilution. Transfer sodium azide in a manner that does not generate excess material for disposal.

Hexane, methane, ethanol, and the tri-alcohol cleaning mixture are highly flammable and need to be stored in the flammables cabinet at all times. Limit volumes of these solvents used at any given time and take precautions to avoid contact with heat sources.

6.8 Extremely Hazardous Materials

Chemicals that are suspected or known human carcinogens, teratogens, mutagens or materials that are highly toxic (as defined in Appendix A of OSHA 29 CFR 1910.1200) will only be approved for use after all possible substitutions have been investigated. A chemical-specific risk assessment will be performed prior to the use of any extremely hazardous substance. Work with these materials will be done in a fume hood. The chemicals will be handled using appropriate gloves, eye protection, and a chemical apron, at a minimum.

6.9 Decontamination Procedures

PPE and laboratory equipment that encounter particularly hazardous chemicals must be decontaminated prior to reuse or leaving the EGL. Decontamination procedures will vary depending on the equipment and chemicals in use and should be determined prior to exposure. A decontamination plan should be produced prior to working with chemicals that require decontamination procedures. At the very least, EGL staff should properly dispose of all disposable PPE, appropriately decontaminate and stow all reusable PPE, and wash their hands well before leaving the EGL.

6.10 Laboratory Ventilation

The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere using hoods and other ventilation devices. To determine the best choice for laboratory ventilation using engineering controls for personal protection, employers are referred to Table 9.3 of *Prudent Practices in the Laboratory* (NAS 2011). Laboratory chemical hoods are the most important components used to protect EGL personnel from exposure to hazardous chemicals:

- Toxic or corrosive chemicals that require vented storage should be stored in vented cabinets instead of in a chemical hood.
- Chemical waste should not be disposed of by evaporation in a chemical hood.
- Keep chemical hood areas clean and free of debris at all times.
- Solid objects and materials, such as paper, should be prevented from entering the exhaust ducts as they can reduce the air flow.
- Chemical hoods should be maintained, monitored and routinely tested for proper performance.

A laboratory ventilation system should include the following characteristics and practices:

- Heating and cooling should be adequate for the comfort of workers and operation of equipment. Before modification of any building HVAC, the impact on laboratory or hood ventilation should be considered, as well as how laboratory ventilation changes may affect the building HVAC.
- A negative pressure differential should exist between the amount of air exhausted from the laboratory and the amount supplied to the laboratory to prevent uncontrolled chemical vapors from leaving the laboratory.
- Local exhaust ventilation devices should be appropriate to the materials and operations in the laboratory.
- The air in chemical laboratories should be continuously replaced so that concentrations of odoriferous or toxic substances do not increase during the workday.
- Laboratory air should not be recirculated but exhausted directly outdoors.

- Air pressure should be negative with respect to the rest of the building. Local capture equipment and systems should be designed only by an experienced engineer or industrial hygienist.
- Ventilation systems should be inspected and maintained on a regular basis. There should be no areas where air remains static or areas that have unusually high airflow velocities.

Before work begins, laboratory workers should be provided with proper training that includes how to use the ventilation equipment, how to ensure that it is functioning properly, the consequences of improper use, what to do in the event of a system failure or power outage, special considerations, and the importance of signage and postings.

6.11 Fume Hood

Laboratory activities involving the use of volatile chemicals with PELs or 8-hour time-weighted average (TWA) concentrations less than 50 ppm will be conducted in a fume hood (see Table 3 in Section 12). The fume hood will have a permanent velocity indicator (mechanical or electrical) installed to provide continuous monitoring of air flow. The hood face velocity at a sash height of 12 inches will be verified to greater than 70 feet per minute (0.4 meter per second) prior to each use. If the velocity meter indicates insufficient air movement, the employee must stop work and have the hood checked prior to reuse. Fume hood sashes will be maintained at marked locations to maintain minimum face velocities except when moving equipment or materials in and out of the hoods. If problems are encountered at any time, contact Anthony Dalton-Atha and the CHO immediately.

The fume hood will be tested annually by the HVAC contractor (Hunter-Davison). Annual testing will include, at a minimum, face velocity testing and smoke (flow visualization) testing. Documentation of annual testing will be maintained by the CHO.

7 Physical Hazards

7.1 Flammable Liquids

Most solvents are flammable. Never use any type of open flame or any source of ignition around flammable chemicals. The vapors from flammable liquids, coupled with oxygen and an ignition source, may cause a fire or explosion. Flammable liquids (such as acetone, ethanol, isopropyl alcohol, and methanol) should always be used in a well ventilated area (or under a hood) and away from any open flames. Flammables and combustibles must never be heated on a hot plate. Vapors are present when a bottle of flammable liquid is opened. Flammable liquids will be heated with a water bath or other indirect method. Open flames will not be used in the EGL.

Solvents that may be exposed in open containers will be used in a fume hood equipped with electrical devices rated for Class 1 Division 1 conditions.

Static electricity is a source of ignition; therefore, when pouring solvents, a grounding cable must be used.

7.2 Explosives

Sodium azide, occasionally added in trace quantities (less than 1% of sediment mass) to disrupt microbial metabolism, is potentially explosive if exposed to impact, spark, or metals. Sodium azide will only be handled in small quantities, and all transfers will be performed with plastic implements, behind protective shielding. The CHO will be informed prior to the use of sodium azide. Special training is required for the use of explosives.

7.3 Oxidizing Agents/Oxidizers and Reducing Agents

An oxidizing agent or oxidizer is a substance that causes oxidation, or the loss of electrons from an atom, compound, or molecule. A reducing agent is a substance that causes reduction, or the gain of electrons. Oxidation and reduction always occur together. Oxidation-reduction reactions tend to release heat, so oxidizers and reducing agents can cause other materials to combust more readily. Always store oxidizing and reducing agents away from each other and from flammable materials. Look up which substances are incompatible in the SDSs. Oxidizers (such as hydrogen peroxide) will not be used where they could come in contact with oxidizable, organic, or other flammable or combustible materials. Oxidizers will be used in the fume hood with plastic sheeting protecting work surfaces. Tyvek laboratory coats, Tyvek sleeves, chemical goggles, and double gloves will be worn by EGL personnel when using strong oxidizers.

7.4 Compressed Gases

Compressed gas cylinders come in all sizes. Large gas cylinders, which require the use of special pressure regulators and valves, must always be kept secure. The cap should always be on when not in use. Gas cylinders will be secured with straps or chains, and the tank valve will be closed when not in use. The valves and regulators should be routinely checked for leaks.

8 X-Ray Equipment Use

Rental and use of an X-ray fluorescence (XRF) gun requires compliance with the Oregon Health Authority Center for Health Protection rules and Oregon Administrative Rules (OARs) 333-120 and 333-108-0001:

1. A current X-ray use license must be in place with the Oregon Health Authority. The EGL's license expires on September 30, 2021.
2. Radiation safety and XRF gun operations should be reviewed prior to use—a written record of this training must be filed with the CHO prior to XRF gun use.
3. "X-Rays in Use" signs must be conspicuously posted in the area of XRF gun use.
4. The owner's performance of routine safety checks on the XRF gun should be confirmed.
5. Dosimetry may be required if using the XRF gun in "point-and-shoot" mode. If point-and-shoot will be used, contact the CHSD.
6. Radiation surveys are not required for periodic use of rented XRF guns.

9 Laboratory Hazard Communication Plan

9.1 Identifying Hazardous Chemicals

A list is attached to this CHP that identifies all hazardous chemicals with a potential for employee exposure in the EGL (Appendix B). Detailed information about the physical, health, and other hazards of each chemical is included in an SDS; the product identifier for each chemical on the list matches and can be easily cross-referenced with the product identifier on its label and on its SDS.

9.2 Identifying Containers of Hazardous Chemicals

All hazardous chemical containers used in the EGL will either have the original manufacturer's label that includes a product identifier; an appropriate signal word; hazard statement; pictogram; precautionary statement; and the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party, or they will have a secondary container label with the chemical name, specified pictogram, hazard statement, signal word, and precautionary statement for each hazard class and category.

Jessica Goin will ensure that all containers are appropriately labeled. No container will be released for use until this information is verified. Workplace labels must be legible and in English.

9.3 Keeping Safety Data Sheets (Previously Known as Material Safety Data Sheets)

SDSs are readily available to all employees during work. Employees can review SDSs for all hazardous chemicals used in the EGL. Printed copies of the SDSs may be found in two large binders (A–L and M–Z) on the bookshelf near the main laboratory door. PDF versions of the SDSs may be found on the Microsoft Teams EGL page in the folder titled "Safety Data Sheets." SDSs are also available via the searchable database at MSDSonline.com; the login information for that database can be found on the Health and Safety SharePoint page.[2]

The SDSs are updated and managed by Jessica Goin. If an SDS is not immediately available for a hazardous chemical, employees should call Jessica.

9.4 Training Employees About Chemical Hazards

Before starting a new project in the EGL or before potential exposure to new hazardous chemicals, employees must attend a hazard communication training that covers the following topics:

- An overview of the requirements in Oregon OSHA's hazard communication rules
- Hazardous chemicals present in the EGL

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[2] http://intranet/peopleandgroups/healthandsafety/Material%20Safety%20Data%20Sheets/Forms/AllItems.aspx.

- Any operations in the EGL where hazardous chemicals are used
- The location of the written hazard communication plan and where it may be reviewed
- How to understand and use the information on labels and in SDSs
- Physical and health hazards of the chemicals in the EGL
- Methods used to detect the presence or release of hazardous chemicals in the EGL
- Steps Anchor QEA has taken to prevent or reduce exposure to these chemicals
- How employees can protect themselves from exposure to these hazardous chemicals through use of engineering controls/work practices and PPE
- An explanation of any special labeling present in the EGL
- Emergency procedures to follow if an employee is exposed to these chemicals

The CHO is responsible to ensure that employees receive this training. After attending the training, employees will sign a form verifying that they understand the above topics and how the topics are related to our hazard communication plan.

9.5 Informing Employees Who Do Special Tasks

Before employees perform special (non-routine) tasks that may expose them to hazardous chemicals, the LD or the Laboratory Manager responsible for the project will inform the staff about the specific tasks and chemicals' hazards. The staff will also be informed about how to control exposure and what to do in an emergency. The CHO will evaluate the health and safety hazards of these tasks and provide appropriate controls including PPE. Any additional training will be provided at this point as well.

Examples of special tasks that may expose employees to hazardous chemicals include the following:

- Exposure during solid-phase microextraction (SPME) work due to the use of polycyclic aromatic hydrocarbon (PAH) standards, which are carcinogens and potential teratogens, or hexanes, which are potential teratogens
  - This work should be performed in the fume hood.
- Use of sodium azide to generate "killed controls" for SPME or other microbiological batch tests as sodium azide is poisonous with trace levels of exposure
  - This work should be performed in the fume hood with appropriate safety gear.

9.6 Informing Contractors and Other Employers About Our Hazardous Chemicals

If employees of other employers may be exposed to hazardous chemicals at our workplace (for example, employees of a construction contractor working on site), it is the responsibility of Jessica Goin to provide contractors and their employees with the following information:

- The identity of the chemicals

- How to review our SDSs
- An explanation of the container and pipe labeling system
- Safe work practices to prevent exposure

Jessica Goin will also obtain an SDS for any hazardous chemical brought into the EGL by a contractor.

10 Chemical Procurement, Distribution, And Storage

10.1 Acquiring New Chemicals or Equipment

The CHO will be informed of any new chemicals prior to ordering. This applies to all chemicals covered by the hazard communication plan, including vendor samples and experimental chemicals and amendments. Arrangements necessary for the delivery and storage of hazardous chemicals, such as preparation of chemical containment and signage, will be conducted prior to the delivery of the chemicals. Risk evaluation should be conducted prior to beginning work with any first-time use hazardous chemical.

10.2 Distributing Chemicals

Before pouring a chemical, check container labels to ensure that the chemical in the bottle is the same as that listed on the chemical container. Chemicals will not be poured into a secondary container that does not have an appropriate secondary container label.

When pouring chemicals, containers will be handled one at a time. Containers must be bonded or grounded as warranted.

Uncapped liquid or volatile chemical containers will always be kept in the fume hood during use. Containers will be capped before being removed from the fume hood or exhaust. This is particularly important for volatile chemicals.

There should be no storage of uncapped liquid or volatile chemical containers in the fume hood. Chemical bottles will be tightly capped and the exterior container surfaces wiped clean before being returned to the appropriate chemical storage location (see Section 10.3).

Chemical containers will not be used for any purpose other than storage of the original chemical, unless the container has been properly rinsed and appropriately labeled for the chemical contents.

All hazardous chemical containers used in the EGL will either have the original manufacturer’s label that includes a product identifier; an appropriate signal word; hazard statements; pictograms; precautionary statements; and the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party, or they will have a secondary container label with the chemical name, specified pictogram, hazard statement, signal word and precautionary statement for each hazard class and category.

10.3 Chemical Storage

Incompatible chemicals will not be stored in the same location. Chemical compatibility will be checked against the U.S. Environmental Protection Agency Chemical Compatibility Chart

(EPA 600/2-80-076) which is attached to this CHP (Appendix C), and the SDS. SDS and label information should be followed for storage requirements. All stored chemicals will be appropriately labeled.

11 Signs and Labeling

Laboratory areas containing unusual hazards (such as tripping hazards or low clearance areas), if present, will be posted with warning signs. Emergency contact numbers are to be posted next to telephones. Safety equipment such as fire extinguishers, eyewash stations, and exits are also posted. When X-ray equipment (XRF gun) is in use, appropriate signage will be displayed clearly visible to all staff. Signage will be posted when laboratory conditions or processes require additional PPE.

In addition to the manufacturer's container labeling, all chemicals that come into the EGL will be labeled with the date received, who received it, the date it was opened, and who opened it. Secondary labels will be placed on all chemical containers prepared in the EGL and will identify the chemical and its concentration, the date it was prepared, and who prepared it.

Sample labels will be posted on samples entering the EGL from any source external to the EGL. The sample label will identify the sample, date received, who received it, and who submitted the sample.

12 Employee Exposure Determination

Under Oregon law, employers will measure employee's exposure to any substance regulated by an OSHA standard that requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level or the PEL. Anchor QEA has reviewed the chemicals used in the EGL and determined one or both of the following situations apply: 1) chemicals that are routinely present in the EGL do not have action level or PEL standards; or 2) exposures above the action level or PEL are very unlikely with the use of provided engineering controls (i.e., fume hood). However, employees have the right and are encouraged to seek medical consultation or examination if they have been injured or believe they have been exposed to a hazardous substance on the job. This includes employees involved in a spill or release of a material or employees who routinely handle a material who develop signs or symptoms of exposure.

OSHA regulatory required 8-hour TWA PELs and other most conservative recommended exposure limits as published in the National Institute of Occupational Safety and Health (NIOSH) recommended exposure limits (RELs)[3] or the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs)[4] for chemicals that may be encountered in the EGL are listed in Table 3 (CDC 2016; ACGIH 2020).

Table 3
PELs and 8-Hour TWAs for Potential Laboratory Chemicals

Substance	OSHA 8-hour TWA PEL (ppm)	Most Conservative Published Occupational Exposure Limits
Acetic acid	10	10 ppm – 8-hour TWA (STEL) 15 ppm
Ethyl alcohol (ethanol)	1,000	1,000 ppm – 8-hour TWA (STEL) 1000 ppm
n-Hexane	500	50 ppm – 8-hour TWA
Hydrogen peroxide	1	1 ppm – 8-hour TWA
Hydrochloric acid	(C) 5	(CL) 2 ppm
Isopropyl alcohol	400	200 ppm – 8-hour TWA (STEL) 400 ppm
Methyl alcohol (methanol)	200	200 ppm – 8-hour TWA (STEL) 250 ppm
Nitric acid	2	2 ppm – 8-hour TWA (STEL) 4 ppm
Potassium hydroxide	--	(CL) 2 mg/m^3

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[3] RELs are occupational exposure limits recommended by NIOSH.

[4] TLVs are guidelines from ACGIH that recommend the level of exposure that the worker can experience without an unreasonable risk of disease or injury.

Substance	OSHA 8-hour TWA PEL (ppm)	Most Conservative Published Occupational Exposure Limits
Oxalic acid	1 mg/m^3	1 mg/m^3 – 8-hour TWA (STEL) 2 mg/m^3
Sodium hydroxide	2 mg/m^3	2 mg/m^3 – 8-hour TWA (CL) 2 mg/m^3
Sulfuric acid	1 mg/m^3	0.2 mg/m^3 – 8-hour TWA (thoracic fraction of the aerosol)
Calcium hydroxide (dust)	15 mg/m^3 (total dust) 5 mg/m^3 (respirable fraction)	5 mg/m^3 – 8-hour TWA
Calcium oxide (dust)	5 mg/m^3	2 mg/m^3 – 8-hour TWA
Coal dust	2.4 mg/m^3	0.4 mg/m^3 (respirable fraction of the dust)
Gypsum (calcium sulfate, dust)	15 mg/m^3 (total dust) 5 mg/m^3 (respirable dust)	10 mg/m^3 (inhalable fraction) – 8-hour TWA
Limestone (calcium carbonate, dust)	15 mg/m^3 (total dust) 5 mg/m^3 (respirable dust)	10 mg/m^3 (total dust) – 8-hour TWA
Magnesium oxide (particulates)	15 mg/m^3 (total particulate)	10 mg/m^3 (inhalable fraction) – 8-hour TWA
Portland cement (dust)	15 mg/m^3 (total dust) 5 mg/m^3 (respirable dust)	1 mg/m^3 (inhalable fraction) – 8-hour TWA
Acetone	1,000	250 ppm – 8-hour TWA (STEL) 500 ppm
Benzene	1	0.1 ppm – 8-hour TWA (STEL) 1 ppm
Ethyl acetate	400	400 ppm – 8-hour TWA
Toluene	200	20 ppm – 8-hour TWA (STEL) 150 ppm (CL) 300 ppm
Xylenes (o-, m-, p-isomers)	100	100 ppm- 8-hour TWA (STEL) 150 ppm

Notes:
--: no applicable 8-hour TWA
The CL is the concentration of a substance in air that that should not be exceeded at any time.

13 Medical Consultation and Medical Examinations

13.1 Medical Consultation and Medical Examinations (per OAR 437 Division 2 Subdivision Z)

Employees have the right and are encouraged to seek medical consultation or examination if they have been injured or believe they have been exposed to a hazardous substance on the job. Employees who have been injured or feel that they have been exposed to a hazardous substance on the job should notify the lab manager, their staff manager and contact WorkCare. The staff manager will follow the incident flow chart to include notifying Human Resources and the CHSD. All medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided without cost to the employee. Anchor QEA will provide the physician the following information:

- The identity of the hazardous chemical or chemicals to which the employee may have been exposed
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available
- A description of the signs and symptoms of exposure that the employee is experiencing, if any

13.2 Medical Surveillance Program

Participation in the Medical Surveillance Program is available for employees as follows:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed to in the EGL
- Employees routinely working in the EGL (20 or more days per year)
- For EGL staff handling arsenic, mercury, or samples from Newtown Creek who may need additional medical monitoring including vaccines, and pre-program and post-program physicals

14 Emergency Procedures

14.1 Spill Plan

Spill kits will be available in the EGL in a clearly marked location. All employees will be familiar with the location of the spill kits.

Acid spills will be neutralized to a pH between 3 and 11 with a base. Caustic spills will be neutralized to a pH between 3 and 11 with dilute acid. The spill location will be cleaned with absorbent cloths from the spill kit.

Solvent spills will be cleaned up with absorbent materials from the spill kit.

Liquid mercury will not be routinely handled in the EGL; however, mercury may be present in laboratory equipment or samples. Mercury spills should be cleaned up with mercury spill kit materials located in the spill kit cabinet.

14.2 Eyewash Stations

The eyewash station is attached to the utility sink. A backup eyewash with lesser flow that is not temperature controlled was retained on the sink in the main EGL space. However, the primary eyewash station should be used in the case of an eye emergency. Anthony Dalton-Atha is responsible for weekly eyewash checks.

14.3 Fire Safety

There are two fire extinguishers in the EGL: one by the main laboratory door and one next to the fume hood in the back room. All employees working in the EGL will be familiar with the location of the fire extinguishers and will review the operating instructions with the office Health and Safety representative, Rick Schwarz.

14.4 Safety Lights

In the event of a power outage, safety lights placed in outlets in the back rooms and the main EGL will come on automatically. These lights may be unplugged and used as flashlights as needed. If removed for any reason, these lights must be returned to the power interrupt mode and returned to the designated outlet after use.

14.5 Evacuation Routes

An evacuation route map is located near the entry to the EGL. All employees working in the EGL will review the evacuation plan with the office Health and Safety representative, Rick Schwarz.

14.6 Additional Safety Procedures

Emergency guidelines and procedures that are not specific to the laboratory work contained within this plan are accessible to employees in the Portland office's *Emergency Response Plan* available on the Health & Safety SharePoint page.[5]

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[5] http://intranet/peopleandgroups/healthandsafety/Emergency%20Evacuation/Forms/AllItems.aspx

15 Materials Disposition

15.1 Liquid Acid and Caustic Wastes

Liquids that do not contain hazardous substances will be neutralized prior to disposal.

15.2 Solid Cleanup Wastes

If cleanup of a chemical spill results in hazardous waste, then it will be disposed of in accordance with state and federal requirements.

If a cleanup involves sample material containing hazardous substances, then it will be returned to the site for appropriate disposal.

15.3 Non-Hazardous Solid Wastes

All solid cleanup materials, such as empty containers, disposable paper towels, wipes, and filters, are to be placed in plastic-lined waste containers located in the EGL work area.

15.4 Samples and Related Materials

Following project completion, any sample containing hazardous materials will be returned to the site of origin for disposal.

15.5 Laboratory Glassware and Sharps Disposal

Laboratory glassware not contaminated by hazardous materials (e.g., Pasteur pipettes) and broken glassware will be separated from other waste and enclosed in an appropriate container (such as a sturdy cardboard box) prior to disposal.

If applicable, syringe needles and razor blades must be disposed of in a designated sharps waste container. When full, the container is to be sealed with tape and placed in the building dumpster.

16 Employee Training Requirements

16.1 Laboratory Orientation

On the first day of assignment in the EGL, staff will be given an orientation that includes safety instructions, a review of the CHP, and a tour including the following:

- Location of the SDS binder
- Location and review of use of the fire extinguishers
- Review of the evacuation plan
- Location and review of appropriate spill response procedures
- Location and review of use of the eyewash stations
- Review of fume hood operation and requirements
- Review of Laboratory contact list and emergency contact information

16.2 Laboratory Annual Training

All EGL personnel are required to attend a yearly CHP training session. Training topics will include the following:

- Location, availability, and contents of the CHP
    - Laboratory rules and safe work practices
    - Health and physical hazards of chemicals used in the EGL
    - SDS and other reference materials available
    - PELs for chemicals used in the EGL
    - Signs and symptoms of exposure as listed on SDS or chemical container labels
    - Appropriate labeling of containers
    - PPE
    - Emergency procedures

16.3 New Chemicals, Processes, or Equipment

A training session will be held with affected employees each time a new chemical, process, or equipment is introduced into the EGL.

17 Annual Chemical Hygiene Plan Review

The CHSD, LD, CHO, and Laboratory Managers will conduct an annual review of the CHP to assess whether all elements of the plan are current, functional, and implemented consistent with OSHA 29 CFR 1910.1450 and OSHA 29 CFR 1910.1200. This ensures a continued safe working environment for EGL employees.

18 Records Retention

Records maintained in the EGL include the following:

- A copy of this CHP
- Binders containing SDSs for chemicals present in the EGL
- Equipment documentation
- X-ray use records as appropriate

Medical consultation and surveillance records are maintained by a third party, and information is available from Human Resources.

Approval: ______________________________ Date: ________________

Chemical Hygiene Officer

Approval: ______________________________ Date: ________________

CHSD

19 References

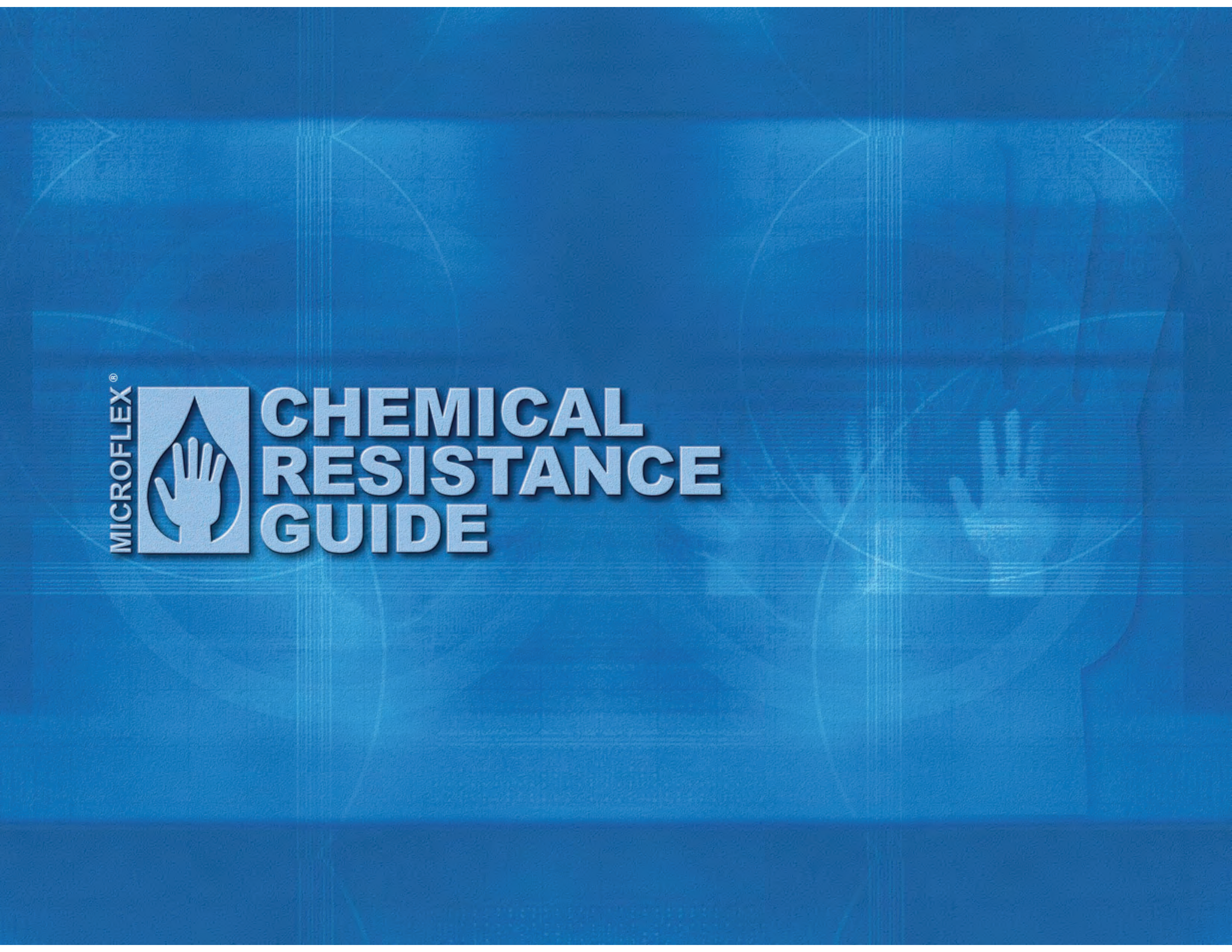
ACGIH (American Conference of Governmental Industrial Hygienists), 2020. TLV/BEI Guidelines. Last modified in 2020. Available at: https://www.acgih.org/tlv-bei-guidelines/policies-procedures-presentations/overview.

CDC (Centers for Disease Control and Prevention), 2016. The National Institute for Occupational Safety and Health (NIOSH): NIOSH Pocket Guide to Chemical Hazards: Introduction. Last modified March 7, 2016. Available at: https://www.cdc.gov/niosh/npg/pgintrod.html#exposure.

National Academy of Sciences (NAS), 2011. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Updated version. Washington, D.C.: National Academies Press.

Appendix A

Glove Chemical Resistance Guide



MICROFLEX®

CHEMICAL RESISTANCE GUIDE

MICROFLEX®

CHEMICAL RESISTANCE GUIDE

For NeoPro® and NeoPro®EC Gloves.

Test Method Description: The test method uses analytical equipment to determine the concentration of and the time at which the challenge chemical permeates through the glove film. The liquid challenge chemical is collected in a liquid miscible chemical (collection media). Data is collected in three separate cells; each cell is compared to a blank cell which uses the same collection media as both the challenge and collection chemical.

Cautionary Information: These glove recommendations are offered as a guide and for reference purposes only. The barrier properties of each glove type may be affected by differences in material thickness, chemical concentration, temperature, and length of exposure to chemicals. Thin-film gloves are designed for transient and single-use only. Gloves should be removed and replaced with a new pair upon exposure to chemicals. Please follow your institution's policies for use.

The data presented in this guide is deemed accurate to the best of Microflex's knowledge.

Test Method: ASTM F739 continuous contact

Chemicals	NeoPro® NeoPro®EC ◆
Acetaldehyde	0
Acetic acid (50%)	NBT
Aluminum nitrate (10%)	NBT
Ammonium hydroxide (30%)	10
Benzene	0
Butyl acetate	5
Chloroform	0
Chlonidine hydrochloride (0.10%)	NBT
Copper(II) ethylenediamine (1 molar)	NBT
Diesel fuel (1%)	10
Dimethylformamide	1
Dimethyl sulfoxide	30
Ethanol	NBT
Ethanolamine (99%)	NBT
Ether	2
Ethidium bromide (1%)	NBT
Ethyl acetate	1
Formaldehyde (37%)	NBT
Formamide	NBT
Gluteraldehyde (50%)	NBT
Guanidine hydrochloride	NBT
Hydrochloric acid (50%)	0
Isopropanol	NBT
Methanol	NBT
Methyl ethyl ketone	0
Methyl methacrylate (33%)	0
Nitric acid (50%)	NBT
Periodic acid (50%)	NBT
Phenol (0.10%)	NBT
Phenylmethylsulfonyl fluoride (5%)	0
Silver nitrate (10%)	NBT
Sodium dodecyl sulfate (0.10%)	NBT
Sodium hydroxide (50%)	10
Sodium selenate (10%)	NBT
Sulfuric acid (50%)	NBT
Tetrahydrofuran	0
Toluene	0
Trifluoroacetic acid	0
Xylene	0

◆ **CAUTION (SYNTHETIC):** Components used in making these gloves may cause allergic reactions in some users. Follow your institution's policies for use.

KEY: CHEMICAL PERMEATION RATES

Greater than 60 minutes = **Excellent**; 31-60 minutes = **Very Good**

21-30 minutes = **Good**; 11-20 minutes = **Fair**; 3-10 minutes = **Poor**

Less than 3 minutes = **Not Recommended**

Normalized Breakthrough Time: Identified in minutes

NBT = No Breakthrough Time up to 120 minutes

Example: Dimethyl sulfoxide 30

MICROFLEX®
THE MOST TRUSTED NAME IN GLOVES®
REGISTERED ISO 13485

CHEMICAL RESISTANCE GUIDE

FOR MICROFLEX® LATEX AND NITRILE GLOVES.

The following chemical resistance ratings are based on published research data. Microflex® gloves have not been individually tested against the chemicals contained in this chart.

Chemicals	Latex (NATURAL RUBBER)	Nitrile (BUNA N)
Acetaldehyde	🟨	🟥
Acetamide	🟥	🟦
Acetic acid (50% concentration)	🟩	🟩
Acetone	🟥	🟥
Acetonitrile	🟩	🟥
Acetophenone	🟥	🟥
Acetyl chloride	🟥	🟥
Acrylamide (same as 2-propenamide)	⬜	⬜
Acrylic acid	🟩	🟨
Aircraft stripper	🟥	🟩
Aluminum nitrate (nonhydrous) (10% concentration)	🟩	🟩
Ammonia (anhydrous)	🟥	🟩
Ammonium benzoate (same as benzoic acid)	🟥	🟥
Ammonium hydroxide (30% concentration)	🟩	🟦
Ammonium hydroxide (concentrated)	🟥	🟥
Ammonium oxalate	⬜	🟦
Ammonium sulfate (aqueous)	🟦	🟦
Amyl acetate	🟥	🟥
Aniline	🟥	🟥
Antifreeze (methanol-based)	🟦	🟦
Benzaldehyde	🟥	🟥
Benzene	🟥	🟥
Benzoic acid	🟥	🟥
Boric acid	🟦	🟦
Brake cleaner (containing hexane or ethanol)	🟥	🟦
Brake cleaner, non-chlorinated (containing acetone, n-heptane and/or xylene)	🟥	🟥
Brake fluid	🟩	🟩
Bromine (anhydrous liquid)	🟥	🟥
Bromoethane (methyl bromide)	🟥	🟥
Butyl acetate	🟥	🟥
n-Butyl alcohol (propyl carbinol)	🟩	🟦
n-Butyl chloride	🟥	🟥
1, 3-Butylene glycol (1,3-butanediol)	⬜	🟩
Calcium chloride (aqueous)	🟦	🟦
Calcium hydroxide (dental)	🟦	🟦
Carbamide peroxide (urea+hydrogen peroxide at 1:1 ratio)	🟩	🟨
Carbon dioxide	🟩	🟦

Chemicals	Latex (NATURAL RUBBER)	Nitrile (BUNA N)
Hydrogen peroxide (30% concentration)	🟩	🟥
Hydrogen peroxide (concentrated)	🟥	🟥
Hydroquinone	🟩	🟨
Hydroxylamine hydrochloride	⬜	⬜
Imidazole	⬜	⬜
Isobutanol (isobutyl alcohol)	🟦	🟩
Isooctane	🟥	🟦
Isopropanol (isopropyl alcohol)	🟦	🟦
Kerosene	🟥	🟦
Ketones	🟩	🟥
Lacquers	🟥	🟥
Lacquer thinners	🟥	🟥
Lactic acid (85% concentration)	🟦	🟦
Laurel alcohol (lauryl alcohol)	🟦	🟦
Lauric acid (36% concentration)	🟥	🟥
Lead acetate	🟦	🟩
Linoleic acid	🟥	🟩
Linseed oil	🟥	🟩
Lubricants (containing mineral spirits as primary component)	🟥	🟦
Maleic acid	🟨	🟨
2-Mercaptoethanol	⬜	⬜
Mercuric chloride	🟦	🟦
Mercury	🟦	🟦
Methane	🟥	🟦
Methyl alcohol (methanol)	🟨	🟩
2-Methoxyethanol (ethylene glycol monomethyl)	🟥	🟨
Methyl amine	🟨	🟩
Methyl bromide	🟨	🟨
Methyl butyl ketone	🟥	🟥
Methylene chloride	🟥	🟥
Methyl chloride	🟥	🟥
Methyl ethyl ketone (MEK)	🟥	🟥
Methyl isobutyl ketone (MIBK)	🟥	🟥
Methyl methacrylate	🟥	🟥
Mineral spirits	🟥	🟦
Monoethanolamine	🟩	🟩
Morpholine	🟥	🟥

Carbon disulfide	🟥	🟥
Carbon tetrachloride	🟥	🟩
Carburetor cleaner (typically xylene, toluene and/or acetone	🟥	🟥
Castor Oil	🟦	🟦
Chlorine (wet)	🟥	🟥
Chlorobenezene	🟥	🟥
Chloroform	🟥	🟥
o-Chloronaphthalene	🟥	🟥
Chromic acid (50% concentration)	🟥	🟨
Citric acid (10% concentration)	🟦	🟦
Clonidine hydrochloride (0.1% concentration)	▨	▨
Cresols	🟥	🟥
Cupric sulfate (copper sulfate)	🟩	🟦
Cyanic compounds	▨	🟨
Cyclohexane	🟥	🟦
Cyclohexanol	🟨	🟩
Cyclohexanone	🟥	🟥
Decahydronaphthalene (decalin)	🟥	🟥
Denatured alcohol	🟦	🟦
Dental etching material	🟩	🟩
Dental resin cement	🟨	▨
Dental waxes	🟥	🟦
Denture polishing material	🟥	🟩
Detergent solutions	🟩	🟦
Developing fluids	🟦	🟦
Diamond polishing paste	🟩	🟩
Dibutyl phthalate	🟥	🟥
o-dichlorobenzene	🟥	🟥
p-dichlorobenzene	🟥	🟥
Dichloromethane	🟥	🟥
Diesel fuel	🟥	🟩
Diesel fuel additive	🟥	🟩
Diethylamine	🟨	🟨
Diethylene glycol	🟦	🟦
Diisobutyl ketone (DIBK)	🟥	🟥
N, N-dimethyl acetamide (same as dimethyl acetamide (DMAC), same as acetic acid)	🟩	🟩
Dimethylformamide	🟥	🟩
Dimethyl sulfoxide (DMSO)	🟥	🟥
Dioctyl phthalate (DOP)	🟥	🟥
Dioxane	🟥	🟥
EDTA (17% solution)	🟩	🟩
Engine cleaner and degreaser (containing kersosene, petroleum distillates or propane-isobutane-n-butane as main components)	🟥	🟩
Epoxy primer (containing toluene, acetone, MEK and/or n-butyl acetate)	🟥	🟥
Ethanol (ethyl alcohol) (95% concentration)	🟦	🟦
Ethanolamine	🟩	🟩
Ether	🟥	🟥
Ethidium bromide (0.5% concentration)	▨	▨
2-ethoxyethanol (ethoxyethanol)	🟩	🟦
Ethyl acetate	🟥	🟥
Ethyl ether	🟥	🟥
Ethylene dichloride	🟥	🟥
Ethylene glycol	🟦	🟦
Motor oil (includes oils made from petroleum distillates, synthetic oils, diesel oils, 2-stroke oils, and hydraulic oils)	🟥	🟦
Naphtha	🟥	🟦
Naphthalene	🟥	🟥
Nitric acid (50% concentration)	🟥	🟥
Nitromethane (95.5% concentration)	🟨	🟥
Nitropropane (95.5% concentration)	🟥	🟥
Nitrophenols	▨	▨
Octyl alcohol (octanol)	🟩	🟩
Oleic acid	🟨	🟩
Oxalic acid	🟩	🟩
Paint (latex-based)	🟥	🟨
Paint (oil-based)	🟥	🟩
Paint, automotive (paint containing V.M.&P. naphtha, mineral spirits; with small amounts of toluene, xylene or n-butyl acetate)	🟥	🟩
Paint, automotive (paints containing large amounts of toluene, xylene or n-butyl acetate)	🟥	🟥
Paint activator, automotive (containing MEK, polyisocyanate resin, and/or butyl acetate)	🟥	🟨
Paint reducers/thinners, automotive (aliphatic hydrocarbons, eg. V.M.&P. naphtha or mineral spirits)	🟥	🟦
Paint reducers/thinners, automotive (aromatic hydrocarbons, eg. toluene or xylene)	🟥	🟥
Paint thinner (Duco)	🟥	🟥
Palmitic acid	🟩	🟩
Paraformaldehyde	🟥	🟩
Parts wash, automotive (containing naphtha, n-hexane, cyclohexane and/or MEK)+A64	🟥	🟩
Pentane	🟥	🟦
Pentyl ether (same as pentane)	🟥	🟦
Perchloric acid (60% concentration)	🟨	🟥
Perchloroethylene	🟥	🟩
Periodic acid (50% concentration)	▨	▨
Petroleum distillates (naphthas)	🟥	🟩
Phenol (0.1% concentration)	🟦	🟦
Phenol (approx. 100% concentration)	🟥	🟥
Phenolphthalein (aromatic phenols)	🟥	🟥
Phosphoric acid (0 to 50% concentration)	🟩	🟩
Phosphoric acid (50-85% concentration)	🟩	🟥
Phosphoric acid (100% concentration)	🟥	🟥
Polysorbates	▨	▨
Potassium bromate	🟦	🟦
Potassium chloride	🟦	🟦
Potassium cyanide	🟦	🟦
Potassium dichromate (aqueous)	🟩	🟦
Potassium hydroxide	🟩	🟩
Potassium iodide	🟩	🟦
Potassium permanganate	🟦	🟦
Potassium sulfate (potassium sulphate)	🟩	🟦
Propyl acetate	🟥	🟥
Propyl alcohol	🟩	🟦
Propylene (1-propene, methylethylene)	🟥	🟥
Propylene glycol	🟦	🟦
Pyridine	🟥	🟥
Rust inhibitors, automotive	🟦	🟦
Rust remover, automotive (containing <50% phosphoric aid)	🟩	🟩
Silver nitrate (0.17N)	🟦	🟩
Sodium acetate (aqueous)	🟦	🟩
Sodium azide (sodium salt)	🟦	🟦

Ethylene oxide	🟥	🟥
Ferric chloride (aqueous)	🟦	🟦
Formaldehyde	🟩	🟩
Formalin (40% concentration of formaldehyde)	🟩	🟩
Formamide	⬜	🟦
Formic acid (90% concentration)	🟩	🟩
Freon 11	🟥	🟩
Freon 12	🟥	🟩
Freon 21	🟥	🟥
Freon 22	🟥	🟥
Fuel injector cleaner (primarily kerosene)	🟥	🟩
Furfural	🟥	🟥
Gasoline, leaded	🟥	🟦
Gasoline, unleaded	🟥	🟦
Glass ionomer dental cements	🟩	🟩
Glucose	🟦	🟦
Gluteraldehyde (50% concentration)	⬜	⬜
Glycerin	🟦	🟦
Glycerol	🟦	🟦
Grease, automotive (petroleum-based)	🟥	🟦
Grease, automotive (silicon-based)	🟩	🟩
Grease, automotive (synthetic)	🟥	🟩
Heptane (n-heptane)	🟥	🟦
Hexane	🟥	🟩
Hydraulic fluid (petroleum-based)	🟥	🟩
Hydrochloric acid (20% concentration)	🟦	🟩
Hydrochloric acid (50% concentration)	🟦	🟨
Hydrochloric acid (concentrated)	🟩	🟥
Hydroflouric acid (48% concentration)	🟨	🟩
Hydroflouric acid (concentrated)	🟥	🟥
Hydrogen peroxide (3% concentration)	🟩	🟩

Sodium bicarbonate (aqueous) (baking soda)	🟦	🟦
Sodium chloride (aqueous)	🟦	🟦
Sodium cyanide (aqueous)	🟦	🟦
Sodium hydroxide (50% concentration)	🟦	🟦
Sodium hypochlorite (bleach)	🟨	🟨
Sodium selenate (10% concentration)	⬜	⬜
Sodium thiosulfate (developing fluids)	🟩	🟩
Staining rating (all stains)	🟦	🟨
Styrene	🟥	🟥
Sulfuric acid (50% concentration)	🟦	🟦
Sulfuric acid (93-98% concentration)	🟥	🟥
Tannic acid (65% concentration)	🟦	🟦
Tetrachloroethylene	🟥	🟨
Tetrahydrofuran	🟥	🟥
Tetramethylurea	⬜	⬜
Toluene	🟥	🟥
Toluene diisocyanate	🟨	🟥
Transmission fluid, Type A	🟥	🟦
Transmission fluid, synthetic	🟥	🟩
Trichloroethylene	🟥	🟥
Triethanolamine	🟩	🟩
Triton X-100, Igepal CA, Polytergent G (octoxynol with varying ethylene oxide units)	🟦	🟦
Tung oil	🟥	🟦
Turpentine	🟥	🟦
Undercoater, rubberized (automotive)	🟥	🟩
Urea	🟦	🟩
Varnish	🟥	🟩
Vinyl chloride	🟥	🟥
Water	🟦	🟦
Wax remover, automotive (containing V.M.&P. naphtha, xylene and/or ethylbenzene)	🟥	🟥
Xylene (Xylol)	🟥	🟥

– CHEMICAL RATINGS KEY –

🟦	EXCELLENT
🟩	GOOD
🟨	FAIR
🟥	NOT RECOMMENDED
⬜	NO DATA

General Information and Cautions

Your understanding of how to use thin-film gloves is extremely important to your safety.

Microflex gloves are intended for use as protection against incidental exposure to chemicals and other harmful substances. These gloves do not offer protection against all chemicals under all conditions, and are not designed to provide protection against prolonged or continuous exposure to harmful substances.

As a precaution, glove users are advised to change gloves immediately upon exposure to harmful substances. It is the responsibility of the user to choose the appropriate glove type, thickness and to change gloves as they become contaminated.

This Chemical Resistance Chart is offered as a guide and for reference purposes only. The chemical resistance ratings are based on published research data. Microflex cannot certify the accuracy of the data and therefore does not represent nor warrant that the information in the chemical resistance chart is accurate or complete. Microflex gloves have **NOT** been individually tested against the chemicals contained in this chart. The barrier properties of each glove type may be affected by differences in material thickness, chemical concentration, temperature, and length of exposure to chemicals.

References

Chemical Resistance Guide to Elastomers III; A Guide to Chemical Resistance of Rubber and Elastomeric Compounds, Compass Publications, La Jolla, CA, 2005. Plastics Design Library-Chemical Resistance of Plastics and Elastomers, 3rd edition, William Andrew Publishing, 2003. Dupont Dow Elastomers Chemical Resistance Guide; The Los Angeles Rubber Group; www.dupont-dow.com

PLEASE SEE INSIDE PANEL FOR CHEMICAL RESISTANCE GUIDE FOR MICROFLEX® LATEX AND NITRILE GLOVES.

POWDER-FREE LATEX[1]

LIGHTLY POWDERED LATEX[1]

POWDER-FREE LATEX[1]
FOR HIGH RISK ENVIRONMENTS

POWDER-FREE NITRILE[2]

POWDER-FREE NITRILE[2]
FOR HIGH RISK ENVIRONMENTS

POWDER-FREE NITRILE[3]
FOR NON-MEDICAL USE

LIGHTLY POWDERED NITRILE[2]

[1] CAUTION (**LATEX**): This product contains natural rubber latex (latex) which may cause allergic reactions. Safe use of this glove by or on latex sensitized individuals has not been established.

[2] CAUTION (**NITRILE: MEDICAL GRADE**): Components used in making these gloves may cause allergic reactions in some users. Follow your institution's policies for use.

[3] CAUTION (**NITRILE: INDUSTRIAL GRADE**): These gloves are for non-medical use only. They may **NOT** be worn for barrier protection in medical or healthcare applications. Please select other gloves for these applications. Components used in making these gloves may cause allergic reactions in some users. Follow your institution's policies for use.

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Appendix B

Chemical Inventory List

Appendix B
Chemical Inventory List

Anchor QEA Laboratory Chemicals	Signal Word	Hazard notes	State	Amount
Acetic acid	DANGER	Corrosive: Acid	Liquid	<1L
Aluminum Sulfate	DANGER	Corrosive: Acid	Solid	>0.5 kg
Ammonium hydroxide	DANGER	Corrosive: Base	Liquid	<1L
Calcium hydroxide	DANGER	Corrosive: Base	Solid	<0.5 kg
Calcium oxide	DANGER	Corrosive: Base	Solid	<0.5 kg
Calcium sulfate (gypsum)	DANGER	Flammable	Solid	<0.5 kg
Dehydrant Solution 95% [ethyl, methyl, isopropyl alcohols]	DANGER	Health Risk: Carcinogen/reproductive toxicity Flammable	Liquid	>1 L
Ethanol, pure [anhydrous]	DANGER	Health Risk: eye danger, aspiration Flammable	Liquid	>1 L
Ethylenediaminetetraacetic acid tetrasodium salt	DANGER	Health Risk: eye danger, carcinogen	Solid	<0.5 kg
Ferric Chloride	DANGER	Corrosive: Acid Health Risk: eye danger	Solid	<0.5 kg
Hexanes	DANGER	Health Risk: reproductive toxicity, aspiration Flammable	Liquid	<1L
Hydrochloric Acid 37% Solution	DANGER	Corrosive: Acid	Liquid	<1L
Hydrogen Peroxide [30%]	DANGER	Corrosive: oxidizer	Liquid	<1L
Hydroxylamine hydrochloride	DANGER	Corrosive Poison: acute toxicity	Solid	<0.5 kg
Lime Sulfur			Solid	
Manganese(II) chloride tetrahydrate	DANGER	Health Risk: eye danger	Solid	<0.5 kg
Mercuric Chloride	DANGER	Corrosive Poison: acute oral/dermal/inhalation toxicity Health Risk: reproductive toxicity	Solid	<0.5 kg
Methanol, HPLC Grade	DANGER	Poison: acute oral/dermal/inhalation toxicity flammable	Liquid	>1 L
Methylmercuric chloride	DANGER	Poison: acute oral/dermal/inhalation toxicity	Solid	<0.5 kg
Nitric acid [67-70%]	DANGER	Corrosive: Acid, oxidizer Poison: inhalation toxicity	Liquid	<1L

Appendix B
Chemical Inventory List

Anchor QEA Laboratory Chemicals	Signal Word	Hazard notes	State	Amount
Oxalic acid dihydrate	DANGER	Corrosive: Acid	Solid	<0.5 kg
Portland cement	DANGER	Corrosive: Base	Solid	>0.5 kg
Potassium bromate	DANGER	Oxidizer (not corrosive) Poison: acute oral toxicity Health Risk: carcinogen	Solid	<0.5 kg
Potassium hydroxide	DANGER	Corrosive: Base	Solid	<0.5 kg
Potassium permanganate	DANGER	Oxidizer (not corrosive)	Solid	<0.5 kg
Sodium Azide (1 g)	DANGER	Poison: acute oral/dermal/inhalation toxicity	Solid	<0.5 kg
Sodium hydroxide	DANGER	Corrosive: Base	Solid	<0.5 kg
Sodium hydroxide, 32-33%	DANGER	Corrosive: Base	Liquid	<1L
Sodium sulfide nonahydrate	DANGER	Sodium sulfide nonahydrate Poison: acute oral toxicity	Solid	>0.5 kg
Sulfuric acid [93-98%]	DANGER	Corrosive: Acid	Liquid	<1L
TEMED (N,N,N',N'-tetramethylethylenediamine)	DANGER	Corrosive: Base Flammable	Solid	<0.5 kg
Zinc (PIG mercury absorbent powder)	DANGER	Flammable	Solid	<0.5 kg
Aluminum phosphate	WARNING	Skin and eye irritant	Solid	<0.5 kg
Ammonium Chloride, Lab Grade	WARNING	Respiratory irritant	Solid	<0.5 kg
Ammonium Iron Sulfate	WARNING	Irritant (skin, eyes, respiratory)	Solid	<0.5 kg
Ammonium Oxalate	WARNING	Skin and respiratory irritant	Solid	<0.5 kg
Calcium chloride, Anhydrous	WARNING	Irritant (skin, eyes, respiratory)	Solid	<0.5 kg
Calcium Phosphate Monobasic	WARNING	Irritant (skin, eyes, respiratory)	Solid	<0.5 kg
Citric Acid, Anhydrous, U.S.P./N.F. (Granular)	WARNING	Eye irritant	Solid	<0.5 kg
Epoxy Resin 105	WARNING	Irritant	Liquid	<1L
Ferric Sulfate (hydrated)	WARNING	Irritant (skin, eyes, respiratory)	Solid	<0.5 kg
Ferrous Iron Reagent	WARNING	Irritant (skin, eyes, respiratory)	Solid	*<0.5 kg*
Ferrous Sulfate heptahydrate	WARNING	Irritant (?)	Solid	>0.5 kg
Magnesium chloride hexahydrate	WARNING	Skin and eye irritant	Solid	<0.5 kg

Appendix B
Chemical Inventory List

Anchor QEA Laboratory Chemicals	Signal Word	Hazard notes	State	Amount
Manganese dioxide	WARNING	Irritant (?)	Solid	>0.5 kg
Manganese(II) sulfate monohydrate	WARNING		Solid	<0.5 kg
Potassium bromide	WARNING	Skin irritant	Solid	<0.5 kg
Potassium chloride	WARNING	Skin irritant	Solid	<0.5 kg
Potassium ferricyanide	WARNING	Acute oral toxicity	Solid	<0.5 kg
potassium nitrate	WARNING	Skin irritant	Solid	<0.5 kg
Sodium Carbonate Anhydrous	WARNING	Irritant (skin, eyes, respiratory)	Solid	<0.5 kg
Sodium tungstate dihydrate	WARNING	Acute oral toxicity	Solid	<0.5 kg
Sulfur (elemental)	WARNING	Skin irritant	Solid	<0.5 kg
Non-Hazardous Chemicals				
Ammonium Acetate Rgt,		Not hazardous	Solid	<0.5 kg
Calcium Carbonate		Not hazardous	Solid	<0.5 kg
Calcium Phosphate Tribasic		Not hazardous	Solid	<0.5 kg
Ferric phosphate		Not hazardous	Solid	<0.5 kg
Ferrous Carbonate		Not hazardous	Solid	<0.5 kg
Granular activated carbon (GAC)		Not hazardous	Solid	<0.5 kg
Iron Filings, (40 Mesh)		Not hazardous	Solid	<0.5 kg
Iron Metal		Not hazardous	Solid	<0.5 kg
Magnesium Sulfate		Not hazardous	Solid	<0.5 kg
Silver wire		Not hazardous	Solid	<0.5 kg
Sodium acetate trihydrate		Not hazardous	Solid	<0.5 kg
Sodium acetate, anhydrous, Redi-Dri(TM), ACS reagent		Not hazardous	Solid	<0.5 kg
Sodium hexametaphosphate		Not hazardous	Solid	<0.5 kg
Sodium Phosphate Dibasic Heptahydrate		Not hazardous	Solid	<0.5 kg

Appendix B
Chemical Inventory List

Anchor QEA Laboratory Chemicals	Signal Word	Hazard notes	State	Amount
Sodium sulfate anhydrous		Not hazardous	Solid	<0.5 kg
Yeast extract powder		Not hazardous	Solid	<0.5 kg
Lithium Metatungstate		Not hazardous	Liquid	<1L
Calcium Sulfate		Not hazardous	Solid	>0.5 kg
QUIK-SOLID		Not hazardous	Solid	>0.5 kg
Sodium Chloride		Not hazardous	Solid	>0.5 kg
Sodium citrate dihydrate		Not hazardous	Solid	>0.5 kg
Sorbond (clay)		Not hazardous	Solid	>0.5 kg
water, ACS Reagent Grade, ASTM Type I, ASTM Type II		Not hazardous	Liquid	>1 L
Very Small Volume Buffers, Standards, Test Kits				
Borate (pH 10 Buffer Solution)	DANGER	Health Risk: reproductive toxicity	Solid	<<0.01 kg
Bromcresol Green-Methyl Red Indicator	DANGER	Health Risk: Carcinogen/reproductive toxicity	Solid	<<0.01 kg
Buffer Solution pH 12	DANGER	Corrosive: Base	Liquid	
Dichloromethane	DANGER		Liquid	<0.01 L
Dioxin/Furan standards	DANGER		Liquid	<0.01 L
Lead Acetate 10%	DANGER	Health Risk: reproductive toxicity	Solid	<<0.01 kg
Mercury(II) nitrate solution [0.07 M]	DANGER	Poison: acute oral/dermal/inhalation toxicity	Solid	<<0.01 kg
Methylmercury (II) chloride 1000 ppm	WARNING	Acute oral toxicity	Solid	<<0.01 kg
Phenolphthalein Indicator, 0.08% in Methanol	DANGER	Health Risk: carcinogen Flammable	Solid	<<0.01 kg
Polycyclic aromatic hydrocarbon standards	DANGER	Poison: acute dermal toxicity Health Risk: Carcinogen/reproductive toxicity flammable	Liquid	<0.01 L
Sodium dithionate/sodium metabisulfate (FerroVer Iron Reagent)	DANGER	Corrosive: Acid Health Risk: oral toxicity	Solid	<<0.01 kg
sulfamic acid (EZ Arsenic Reagent #1)	DANGER	Corrosive: Acid	Solid	<<0.01 kg

Appendix B
Chemical Inventory List

Anchor QEA Laboratory Chemicals	Signal Word	Hazard notes	State	Amount
sulfamic acid (Hach Arsenic Reagent # 4)	WARNING	Skin irritant	Solid	<<0.01 kg
zinc (EZ Arsenic Reagent #2)	DANGER	Flammable	Solid	<<0.01 kg
zinc (Hach Arsenic Reagent # 5)	DANGER	Flammable	Solid	<<0.01 kg
Buffer Powder Citrate Type		Not hazardous	Solid	<<0.01 kg
Buffer Solution (Biphthalate), pH 4		Not hazardous	Solid	<<0.01 kg
Buffer Solution (Phosphate), pH 7		Not hazardous	Solid	<<0.01 kg
Chelex 100 sodium form		Not hazardous	Solid	<<0.01 kg
Conductivity Calibration Solution, 12.88 mS/c		Not hazardous	Solid	<<0.01 kg
Conductivity Calibration Standard 100,000 Solution		Not hazardous	Solid	<<0.01 kg
Iron Standard Solution 1.00 mg/L		Not hazardous	Solid	<<0.01 kg
Phosphate Standard Solution 50.0 mg/l as PO_4		Not hazardous	Solid	<<0.01 kg
Sulfate Standard Solution 50.0 0.5 mg/l as SO_4		Not hazardous	Solid	<<0.01 kg
YSI 3682 Zobell Solution		Not hazardous	Solid	<<0.01 kg
YSI 5580 Confidence Solution		Not hazardous	Solid	<<0.01 kg

Appendix C

Chemical Compatibility Chart

(EPA-600/2-80-076)

EPA's Chemical Compatibility Chart

EPA-600/2-80-076 April 1980

A METHOD FOR DETERMINING THE COMPATIBILITY OF CHEMICAL MIXTURES

Please Note: This chart is intended as an indication of some of the hazards that can be expected on mixing chemical wastes. Because of the differing activities of the thousands of compounds that may be encountered, it is not possible to make any chart definitive and all inclusive. It cannot be assumed to ensure compatibility of wastes because wastes are not classified as hazardous on the chart, nor do any blanks necessarily mean that the mixture cannot result in a hazard occurring. Detailed instructions as to hazards involved in handling and disposing of any given waste should be obtained from the originator of the waste.

CODE	CONSEQUENCE
H	Heat Generation
F	Fire
G	Innocuous and non-flammable gas generation
GT	Toxic Gas formation
GF	Flammable Gas formation
E	Explosion
P	Violent Polymerization
S	Solubilization of toxic substance
U	May be hazardous, but Unknown

#	REACTIVITY GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107
1	Acids, Mineral, Non-oxidizing	1																																								
2	Acids, Mineral, Oxidizing		2																																							
3	Acids, Organic		G H	3																																						
4	Alcohols and Glycols	H	H F	H P	4																																					
5	Aldehydes	H P	H F	H P		5																																				
6	Amides	H	H GT				6																																			
7	Amines, Aliphatic and Aromatic	H	H GT	H		H		7																																		
8	Azo Compounds, Diazo Compounds and Hydrazines	H G	H GT	H G	H G	H			8																																	
9	Carbamates	H G	H GT						G H	9																																
10	Caustics	H	H	H		H				H G	10																															
11	Cyanides	GT GF	GT GF	GT GF					G			11																														
12	Dithiocarbamates	H,F GF	H,F GF	H,GT GF		GF GT		U	H G				12																													
13	Esters	H	H F						H G		H			13																												
14	Ethers	H	H F												14																											
15	Fluorides, Inorganic	GT	GT	GT												15																										
16	Hydrocarbons, Aromatic		H F														16																									
17	Halogenated Organics	H GT	H,F GT					H GT	H G		H GF	H						17																								
18	Isocyanates	H G	H,F GT	H G	H P			H P	H G		H,P G	H G	U						18																							
19	Ketones	H	H F						H G		H	H								19																						
20	Mercaptans and Other Organic Sulfides	GT GF	H,F GT						H G									H	H	H	20																					
21	Metals, Alkali and Alkaline Earth, Elemental	H,F GF	H,F GF	H,F GF	H,F GF	H,F GF	GF H	GF H	GF H	GF H	GF H	GF H	GF,H GT	GF H				H E	GF H	GF H	GF H	21																				
22	Metals, Other Elemental & Alloys as Powders, Vapors, or Sponges	H,F GF	H,F GF	G F					H,F GT	U	GF H							H E	GF H		H,F GF		22																			
23	Metals, Other Elemental & Alloys as Sheets, Rods, Drops, etc.	H,F GF	H,F GF						H,F G									H F						23																		
24	Metals and Metal Compounds, Toxic	S	S	S			S	S			S														24																	
25	Nitrides	GF HF	H,F E	H GF	H,E GF	GF H			U	H G	U	GF H	GF H	GF H				GF H	U	GF H	GF H	E				25																
26	Nitriles	H,GT GF	H,F GT	H							U											H P			S	GF H	26															
27	Nitro Compounds, Organic		H,F GT			H					H E											H,E GF				H,E GF		27														
28	Hydrocarbons, Aliphatic, Unsaturated	H	H F			H																	H E						28													
29	Hydrocarbons, Aliphatic, Saturated		H F																											29												
30	Peroxides and Hydroperoxides, Organic	H G	H E		H F	H G		H GT	H,F E	H,F GT		H,E GT	H,F GT					H E	H	E	H,F GT	H E	H G		H G	H,E GF	H,P GT		H P		30											
31	Phenols and Cresols	H	H F						H G										H P			GF H				GF H					H	31										
32	Organophosphates, Phosphothioates, Phosphodithioates	H GT	H GT						U		H E											H									U		32									
33	Sulfides, Inorganic	GT GF	HF GF	GT		H			E										H												H GT			33								
34	Epoxides	H P	H P	H P	H P	U		H P	H P		H P	H P	U								H P	H P	H P		H P	H P					H P	H P	U	H P	34							
101	Combustible and Flammable Materials, Miscellaneous	H G	H,F GT																			H,F G				H,F GF					H,F GT					101						
102	Explosives	H E	H E	H E					H E		H E			H E								H E	H E	H E	E	E					H E	H E		H E	H E	H E	102					
103	Polymerizable Compounds	P H	P H	P H					P H		P H	P H	U									P H	P H	P H	P H	P H					P H	P H		P H			H E	103				
104	Oxidizing Agents, Strong	H GT		H GT	H F	H F	H,F GT	H,F GT	H E	H,F GT		H,E GT	H,F GT	H F	H F		H F	H GT	H,F GT	H F	H,F GT	H,F E	H,F E	H F		H,F E	H,F GT	H E	H F	H F	H G	H F	H,F GT	H,F GT	H,F G	H,F G	H E	H,F GT	104			
105	Reducing Agents, Strong	H GF	H,F GT	H GF	H,F GF	H,F GF	H GF	H G				H GT	H F				H,F E	H E	H GF	H GF	H GF						H GF	H E			H E	H GF	H,GT GF		H	H GF	H E	H,P GF	H,F E	105		
106	Water and Mixtures Containing Water	H	H						G										H G			H GF	H GF		S	H GF								GT GF						GF GT	106	
107	Water Reactive Substances	<---EXTREMELY REACTIVE! DO NOT MIX WITH ANY CHEMICAL OR WASTE MATERIAL! EXTREMELY REACTIVE!--->																																								107

Appendix C

Standard Operating Procedures

MOISTURE CONTENT

Scope and Application

This Environmental Geochemistry Laboratory (EGL) standard operating procedure (SOP) is applicable to determining the moisture content by mass of soil, rock, and similar materials in accordance with ASTM International (ASTM) Method D2216. The procedures for determining moisture content outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP; additional equipment may be required:

- Appropriate protective equipment
- Drying oven
- Oven mitt and insulated gloves
- Analytical balance of appropriate precision
- Aluminum weigh-boats
- Ceramic drying dish
- Stainless steel bowl and spoon

Procedure

1. Label aluminum weigh-boats in triplicate for each sample
2. Determine and record the mass of the labeled weigh-boats
3. Homogenize the sample
4. Transfer approximately 20 grams of material to each weigh-boat
   note the presence of woody debris or larger grains and increase sample mass as appropriate
5. Measure and record the mass of the container and wet sample
6. Place the weigh-boats in a metal pan
7. Dry for a minimum of 18 hours at 110 ± 5°C
   Ensure that all dry samples have been removed before placing samples to the oven
8. Remove the samples from the oven
9. Immediately measure and record the mass of the container and dry sample

Calculations

Calculate the total solids and moisture content as shown in Equation 1.

Equation 1

$$\boldsymbol{TS = \frac{(M_{wet} - WB) - (M_{dry} - WB)}{(M_{wet} - WB)}}$$

$$MC = 100 * (1 - TS)$$

where:

TS = total solids

MC = moisture content (%)

M_{wet} = mass of the wet sample and the weigh-boat (g)

M_{dry} = mass of the dry sample and the weigh-boat (g)

WB = weigh-boat mass (g)

Quality Assurance/Quality Control

Moisture content should be determined in triplicate. Replicate reproducibility is determined as the relative standard deviation (Equation 2).

Equation 2

$$RSD = 100 * (\frac{StDev}{Avg})$$

where:

RSD = Relative standard deviation

Avg = Average

$StDev$ = Standard deviation

References

ASTM (ASTM International), 2010. *ASTM D2216. Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. West Conshohocken, PA: ASTM International.

Data Sheet

Sample	Replicate	Weigh-Boat Mass (g)	Mass of Wet Sample + Boat (g)	Mass of Dry Sample + Boat (g)

Note:
g: grams

GRAIN SIZE ANALYSIS OF SOILS AND SEDIMENT

Scope and Application

This standard operating procedure (SOP) is applicable to determination of grain size distribution of soils, sediment, or other solids in accordance with ASTM International (ASTM) Method D422 (ASTM 2007). Procedures outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the Environmental Geochemistry Laboratory (EGL) Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP; additional equipment may be required:

- Precision balance
- Standard sieves
    - No. 10 (2.0-millimeter [mm] mesh)
    - No. 18 (1.0 mm mesh)
    - No. 35 (0.500 mm mesh)
    - No. 60 (0.250 mm mesh)
    - No 120 (0.100 mm mesh)
    - No. 200 (0.075 mm mesh)
    - Catch pan and lid
- Mechanical sieve shaker
- Drying oven (110±5°C)
- Aluminum weigh boats
- Crucible or ceramic drying dish
- Hydrometer 151H or 152
- 1,000-milliliter (ml) Sedimentation cylinder (457 mm x 63.5 mm)
- Sodium hexametaphosphate

Procedure

Sieve Procedure

1. Homogenize the sample
2. Transfer approximately 100 grams (g) to a ceramic drying dish
3. Oven dry the sample for at least 18 hours at 110 ± 5°C
4. Measure and record the mass of the dry sample
5. Transfer the material to a #200 sieve with a catch pan and lid
6. Shake until no further material passes through the sieve
7. Discard or set aside the material passing the #200 sieve (fines)
8. Place the sieve over a bowl or catch pan in the sink
9. Rinse the material through the sieve until the rinse water runs clear (always work over a catch basin and do not allow fines to wash down the drain)
10. Oven dry the portion retained on the #200 sieve for at least 18 hours at 110 ± 5°C
11. Measure and record the mass of the retained material
12. Determine the mass of the fines (grain diameter < 0.074 mm) by difference
13. Pass the sample through the sieve set in size order (#10, #18, #35, #60, and #120)
14. Shake thoroughly to ensure complete separation—a mechanical shaker is preferred
15. Record the mass retained on each successive sieve and in the catch pan

Hydrometer Procedure

1. Transfer 50 g of soil to a 250 ml beaker, record exact mass
2. Add 125 ml of sodium hexametaphosphate
3. Stir to wet the soil
4. Soak for 16 hours
5. Stir
6. Transfer to the glass sedimentation cylinder
7. Add reagent water to a total volume of 1,000 ml
8. Cover and invert (approximately 30 times) to mix
9. Record hydrometer reading and temperature at the following times:
    a. 2 minutes
    b. 5 minutes
    c. 15 minutes
    d. 30 minutes
    e. 60 minutes
    f. 250 minutes
    g. 1440 minutes

Calculations

Sieve Analysis

Calculate the percent fines (silt and clay fraction) as shown in Equation 1.

Equation 1

$$F\ (\%) = 100 * \frac{M_{tot} - M_{>200}}{M_{tot}}$$

where:

F = percent silt/clay fraction

M_{tot} = total sample mass (g)

$M_{>200}$ = sample mass retained in the #200 sieve (g)

Calculate the percentage passing by grain size fraction (Equation 2).

Equation 2

$$F_{pass} = 100 * \frac{M_{tot} - \sum M_{ret}}{M_{tot}}$$

where:

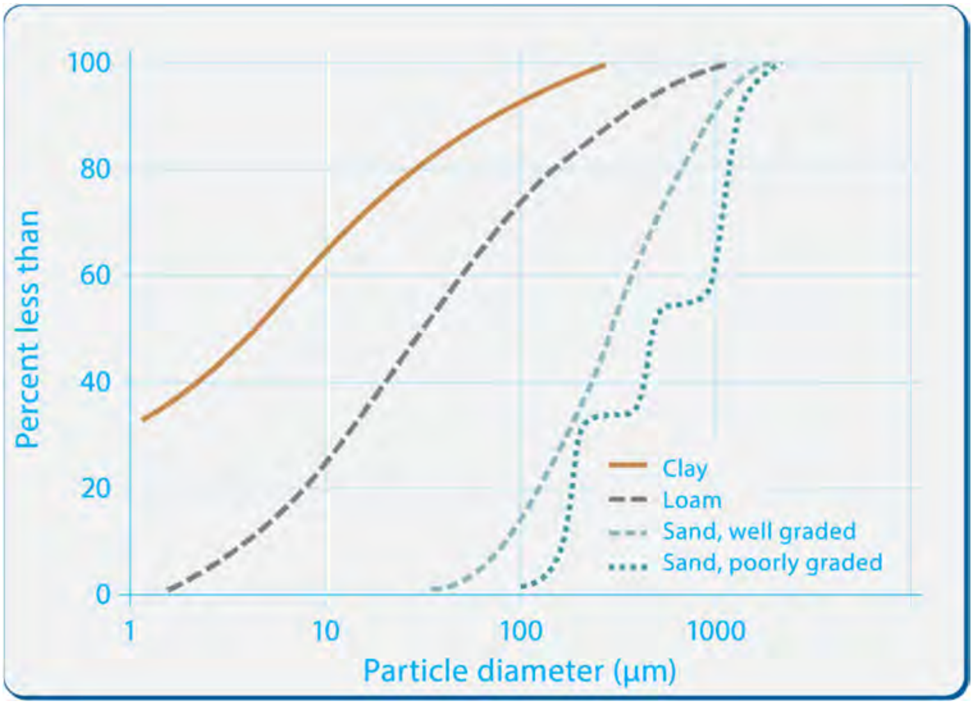
F_{pass} = the fraction passing a given sieve (%)

M_{tot} = the total mass of sample (g)

M_{ret} = mass retained in a given sieve plus and all larger sieves (g)

Plot the cumulative percent passing as a function of the grain diameter (Figure 1).

Figure 1
Example Plot of Percent Passing by Grain Size for Different Soil Types



https://open.oregonstate.education/soilhydrologyandbiophysics/chapter/fundamentals-of-soil-hydrology-and-bio-physics/

Hydrometer Analysis

Calculate the percentage of particles retained in solution at each time step (Equation 3).

Equation 3

$$P_{151H} = \left[\frac{100000}{W} * \frac{G}{G-1}\right] * (R-1)$$

$$P_{152} = \left(\frac{R * \alpha}{W}\right) * 100$$

where:

P_{151H} = percent remaining in solution (hydrometer 151H)
P_{152} = percent remaining in solution (hydrometer 152)
W = total mass of soil sample (g, dry weight)
G = specific gravity of the soil particles
R = hydrometer reading
α = correction factor for hydrometer 152 (1 for specific gravity = 2.65)

Determine the effective depth (L) at which the hydrometer measurement is taken from the hydrometer reading from the table provided in Attachment A. Determine the correction factor (K) from the temperature at the time of each measurement and the specific gravity (Attachment B). Calculate the grain diameter that corresponds to the percentage of the sample remaining in solution at each measurement point (Equation 4).

Equation 4

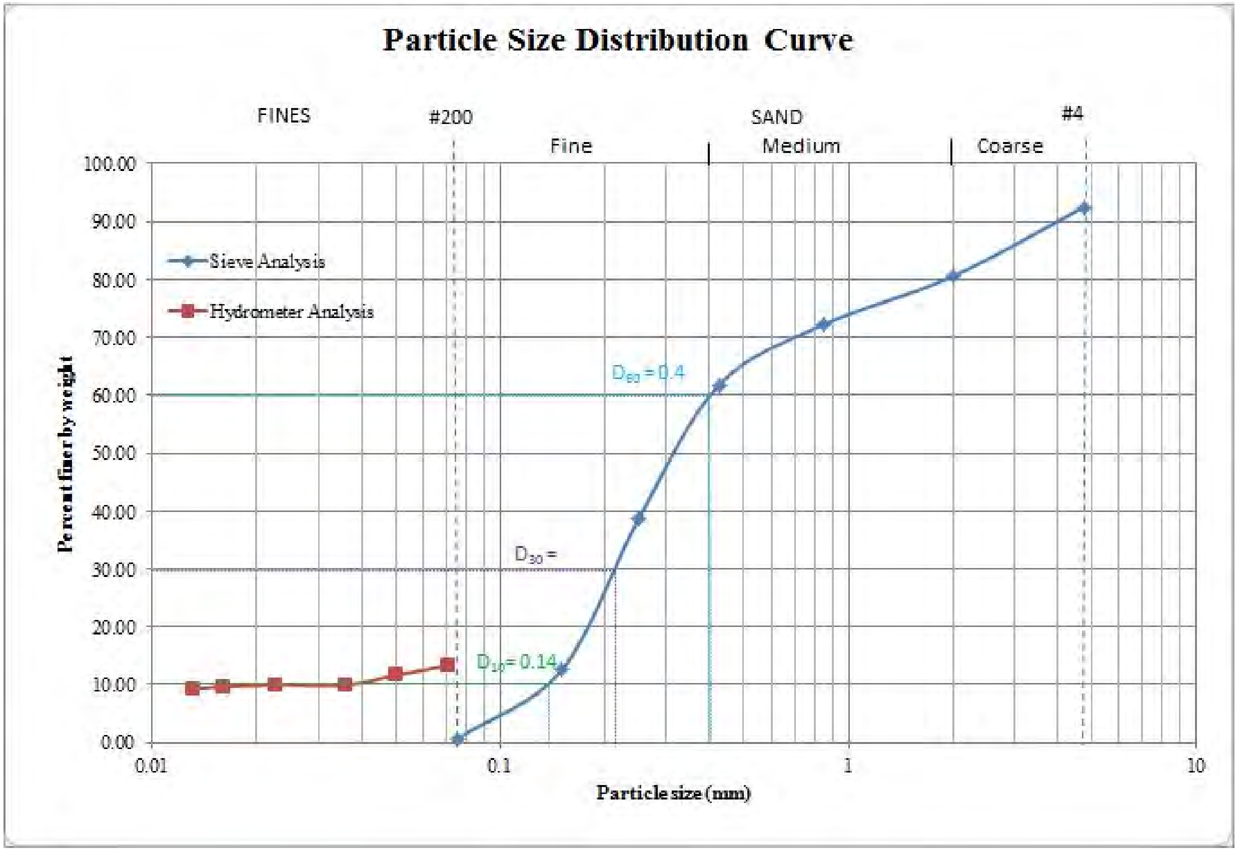
$$\mathrm{D} = \mathrm{K} * \sqrt{L/T}$$

where:

D = diameter of the particles for a given hydrometer reading
K = correction for the temperature and specific gravity
L = effective depth (centimeters [cm])
T = time elapsed (minutes)

Expand the plot of grain diameter and percent passing to include the fines distribution for example as shown in Figure 2.

Figure 2
Example Plot of Percent Passing by Grain Size with Fines



https://jwaskogeo1.files.wordpress.com/2015/03/grainsize.jpg

Quality Assurance/Quality Control

Duplicate samples should be analyzed at a project appropriate rate, with at least one duplicate per event. Duplicate reproducibility is calculated as shown in Equation 5.

Equation 5

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:

RPD = relative percent difference

X_1 = larger result value

X_2 = smaller result value

References

ASTM (ASTM International), 2007. *ASTM D422-63(2007)e2 – Standard Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)*. West Conshohocken, Pennsylvania.

Laboratory Data Record Sheet

Sample	**Total Mass (g, dry)**	**Retained #200 (g, dry)**	**Retained #10 (g)**	**Retained #18 (g)**	**Retained #35 (g)**	**Retained #60 (g)**	**Retained #120 (g)**	**Passing #120 (g)**
	Grain Diameter:	*>0.074 mm*	*>2 mm*	*1-2 mm*	*0.5-1 mm*	*0.25-0.5 mm*	*0.125-0.25 mm*	*0.074-0.125 mm*

Notes:
g: gram
mm: millimeter

Laboratory Data Record Sheet: Hydrometer

Hydrometer: ______________________

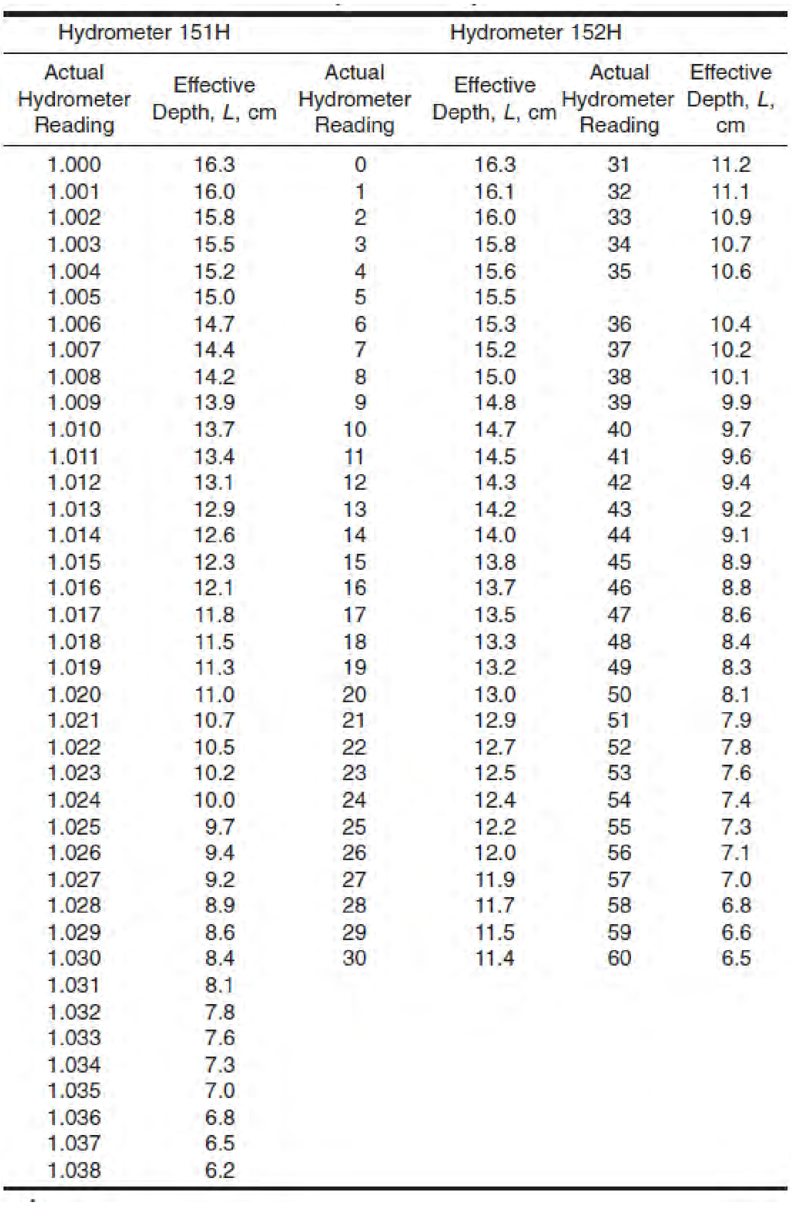
Time (minutes)	Hydrometer Reading	Temperature (°C)
Sample:		
2		
5		
15		
30		
60		
250		
1440		

Time (minutes)	Hydrometer Reading	Temperature (°C)
Sample:		
2		
5		
15		
30		
60		
250		
1440		

Attachment A

Values of Effective Depth from Hydrometer Measurements

Values of Effective Depth from Hydrometer Measurements (Table 2 from ASTM Method D422)



Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

Notes:

L: effective depth

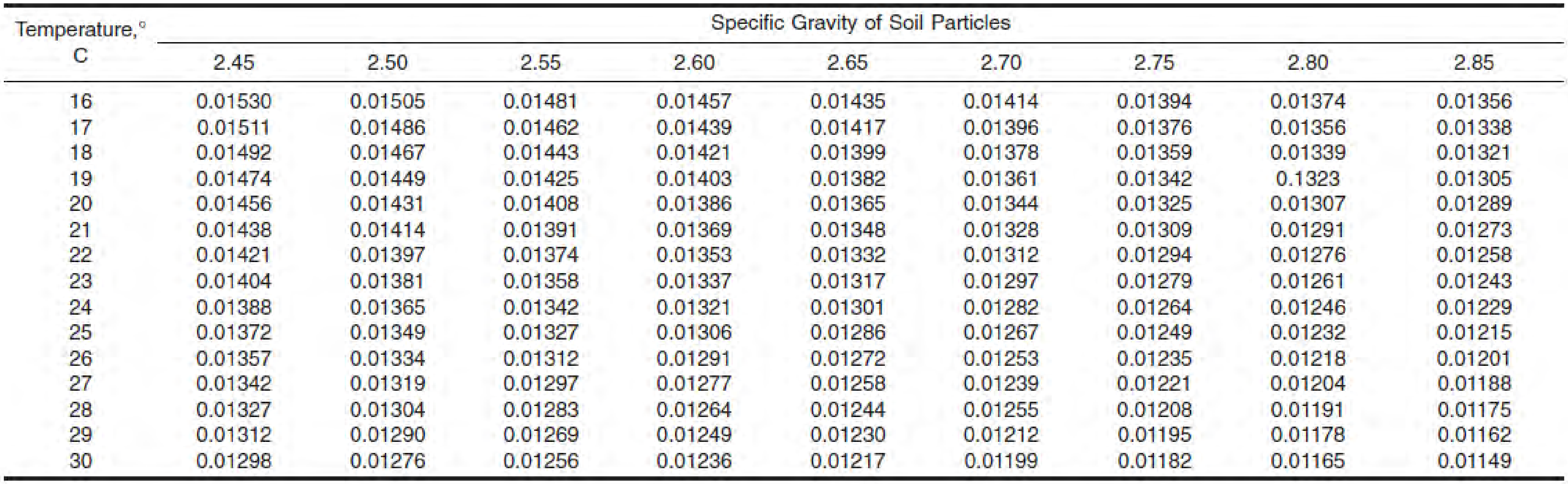
cm: centimeter

Values calculated for the specified sedimentation cylinder

Attachment B

Values of Effective Depth from Hydrometer Measurements

Values of Effective Depth from Hydrometer Measurements (Table 3 from ASTM Method D422)



Temperature, ° C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01530	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01255	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

ATTERBERG LIMITS

Scope and Application

This Environmental Geochemistry Laboratory (EGL) Standard Operating Procedure (SOP) is applicable to determination of the liquid and plastic limit of a soil or sediment in accordance with ASTM International (ASTM) Method 4318 (ASTM 2010). Procedures outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP. Additional equipment may be required

- Appropriate protective equipment
- Liquid limit device
- Evaporating dish
- Flat grooving tool
- Watering bottle
- Balance
- Drying oven
- No. 40 standard sieve
- Airtight storage containers
- Mortar and pestle
- Spatula
- Water bottle
- Drying oven
- Analytical Balance

Atterberg Limit Procedure

Sample Preparation

Remove material larger than 425 micrometers (µm) in diameter with a No. 40 standard sieve. Material that is retained in the No. 40 sieve may be ground with a mortar and pestle for inclusion as appropriate. If material was ground for inclusion in the test, add reagent water until 25 to 35 drops of the liquid limit device cup are required to cause the groove to close. The same material used in the liquid limit test can be prepared for determination of the plastic limit by reducing the water content to the appropriate consistency.

Multipoint Liquid Limit

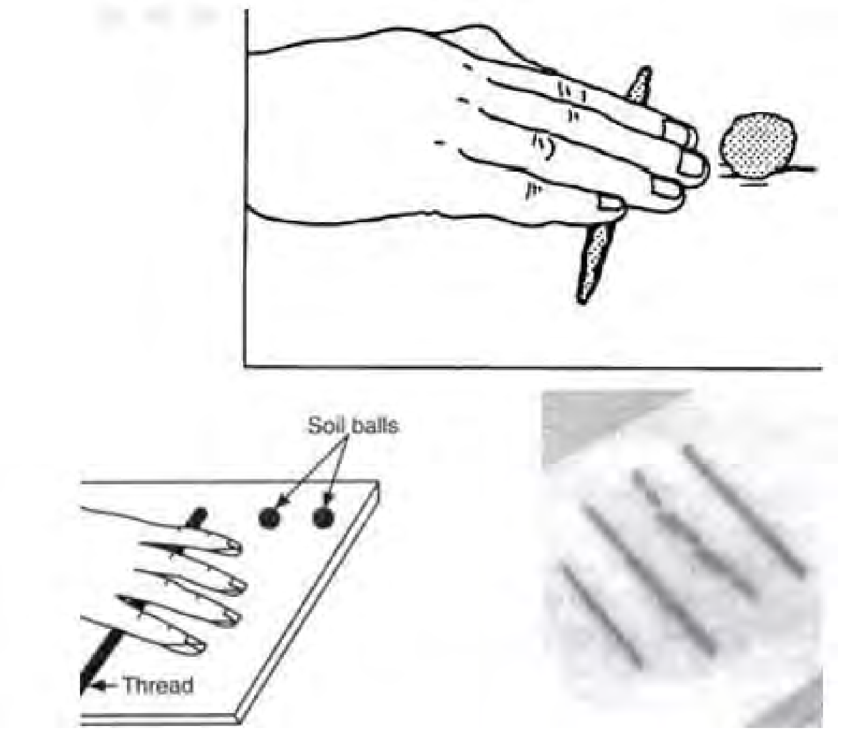
1. Transfer sufficient sample to the cup of the liquid limit apparatus for a depth of approximately 10 millimeters (mm)
2. Spread the sample evenly across the bottom of the cup
3. Form a groove that bisects the sample with the grooving tool (Figure 1)
4. Lift and drop the cup by turning the crank until the two halves come together at the bottom of the groove; record the number of drops required to close this distance
5. Remove a slice of the soil sample and place it in a pre-weighed drying dish; determine the mass and record
6. Return the remaining sample to the evaporating dish
7. Add water to the sample and repeat Steps 1 through 4
8. Test a minimum of three water different water levels to achieve trials with:
    a. 25 to 35 drops
    b. 20 to 30 drops
    c. 15 to 25 drops
9. Determine the moisture content of the sample collected in Step 6 for each trial

Figure 1
Liquid Limit Test Apparatus with Grooved Sample

Plastic Limit

1. Shape a 1.5- to 2.0-gram test sample into a long thread with uniform diameter and break this thread into six pieces; roll each of these pieces until they are approximately 3 mm in diameter (see Figure 2)
2. Work each thread by rolling and breaking on the glass surface (to reduce the water content) until the thread crumbles while being rolled
3. If the sample begins to crumble before its diameter reaches 3 mm, then this is considered a good endpoint as long as the sample has been previously rolled into a 3-mm thread
4. When the plastic limit has been reached, transfer a sample of the soil to a pre-weighed drying dish. Determine the mass and record
5. Repeat Steps 1 through 3 at least three times and combine the samples collected in Step 4
6. Determine the moisture content of the combined sample

Figure 2
Plastic Limit Test Examples



Calculations

The liquid limit is calculated from the number of drops as shown in Equation 1.

Equation 1

$$\text{Liquid Limit} = W * (N/25)^{0.12}$$

where:

W = moisture content

N = drops of the cup required to close the groove

Values for $(N/25)^{0.12}$ are given in Table 1

Table 1:
Values of $(N/25)^{0.12}$

N	$(N/25)^{0.12}$	N	$(N/25)^{0.12}$
15	0.941	23	0.990
16	0.948	24	0.995
17	0.955	25	1.000
18	0.961	26	1.005
19	0.967	27	1.009
20	0.974	28	1.014
21	0.979	29	1.018
22	0.985	30	1.022

Quality Assurance/Quality Control

Duplicate or replicate samples should be analyzed at project appropriate rate, with at least one duplicate or replicate sample per event.

The reproducibility is determined for duplicate samples as shown in Equation 2.

Equation 2

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:

RPD = relative percent difference
X_1 = larger result value
X_2 = smaller result value

Reference

ASTM (ASTM International), 2010. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soil, D4318-10

Liquid Limit Data Record

Sample	Number of Drops	Moisture Content

Plastic Limit Data Record

Sample	Number of Threads Included in Moisture Content Sample	Moisture Content at Thread Break

SOIL PH

Scope and Application

This Environmental Geochemistry Laboratory (EGL) Standard Operating Procedure (SOP) is applicable to determination of soil pH in accordance with the method described in Methods of Soil Analysis: Chemical Analysis (SSSA 1996) and ASTM International (ASTM) Method D4972. The procedures outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP. Additional equipment may be required.

- pH meter
- Combination electrode (calibrate prior to use)
- pH buffers in a sample appropriate range (typically 4, 7, or 10)
- Reagent water
- Beakers
- Potassium chloride
- Calcium chloride

Procedure

1. Calibrate the pH electrode
2. Weigh 20 grams of homogenized soil or sediment into a beaker
3. Add 20 grams of reagent water
4. Mix thoroughly to generate a slurry
5. Allow to the slurry to settle for 1 hour
6. Measure pH in the solution (immediately above the settled material)
7. Rinse the electrode with reagent water
8. Measure the pH of the buffer solution nearest sample pH every third sample at a minimum to confirm calibration (solution should be within 0.1 pH units of the known value)

Alternative Procedures

1. The pH may be determined on a dry weight basis by air-drying the samples prior to the procedure
2. The soil pH may also be measured as pH_{KCl} or pH_{CaCl2}
    a. The reagent water is replaced with a 1 molar solution of potassium chloride to evaluate the influence of exchangeable aluminum on soil pH
    b. The reagent water is replaced with a 0.01 molar solution of calcium chloride to displace exchangeable hydrogen
3. Slurry may be centrifuged if fine particles are not settling within 10 minutes

Quality Assurance/Quality Control

Duplicate or replicate samples should be analyzed at project appropriate rate, with at least one duplicate per event.

The reproducibility is determined for duplicate samples as shown in Equation 1

Equation 1

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:
RPD = relative percent difference
X_1 = larger result value
X_2 = smaller result value

References

ASTM (ASTM International), 2019. D4972 Standard Test Method for pH of Soils.

SSSA (Soil Science Society of America), 1996. Standard Test Methods for Laboratory Determination Thomas, G.W. 1996. Soil pH and Soil Acidity. In Methods of Soil Analysis: Chemical Methods. Part 3. D.L. Sparks, editor. Soil Sci. Soc. of Am., Madison WI.

SPECIFIC GRAVITY

Scope and Application

This Environmental Geochemistry Laboratory (EGL) standard operating procedure (SOP) is applicable to determining the specific gravity of soil, rock, and similar materials in accordance with ASTM International (ASTM) Method D854. The procedures for determining specific gravity outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP; additional equipment may be required:

- Appropriate protective equipment
- Analytical balance of appropriate precision
- Reagent water
- 250 ml volumetric flask
- 500 ml volumetric flask
- Vacuum pump and tubing
- Hot plate
- Pipette
- Vortex mixer
- Beaker
- Funnel
- Water bottle

Procedure

Pycnometer (flask) Calibration

1. Label a clean, dry volumetric flask
2. Determine the mass of the empty flask to 0.001 grams
3. Repeat the measurement 5 times and determine the average mass
4. Fill to the calibration line with reagent water and determine the mass
5. Determine the temperature of the water

6. Repeat the mass and temperature measurement 5 times

Sample Preparation

1. Homogenize the soil
2. Remove any material larger than 4.75 mm from the test sample
3. Determine the total solids of the test sample
4. Transfer a 50-gram aliquot of the moist soil to a beaker and record the exact mass of soil
   Alternatively use a 100-gram aliquot if using the 500 ml flask
5. Add reagent water to the soil sufficient to generate a soil slurry

Specific Gravity Determination

1. Agitate the soil slurry with the vortex mixer
2. Pour the soil slurry into the calibrated pycnometer flask (250 ml volumetric flask)
3. Rinse any soil particles remaining in the beaker or funnel into the flask
4. Add reagent water until the flask is 2/3 full
5. Apply vacuum to the flask for 10 minutes to remove any air bubbles entrained in the soil
6. Fill the flask to the calibration line, use a pipette to fill dropwise until the bottom of the meniscus is at the calibration mark
7. Determine the mass of the flask, soil, and water and record
8. Determine the temperature of the test mixture and record

Calculations

Calculate the temperature corrected mass of the flask and water (Equation 1).

Equation 1

$$\boldsymbol{M_{FW,t} = M_F + (V_W * \rho_{W,t})}$$

where:

$M_{FW,t}$ = temperature corrected mass of flask and reagent water (g)
M_F = mass of the empty, dry flask (g)
V_W = volume of water contained in the flask (ml)
$\rho_{W,t}$ = density of water at the test temperature (g/ml)

Note: values of are tabulated in the method and provided in Figure 1

Calculate the specific gravity of the soil at the test temperature (Equation 2)

Equation 2

$$\boldsymbol{SG_t = \frac{M_s}{M_{FW,t} - (M_{FWS} - M_S)}}$$

where:

SG_t = specific gravity of the soil at the test temperature (g/cm^3)
M_S = total mass of soil times total solids (g)
$M_{FW,t}$ = temperature corrected mass of flask and reagent water (g, from Equation 1)
M_{FWS} = total mass of the flask, water, and soil (g)

Calculate the specific gravity of the soil at the standard reporting temperature of 20°C (Equation 3)

Equation 3

$$\boldsymbol{SG = K * SG_t}$$

where:

SG = specific gravity of the soil (g/cm^3)
K = temperature coefficient for the test temperature
SG_t = specific gravity of the soil at the test temperature (g/cm^3)

Note: temperature coefficients are tabulated in the method and provided in Figure 1

Quality Assurance/Quality Control

Duplicate samples should be analyzed at a project appropriate rate, with at least one duplicate per event. Duplicate reproducibility is calculated as shown in Equation 4.

Equation 4

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:

RPD = relative percent difference

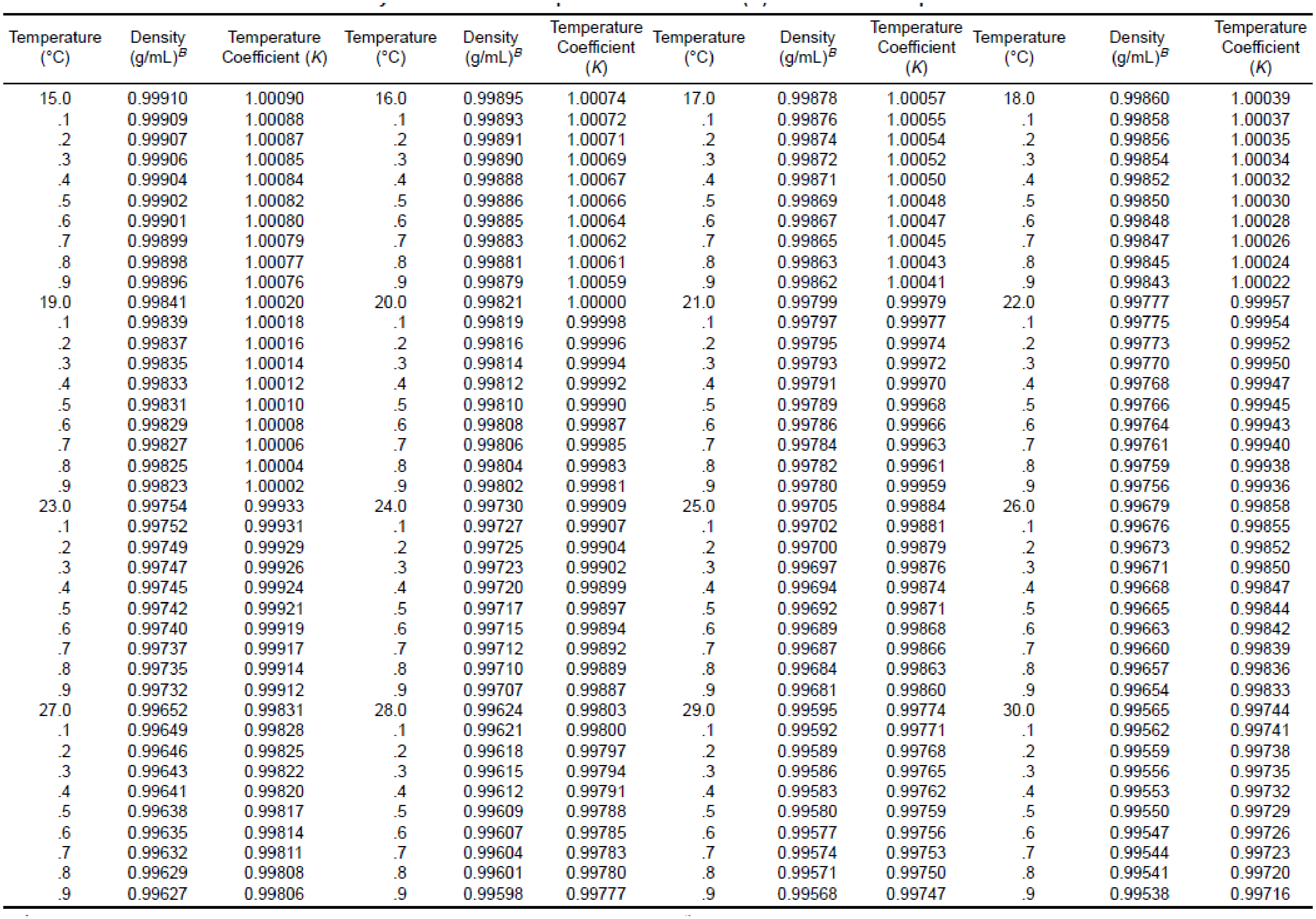
X_1 = larger result value

X_2 = smaller result value

References

ASTM (ASTM International), 2010. *ASTM D845*. *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer*. West Conshohocken, PA: ASTM International.

Figure 1
Density of Water and Temperature Coefficient for Various Temperatures (Method D854 Table 2)



Temperature (°C)	Density (g/mL)^B	Temperature Coefficient (*K*)	Temperature (°C)	Density (g/mL)^B	Temperature Coefficient (*K*)	Temperature (°C)	Density (g/mL)^B	Temperature Coefficient (*K*)	Temperature (°C)	Density (g/mL)^B	Temperature Coefficient (*K*)
15.0	0.99910	1.00090	16.0	0.99895	1.00074	17.0	0.99878	1.00057	18.0	0.99860	1.00039
.1	0.99909	1.00088	.1	0.99893	1.00072	.1	0.99876	1.00055	.1	0.99858	1.00037
.2	0.99907	1.00087	.2	0.99891	1.00071	.2	0.99874	1.00054	.2	0.99856	1.00035
.3	0.99906	1.00085	.3	0.99890	1.00069	.3	0.99872	1.00052	.3	0.99854	1.00034
.4	0.99904	1.00084	.4	0.99888	1.00067	.4	0.99871	1.00050	.4	0.99852	1.00032
.5	0.99902	1.00082	.5	0.99886	1.00066	.5	0.99869	1.00048	.5	0.99850	1.00030
.6	0.99901	1.00080	.6	0.99885	1.00064	.6	0.99867	1.00047	.6	0.99848	1.00028
.7	0.99899	1.00079	.7	0.99883	1.00062	.7	0.99865	1.00045	.7	0.99847	1.00026
.8	0.99898	1.00077	.8	0.99881	1.00061	.8	0.99863	1.00043	.8	0.99845	1.00024
.9	0.99896	1.00076	.9	0.99879	1.00059	.9	0.99862	1.00041	.9	0.99843	1.00022
19.0	0.99841	1.00020	20.0	0.99821	1.00000	21.0	0.99799	0.99979	22.0	0.99777	0.99957
.1	0.99839	1.00018	.1	0.99819	0.99998	.1	0.99797	0.99977	.1	0.99775	0.99954
.2	0.99837	1.00016	.2	0.99816	0.99996	.2	0.99795	0.99974	.2	0.99773	0.99952
.3	0.99835	1.00014	.3	0.99814	0.99994	.3	0.99793	0.99972	.3	0.99770	0.99950
.4	0.99833	1.00012	.4	0.99812	0.99992	.4	0.99791	0.99970	.4	0.99768	0.99947
.5	0.99831	1.00010	.5	0.99810	0.99990	.5	0.99789	0.99968	.5	0.99766	0.99945
.6	0.99829	1.00008	.6	0.99808	0.99987	.6	0.99786	0.99966	.6	0.99764	0.99943
.7	0.99827	1.00006	.7	0.99806	0.99985	.7	0.99784	0.99963	.7	0.99761	0.99940
.8	0.99825	1.00004	.8	0.99804	0.99983	.8	0.99782	0.99961	.8	0.99759	0.99938
.9	0.99823	1.00002	.9	0.99802	0.99981	.9	0.99780	0.99959	.9	0.99756	0.99936
23.0	0.99754	0.99933	24.0	0.99730	0.99909	25.0	0.99705	0.99884	26.0	0.99679	0.99858
.1	0.99752	0.99931	.1	0.99727	0.99907	.1	0.99702	0.99881	.1	0.99676	0.99855
.2	0.99749	0.99929	.2	0.99725	0.99904	.2	0.99700	0.99879	.2	0.99673	0.99852
.3	0.99747	0.99926	.3	0.99723	0.99902	.3	0.99697	0.99876	.3	0.99671	0.99850
.4	0.99745	0.99924	.4	0.99720	0.99899	.4	0.99694	0.99874	.4	0.99668	0.99847
.5	0.99742	0.99921	.5	0.99717	0.99897	.5	0.99692	0.99871	.5	0.99665	0.99844
.6	0.99740	0.99919	.6	0.99715	0.99894	.6	0.99689	0.99868	.6	0.99663	0.99842
.7	0.99737	0.99917	.7	0.99712	0.99892	.7	0.99687	0.99866	.7	0.99660	0.99839
.8	0.99735	0.99914	.8	0.99710	0.99889	.8	0.99684	0.99863	.8	0.99657	0.99836
.9	0.99732	0.99912	.9	0.99707	0.99887	.9	0.99681	0.99860	.9	0.99654	0.99833
27.0	0.99652	0.99831	28.0	0.99624	0.99803	29.0	0.99595	0.99774	30.0	0.99565	0.99744
.1	0.99649	0.99828	.1	0.99621	0.99800	.1	0.99592	0.99771	.1	0.99562	0.99741
.2	0.99646	0.99825	.2	0.99618	0.99797	.2	0.99589	0.99768	.2	0.99559	0.99738
.3	0.99643	0.99822	.3	0.99615	0.99794	.3	0.99586	0.99765	.3	0.99556	0.99735
.4	0.99641	0.99820	.4	0.99612	0.99791	.4	0.99583	0.99762	.4	0.99553	0.99732
.5	0.99638	0.99817	.5	0.99609	0.99788	.5	0.99580	0.99759	.5	0.99550	0.99729
.6	0.99635	0.99814	.6	0.99607	0.99785	.6	0.99577	0.99756	.6	0.99547	0.99726
.7	0.99632	0.99811	.7	0.99604	0.99783	.7	0.99574	0.99753	.7	0.99544	0.99723
.8	0.99629	0.99808	.8	0.99601	0.99780	.8	0.99571	0.99750	.8	0.99541	0.99720
.9	0.99627	0.99806	.9	0.99598	0.99777	.9	0.99568	0.99747	.9	0.99538	0.99716

Data Sheet Pycnometer Flask Calibration

	Replicate	Mass (g)	Temperature (°C)	Average (g)
Clean, Dry Flask	1		--	
	2		--	
	3		--	
	4		--	
	5		--	
Flask + Reagent Water	1			
	2			
	3			
	4			
	5			

Note:
g: grams

Data Sheet

Sample	Mass of Soil (g)	Total Solids	Mass of Flask, Soil, and Water (g)	Test Temperature (°C)

Note:
g: grams
°C: degrees Celsius

Unconfined Strength by Pocket Penetrometer

Scope and Application

This Environmental Geochemistry Laboratory (EGL) Standard Operating Procedure (SOP) is applicable to estimation of the unconfined compressive strength of a sample by pocket penetrometer. The procedures in this SOP will be followed, and any deviations will be noted.

Health and Safety

All laboratory work will be performed by approved staff in accordance with the EGL Chemical Hygiene Plan (CHP). Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the Laboratory Manager, as specified in the CHP.

Equipment and Supplies

The following equipment may be necessary to carry out the procedures in this SOP. Additional equipment may be required.

- Appropriate sample or test container
- Pocket penetrometer
- Adapter foot

Procedure

1. The test should be performed on a well-mixed, representative sample.
2. The sample container or test container must have enough surface area that the container walls do not constrain the material.
3. Hold the penetrometer vertically above the sample surface a minimum of 2 inches from the edge of the sample surface.
4. Press the penetrometer into the sample with steady pressure until the calibration mark is even with the surface of the sample.
5. Record the strength value.
6. Repeat the measurement (not in the same location) twice and record the strength value.
7. For low-strength samples, attach the adapter foot and repeat the measurement. The value measured with the adapter foot is divided by 16 to obtain the strength value.

Quality Assurance/Quality Control

Penetrometer readings should be performed in triplicate.

The reproducibility is determined for replicate samples as follows:

$$RSD = 100 * \frac{StdDev}{Avg}$$

where:

RSD = relative standard deviation
StdDev = the standard deviation of the result values
Avg = the average of the result values

Slump Testing

Scope and Application

This Environmental Geochemistry Laboratory (EGL) Standard Operating Procedure (SOP) is applicable to measurement of the slump of cement or cement admixtures in accordance with ASTM[1] C143. The procedures in this SOP will be followed, and any deviations will be noted.

Health and Safety

All laboratory work will be performed by approved staff in accordance with the EGL Chemical Hygiene Plan (CHP). Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the Laboratory Manager, as specified in the CHP.

Equipment and Supplies

The following equipment may be necessary to carry out the procedures in this SOP. Additional equipment may be required.

- Slump cone and base
- Tamping rod
- Ruler
- Coin or similar marker

Procedure

1. The test should be performed on a well-mixed, representative sample.
2. Secure the slump cone to the base (stand on the anchor points).
3. Fill the cone approximately 1/3 full with sample material.
4. Tamp 25 times with the tamping rod across the sample surface (work in from the edges in a spiral).
5. Add sample material until the cone is approximately 2/3 full.
6. Tamp 25 times with the tamping rod.
7. Add the remaining 1/3 of the sample. (material should be above the rim of the cone.)
8. Tamp 25 times with the tamping rod. If material subsides below the rim of the cone, add additional sample.
9. Remove any sample material from the base around the cone.
10. Level the surface of the sample with the tamping rod so that the surface of the sample is even with the rim of the cone.
11. Place a coin or small marker in the center of the sample surface.

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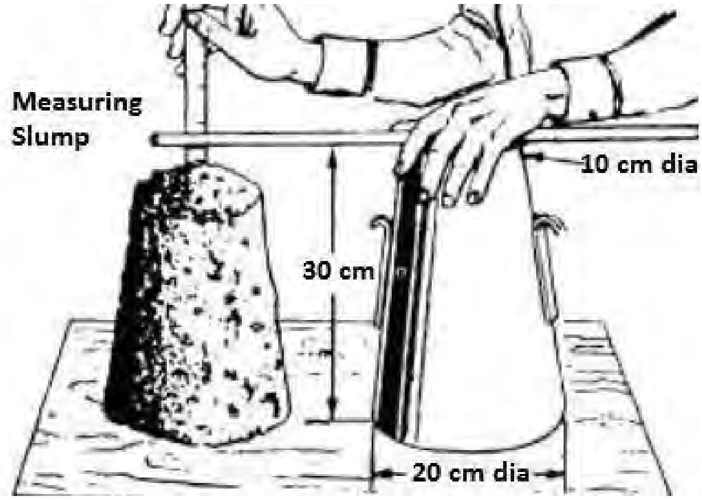
[1] [1] ASTM International

12. Remove the cone vertically from the sample.
13. Place the cone next to the sample with the tamping rod resting on the rim and extending over the sample.
14. Measure the vertical distance from the marker to the tamping rod and record (Figure 1).
15. The time to fill the cone and complete the slump measurement should not exceed 2.5 minutes.

Figure 1
Measurement of Vertical Slump



Quality Assurance/Quality Control

Slump readings should be performed in duplicate. The reproducibility is determined for duplicate samples as follows:

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:
RPD = relative percent difference
X1 = larger result value
X2 = smaller result value

Reference

ASTM (ASTM International), 2017. Standard C143- Standard Test Method for Slump of Portland Cement Concrete. West Conshohocken, Pennsylvania: ASTM International.

LEAF SEMIDYNAMIC MONOLITH LEACHING

Scope and Application

This Environmental Geochemistry Laboratory (EGL) standard operating procedure (SOP) is applicable to performing the Leaching Environmental Assessment Framework Method 1315 Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials Using a Semidynamic Tank Leaching Procedure.[1] The procedures outlined in this SOP will be followed, and any deviations must be noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the laboratory manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP; additional equipment may be required:

- Appropriate personal protective equipment
- Analytical balance
- Leaching vessel (plastic tank or bucket with lid)
- Sample holder (mesh, nylon twine, or similar)
- LabNavigator multiparameter meter
- pH electrode
- Oxidation-reduction electrode
- Conductivity meter
- Thermometer
- 0.45-micron filters
- Reagent water

Procedure (Monolith)

1. Determine the moisture content as applicable
2. Determine the initial mass of the monolith and record
3. Determine the surface area of the monolith and record
4. Place the monolith into the sample holder
5. Determine and record the mass of the monolith and the sample holder
6. Calculate the volume of eluent needed

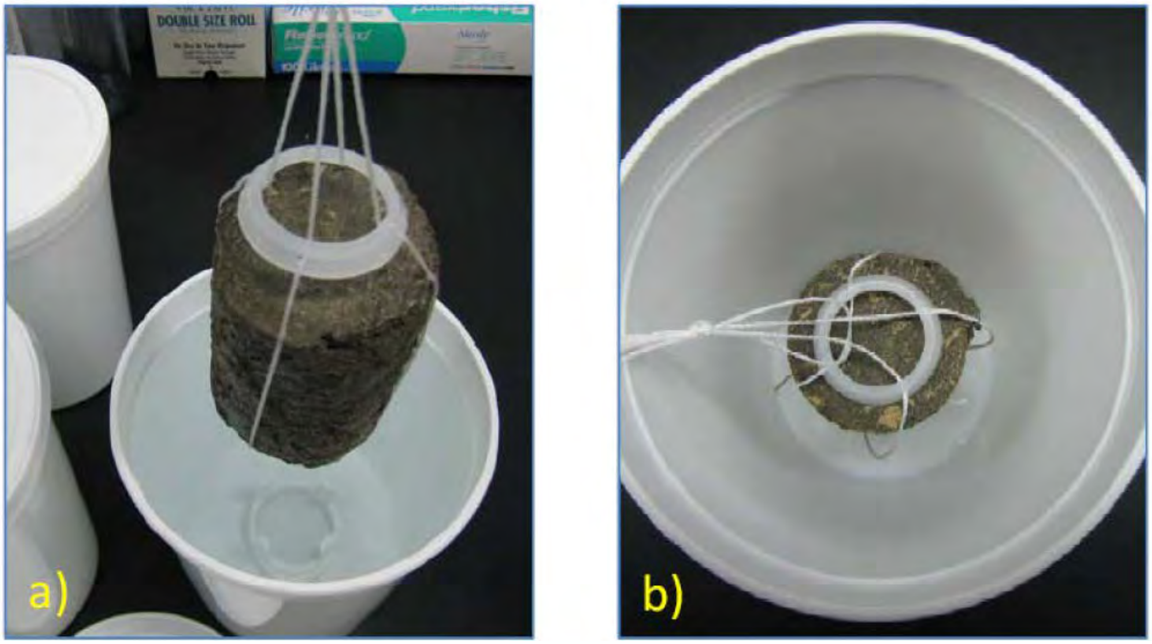
---

[1] This SOP does not address leaching of granular materials by Method 1315 (USEPA 2013).

The volume (milliliters [ml]) of the leaching solution is always at a ratio of 9±1 with the surface area of the monolith (centimeters squared [cm^2*])*

7. Fill a clean leaching vessel with the appropriate volume of reagent water (or applicable site water)
8. Submerge the monolith in the center of the leaching vessel (Figure 1)

Figure 1
Sample and Sample Holder Placement in the Leaching Vessel (Method 1315 Figure 6)



Notes:
A plastic stand and holder (a) are used to position the monolith in the center of the leaching solution (b)
Source: USEPA 2013

9. Cover the leaching vessel (lid should be airtight)
10. Exchange the eluant at the specified intervals (Table 1)

Table 1
Target Fractions

Fraction	Duration	Cumulative Time (days)
F01	2.0±0.25 hours	0.08
F02	23±0.5 hours	1.0
F03	23±0.5 hours	2.0
F04	5.0±0.1 days	7
F05	7.0±0.1 days	14
F06	14±0.1 days	28
F07	14±0.1 days	42
F08	7.0±0.1 days	49
F09	14±0.1 days	63
Additional Fractions[1]	14±0.1 days	TBD

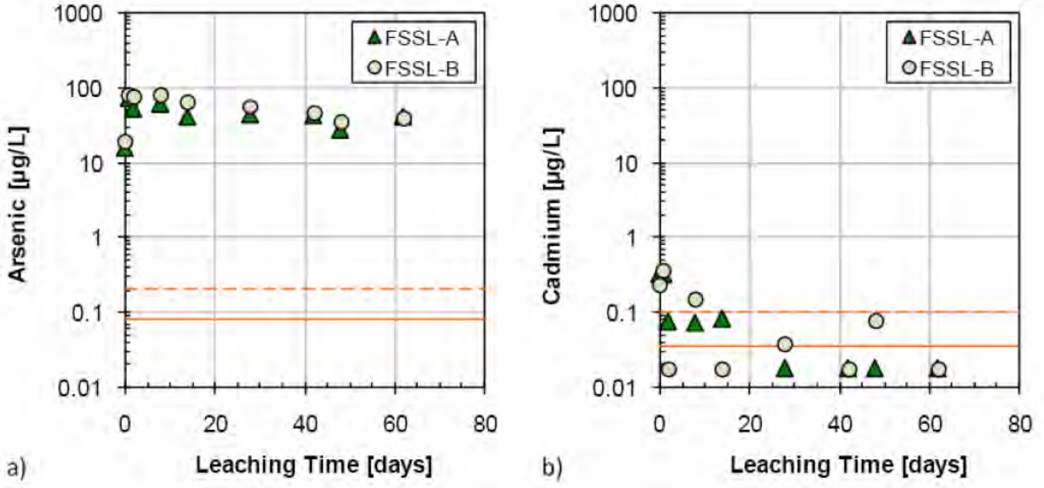
Notes:
1. additional fractions of 14-day duration may be performed to assess long-term leaching
TBD: to be determined

11. Remove the monolith from the leaching solution and allow liquid to drain off the sample for 20 seconds
12. For each fraction immediately:
    a. Determine and record the total mass of the cylinder and the sample holder
    b. Determine and record the oxidation-reduction potential (ORP), pH, temperature, and specific conductance (SC)
    Determine these parameters within 15 minutes of eluant exchange
    c. Filter (0.45-micron) the analytical sample (s) into appropriately preserved jars for the constituents of potential concern (COPC)
13. Place the monolith in a clean leaching vessel with the appropriate volume of eluant for the next leaching interval

Reporting and Calculations

Plot the mass of each COPC and the water quality parameters as a function of cumulative leaching time (Figure 2).

Figure 2
Example Plots COPC Concentration as a Function of Leaching Time (Method 1315 Figure 8)



Source: USEPA 2013

Calculate the mass released for each COPC for each interval (Equation 1)

Equation 1

$$M_i = \frac{C_i * V_i}{A}$$

where:

M_i = the mass release of a COPC for the interval, i (mg/m^2)
C_i = the COPC concentration in the eluate for interval, i (mg/L)
V_i = the total eluate volume of the interval (L)
A = the surface area of the monolith (m^2) exposed to the eluate

Calculate the flux of the COPCs for each interval (Equation 2).

Equation 2

$$F_i = \frac{\mathrm{M}_i}{t_i - t_{i-1}}$$

where:

F_i = the flux for the interval, i (mg/m^2*S)

M_i = the mass release of a COPC for the interval, i (mg/m^2)

t_i = the cumulative time elapsed at the end of the interval, i (s)t_{i-1} = the cumulative time elapsed at the end of the prior interval, *i-1* (s)

Calculate the mean interval time for each interval (Equation 3)

Equation 3

$$\bar{t}_i = \left(\frac{\sqrt{t_i} + \sqrt{t_{i-1}}}{2}\right)$$

where:

$\bar{t}_i$ = the generalized mean time leaching time of the interval, i (s)

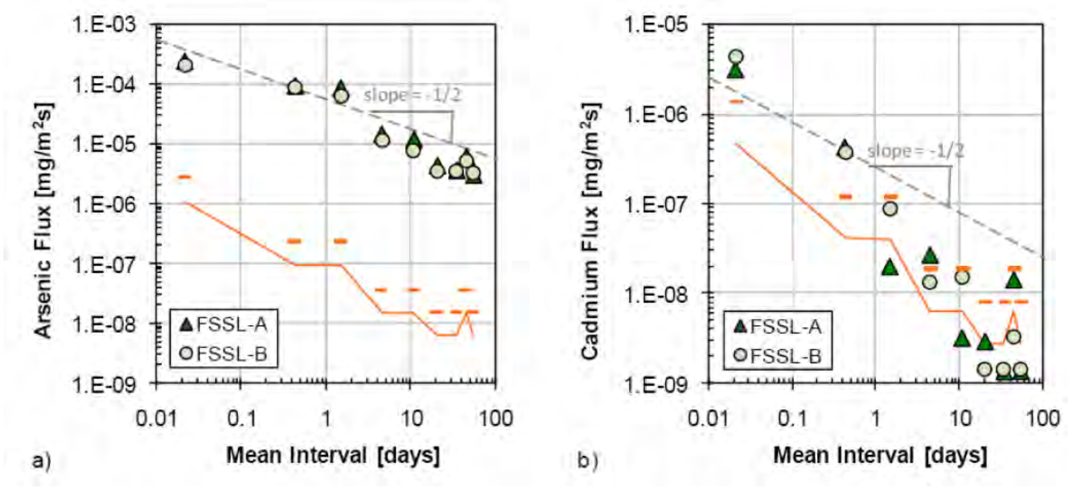
t_i = the cumulative time elapsed at the end of the interval, i (s)

t_{i-1} = the cumulative time elapsed at the end of the prior interval, *i-1* (s)

Plot the flux as a function of the mean interval time (Figure 3).

Figure 3

Example Plots COPC Flux as a Function of Mean Interval (Method 1315 Figure 10)



Source: USEPA 2013

Quality Assurance/Quality Control

Method blanks and duplicates should be analyzed at a project appropriate rate. The reproducibility is determined for duplicate samples as shown in Equation 4.

Equation 4

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:

RPD = relative percent difference

X_1 = larger result value

X_2 = smaller result value

References

USEPA (U.S. Environmental Protection Agency), 2013. *Method 1315 Mass Transfer Rates in Monolithic and Compacted Granular Materials*. SW-846 Update V.

Data Record

Sample Name: ______________________________

Sample Mass (g): ___________________________

Surface Area (m^2): _________________________

Fraction	Sample Mass with Holder (g)	Eluate Volume (L)	Start Time	End Time	pH	SC (µS/cm)	ORP (mV)	Temperature (°C)
Initial								
F01								
F02								
F03								
F04								
F05								
F06								
F07								
F08								
F09								

Notes:
µs/cm: microsiemens per centimeter
g: gram
L: liter
m^2: meters squared
mV: millivolts
ORP: oxidation reduction potential
SC: specific conductance

SYNTHETIC PRECIPITATION LEACHING PROCEDURE

Scope and Application

This Environmental Geochemistry Laboratory (EGL) standard operating procedure (SOP) is applicable to the Synthetic Precipitation Leaching Procedure (SPLP) of non-volatile or semivolatile analytes in liquids, soils, and wastes in accordance with EPA Method 1312. Procedures for extraction outlined in this SOP will be followed and any deviations noted.

Health and Safety

All laboratory work will be performed in accordance with the EGL Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the Laboratory Manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment that may be necessary to carry out the procedures contained in this SOP; additional equipment may be required:

- Appropriate protective equipment
- Analytical balance of appropriate precision (1/1000 gram [g])
- Laboratory shaker
- Extraction vessel (1 liter borosilicate or HDPE bottle)
- pH meter
- Sulfuric acid
- Nitric acid
- Reagent water
- Glass filter membranes (borosilicate, 0.6 to 0.8 micron)
- 0.45-micron PES filters
- Pre-preserved sample bottles

Extraction Solutions

1. Combine 30 g of sulfuric acid and 20 g of nitric acid (ACS grade or better)
2. Dilute the acid mixture 10:1 with reagent water
3. Prepare the appropriate extraction fluid

Extraction Fluid #1 (sites east of the Mississippi River, all wastes)
Add reagent water to a clean jar or beaker (1 liter per sample)
Add the diluted sulfuric/nitric mix until the pH is 4.2±0.1

Extraction Fluid #2 (sites west of the Mississippi River)

Add reagent water to a clean jar or beaker (1 liter per sample)

Add the diluted sulfuric/nitric mix until the pH is 5.0±0.1

Leaching Procedure

If the sample yields free liquid upon settling:

1. Weigh out a 100 g aliquot of sample
2. Allow the sample to settle until the liquid separates
3. Decant the free liquid and determine the mass
4. Set aside the liquid for inclusion in the leachate
    a. The liquid is added back in proportionally to the total mass of sample (Equation 1)
5. Determine the moisture content of the solid portion of the sample
6. Process as described for predominantly solid samples

Equation 1

$$V_l = M_s * \frac{M_l}{100\ g}$$

where:

V_l = volume of free liquid added to the leachate (mL)

M_s = total mass of sample leached (g)

M_l = mass of free liquid decanted (g)

If the sample does not produce a separate liquid phase upon settling (or if the liquid phase has been separated):

1. Determine the moisture content
2. Transfer 50 grams of sample (dry weight basis) to the extraction vessel
3. Add the appropriate extraction solution at L/S = 20 (1 liter for a 50 gram sample)
4. Seal the extraction vessel
5. Shake to mix
6. Transfer to a shaker table for 18±2 hours
7. For total analytes separate the leachate by centrifugation or filtration through a glass fiber filter
8. For dissolved analytes filter the leachate through a 0.45 micron PES filter
9. Transfer the samples to a pre-preserved bottle and submit for analysis

Quality Assurance/Quality Control

Duplicate or replicate samples should be analyzed at a project appropriate rate, with at least one duplicate or replicate sample per event. An extraction solution blank will be submitted for each event.

The reproducibility is determined for duplicate samples as shown in Equation 2.

Equation 2

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) \div 2}$$

where:

RPD = relative percent difference
X1 = larger result value
X2 = smaller result value

Reference

U.S. Environmental Protection Agency SW-846 Test Method 1312: Synthetic Precipitation Leaching Procedure

APPENDIX C

Inadvertent Discovery Plan

DEPARTMENT OF
ECOLOGY
State of Washington

PLAN AND PROCEDURES FOR THE UNANTICIPATED DISCOVERY OF CULTURAL RESOURCES AND HUMAN SKELETAL REMAINS[1]

PROJECT TITLE: Chlor-Alkali RAU Pre-Remedial Design Investigation

COUNTY WASHINGTON: Whatcom

Section, Township, Range: Section 30 T38N R3E

1. INTRODUCTION

The following Inadvertent Discovery Plan (IDP) outlines procedures to perform in the event of discovering archaeological materials or human remains, in accordance with state and federal laws.

2. RECOGNIZING CULTURAL RESOURCES

A cultural resource discovery could be prehistoric or historic. Examples include:

a. An accumulation of shell, burned rocks, or other food related materials.
b. Bones or small pieces of bone.
c. An area of charcoal or very dark stained soil with artifacts.
d. Stone tools or waste flakes (i.e. an arrowhead. or stone chips).
e. Clusters of tin cans or bottles, logging or agricultural equipment that appears to be older than 50 years.
f. Buried railroad tracks, decking, or other industrial materials.

When in doubt, assume the material is a cultural resource.

3. ON-SITE RESPONSIBILITIES

STEP 1: *Stop Work*. If any employee, contractor or subcontractor believes that he or she has uncovered a cultural resource at any point in the project, all work must stop immediately. Notify the appropriate party(s). Leave the surrounding area untouched, and provide a demarcation adequate to provide the total security, protection, and integrity of the discovery. The discovery location must be secured at all times by a temporary fence or other onsite security.

STEP 2: *Notify Archaeological Monitor or Licensed Archaeologist*. If there is an Archaeological Monitor for the project, notify that person. If there is a monitoring plan in place, the monitor will follow the outlined procedure.

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[1] If you need this document in a format for the visually impaired, call Water Quality Reception at Ecology, (360) 407-6600. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

STEP 3: *Notify the Project Manager* of this project and contact the Ecology Staff Project Manager, or other applicable contacts:

Environmental Project Manager: Name: Ben Howard Phone: 360-676-2500 Email: Benh@portofbellingham.com	Ecology Staff Project Manager Name: John Rapp Phone: 360.407.6265 Email: john.rapp@ECY.WA.GOV

Assigned Alternates:

Assigned Project Manager Alternate: Name: Gina Stark Phone: 360-676-2500 Email: GinaS@portofbellingham.com	Ecology Cultural Resource Specialist (Alternate): Name: Phone: email:

The Project Manager or applicable staff will make all calls and necessary notifications. **If human remains are encountered**, treat them with dignity and respect at all times. Cover the remains with a tarp or other materials (not soil or rocks) for temporary protection and to shield them from being photographed. **Do not call 911 or speak with the media. Do not take pictures unless directed to do so by DAHP. See Section 5.**

4. FURTHER CONTACTS AND CONSULTATION

A. **Project Manager's Responsibilities**:

- *Protect Find*: The Project Manager is responsible for taking appropriate steps to protect the discovery site. All work will stop immediately in a surrounding area adequate to provide for the complete security of location, protection, and integrity of the resource. Vehicles, equipment, and unauthorized personnel will not be permitted to traverse the discovery site. Work in the immediate area will not resume until treatment of the discovery has been completed following provisions for treating archaeological/cultural material as set forth in this document.

- *Direct Construction Elsewhere on-Site*: The Project Manager may direct construction away from cultural resources to work in other areas prior to contacting the concerned parties.

- *Contact Senior Staff*: If the Senior Staff person has not yet been contacted, the Project Manager must do so.

B. **Senior Staff Responsibilities**:

- *Identify Find*: The Senior Staff (or a delegated Cultural Resource Specialist), will ensure that a qualified professional archaeologist examines the area to determine if there is an archaeological find.

    - If it is determined not to be of archaeological, historical, or human remains, work may proceed with no further delay.
    - If it is determined to be an archaeological find, the Senior Staff or Cultural Resource Specialist will continue with all notifications.
    - If the find may be human remains or funerary objects, the Senior Staff or Cultural Resource Specialist will ensure that a qualified physical anthropologist examines the find. **If it is determined to be human remains, the procedure described in Section 5 will be followed.**

- *Notify DAHP*: The Senior Staff (or a delegated Cultural Resource Specialist) will contact the involved federal agencies (if any) and the Washington Department of Archaeology and Historic Preservation (DAHP).
- *Notify Tribes*: If the discovery may be of interest to Native American Tribes, the DAHP and Ecology Supervisor or Coordinator will coordinate with the interested and/or affected tribes.

General Contacts

Federal Agencies:	**State Agencies**:
Agency: Name Title Number Email	Agency: Name Title Number Email

Department of Archaeology and Historic Preservation:

Dr. Allyson Brooks State Historic Preservation Officer 360-586-3066 Assigned Alternate:	Rob Whitlam, Ph.D. Staff Archaeologist 360-586-3050 Assigned Alternate:

The DAHP or appropriate Ecology Staff will contact the interested and affected Tribes for a specific project.

Tribes consulted on this project are:

Tribe: Lummi Nation	Tribe: Upper Skagit Tribe
Name: Lena Tso	Name: Scott Schuyler
Title: THPO	Title: Cultural Resources
Phone: 360-312-2257	Phone: 360-854-7009
Email: lenat@lummi-nsn.gov	Email: sschuyler@upperskagit.com

Tribe: Swinomish Tribal Community	Tribe: Nooksack Tribe
Name: Larry Campbell	Name: Trevor Delgado
Title: THPO	Title: THPO
Phone: 360-466-7314	Phone: 360-592-5176 ext. 32234
Email: lcampbell@swinomish.nsn.us	Email: tdelgado@nooksack-nsn.gov

Further Activities

- Archaeological discoveries will be documented as described in Section 6.
- Construction in the discovery area may resume as described in Section 7.

5. SPECIAL PROCEDURES FOR THE DISCOVERY OF HUMAN SKELETAL MATERIAL

Any human skeletal remains, regardless of antiquity or ethnic origin, will at all times be treated with dignity and respect. Do not take photographs by any means, unless you are pre-approved to do so.

If the project occurs on federal lands or receives federal funding (e.g., national forest or park, military reservation) the provisions of the Native American Graves Protection and Repatriation Act of 1990 apply, and the responsible federal agency will follow its provisions. Note that state highways that cross federal lands are on an easement and are not owned by the state.

If the project occurs on non-federal lands, the Project Manager will comply with applicable state and federal laws, and the following procedure:

A. **In all cases you must notify a law enforcement agency or Medical Examiner/Coroner's Office**:

In addition to the actions described in Sections 3 and 4, the Project Manager will immediately notify the local law enforcement agency or medical examiner/coroner's office.

The Medical Examiner/Coroner (with assistance of law enforcement personnel) will determine if the remains are human, whether the discovery site constitutes a crime scene, and will then notify DAHP.

Enter contact information below:

City of Bellingham Police Department
360-778-8800

B. **Participate in Consultation**:

Per RCW 27.44.055, RCW 68.50, and RCW 68.60, DAHP will have jurisdiction over non-forensic human remains. Ecology staff will participate in consultation.

C. **Further Activities**:

- Documentation of human skeletal remains and funerary objects will be agreed upon through the consultation process described in RCW 27.44.055, RCW 68.50, and RCW 68.60.

- When consultation and documentation activities are complete, construction in the discovery area may resume as described in Section 7.

6. DOCUMENTATION OF ARCHAEOLOGICAL MATERIALS

Archaeological deposits discovered during construction will be assumed eligible for inclusion in the National Register of Historic Places under Criterion D until a formal Determination of Eligibility is made.

Project staff will ensure the proper documentation and field assessment will be made of any discovered cultural resources in cooperation with all parties: the federal agencies (if any), DAHP, Ecology, affected tribes, and a contracted consultant (if any).

All prehistoric and historic cultural material discovered during project construction will be recorded by a professional archaeologist on a cultural resource site or isolate form using standard and approved techniques. Site overviews, features, and artifacts will be photographed; stratigraphic profiles and soil/sediment descriptions will be prepared for minimal subsurface exposures. Discovery locations will be documented on scaled site plans and site location maps.

Cultural features, horizons and artifacts detected in buried sediments may require further evaluation using hand-dug test units. Units may be dug in controlled fashion to expose features, collect samples from undisturbed contexts, or to interpret complex stratigraphy. A test excavation unit or small trench might also be used to determine if an intact occupation surface is present. Test units will be used only when necessary to gather information on the nature, extent, and integrity of subsurface cultural deposits to evaluate the site's significance. Excavations will be conducted using state-of-the-art techniques for controlling provenience, and the chronology of ownership, custody and location recorded with precision.

Spatial information, depth of excavation levels, natural and cultural stratigraphy, presence or absence of cultural material, and depth to sterile soil, regolith, or bedrock will be recorded for each probe on a standard form. Test excavation units will be recorded on unit-level forms, which include plan maps for each excavated level, and material type, number, and vertical provenience (depth below surface and stratum association where applicable) for all artifacts recovered from the level. A stratigraphic profile will be drawn for at least one wall of each test excavation unit.

Sediments excavated for purposes of cultural resources investigation will be screened through 1/8-inch mesh, unless soil conditions warrant ¼-inch mesh.

All prehistoric and historic artifacts collected from the surface and from probes and excavation units will be analyzed, catalogued, and temporarily curated. Ultimate disposition of cultural materials will be determined in consultation with the federal agencies (if any), DAHP, Ecology and the affected tribes.

Within 90 days of concluding fieldwork, a technical report describing any and all monitoring and resultant archaeological excavations will be provided to the Project Manager, who will forward the report for review and delivery to Ecology, the federal agencies (if any), DAHP, and the affected tribe(s).

If assessment activity exposes human remains (burials, isolated teeth, or bones), the process described in Section 5 will be followed.

7. PROCEEDING WITH WORK

Work outside the discovery location may continue while documentation and assessment of the cultural resources proceed. A professional archaeologist must determine the boundaries of the discovery location. In consultation with Ecology, DAHP and any affected tribes, the Project Manager will determine the appropriate level of documentation and treatment of the resource. If there is a federal nexus, Section 106 consultation and associated federal laws will make the final determinations about treatment and documentation.

Work may continue at the discovery location only after the process outlined in this plan is followed and the Project Manager, DAHP, any affected tribes, Ecology (and the federal agencies, if any) determine that compliance with state and federal law is complete.

8. RECIPIENT/PROJECT PARTNER RESPONSIBILITY

The Project Recipient/Project Partner is responsible for developing an IDP. The IDP must be immediately available onsite, be implemented to address any discovery, and be available by request by any party. The Project Manager and staff will review the IDP during a project kickoff or pre-construction meeting.

We recommend that you print images in color for accuracy.

Implement the IDP / UDP if …

You see chipped stone artifacts.

- Glass-like material
- Angular
- “Unusual” material for area
- “Unusual” shape
- Regularity of flaking
- Variability of size

Implement the IDP / UDP if …

You see ground or pecked stone artifacts.

- Striations or scratching
- Unusual or unnatural shapes
- Unusual stone
- Etching
- Perforations
- Pecking
- Regularity in modifications
- Variability of size, function, and complexity

Implement the IDP / UDP if …

You see bone or shell artifacts.

- Often smooth
- Unusual shape
- Carved
- Often pointed if used as a tool
- Often wedge shaped like a "shoehorn"

Bone Awls from Oregon and Bone Wedge from California

Implement the IDP / UDP if …

You see bone or shell artifacts.

- Often smooth
- Unusual shape
- Perforated
- Variability of size

Tooth Pendant and Bone Pendants from Oregon and Washington

Implement the IDP / UDP if …

You see fiber or wood artifacts.

- Wet environments needed for preservation
- Variability of size, function, and complexity
- Rare

Artifacts from Mud Bay, Olympia, Washington

Implement the IDP / UDP if …

You see historic period artifacts.

Artifacts from Downtown Seattle, Alaskan Way Viaduct (Upper Left and Lower) and Unknown Site (Upper Right)

Implement the IDP / UDP if …

You see strange, different or interesting looking dirt, rocks, or

- Human activities leave traces in the ground that may or may not have artifacts associated with them
- “Unusual” accumulations of rock (especially fire-cracked rock)
- “Unusual” shaped accumulations of rock (e.g., similar to a fire ring)
- Charcoal or charcoal-stained soils
- Oxidized or burnt-looking soils
- Accumulations of shell
- Accumulations of bones or artifacts
- Look for the “unusual” or out of place (e.g., rock piles or accumulations in areas with few rock)

Implement the IDP / UDP if …

You see strange, different or interesting looking dirt, rocks, or

- “Unusual” accumulations of rock (especially fire-cracked rock)
- “Unusual” shaped accumulations of rock (e.g., similar to a fire ring)
- Look for the “unusual” or out of place (e.g., rock piles or accumulations in areas with few rock)

Site on Muckleshoot Indian Reservation, near WSDOT ROW along SR 164

Implement the IDP / UDP if …

You see strange, different or interesting looking dirt, rocks, or

- Often have a layered or "layer cake" appearance
- Often associated with black or blackish soil
- Often have very crushed and compacted shells

Implement the IDP / UDP if …

You see historic foundations or buried structures.

45KI924, In WSDOT ROW for SR 99 Tunnel

APPENDIX D

Material Specifications

Dexpan®

Dexpan® Expansive Demolition Grout for Concrete & Rock Breaking

What is Dexpan® Non-Explosive Demolition Agent?

Concrete Demolition

Rock Breaking

Stone Quarrying

Free Sample! **Business Only*
Free Job Estimates!
Free Drilling Designs!

- ***Amazing 18,000 PSI Expansive Strength to break concrete & rock.***
- ***Easy to use: Drill, Mix and Pour.***
- ***No Noise, No Vibration, No Dust.***
- ***SDS is available upon request.***

- Our Technical staff can help you save time and money by allowing us to quote and discuss your next project!
- Expansion time varies by the job, the expansion process is 24 hours, cracks should be visible within that time.

Types of Dexpan®

(Based on Ambient and Core Temperature)

- **Dexpan® I** 77 to 104 F° (25 to 40 C°)
- **Dexpan® II** 50 to 77 F° (10 to 25 C°)
- **Dexpan® III** 23 to 50 F° (-5 to 10 C°)

- **In the demolition, concrete cutting and excavating industry**, Dexpan® helps break reinforced concrete and rock into chunks, so you may easily cut off rebar, haul it away without damage to the existing structure.
- **In the mining and quarrying industry**, Dexpan® helps to achieve almost perfect slabs and blocks from limestone, onyx, marble, granite or any other type of stone you are working with. Compared to blasting, Dexpan® helps to conserve the waste of valuable stone, high insurance, costly storage and labor.

- **Packaging:**
  Each 44 Lb. Box and/or Bucket contain Four 11 Lb. bags of the Dexpan Powder.
  11 Lb. Bucket Contains one 11 Lb. Bag of the Dexpan Powder.
- **Mixture:** Thick Pourable Slurry.

Dexpan® USA / Archer Company USA inc.
Technical Support: 1-866-272-4378 or +1-575-528-5454 *(Se Habla Español)*
Download Instructions, Videos, and SDS at **www.Dexpan.com**

Dexpan®

Concrete Demolition and Rock Breaking has Never been Easier!

Visit www.Dexpan.com for more Job Photos

Concrete Demolition Jobs


Demolition of Highway Bridge

Residential Demolition


Concrete Demolition

Interior Demolition

Rock Breaking Jobs


Boulder Breaking


Rock Breaking


Swimming Pool Excavating


Rock Trenching

Stone Quarrying Jobs


Granite Quarrying


Marble Quarrying


Limestone Quarrying


Sandstone Quarrying

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V20150901

SAFETY DATA SHEET

DEXPAN (Expansive Cement)

Section 1. Identification

GHS product identifier : DEXPAN (Expansive Cement)

Product code : Not available.

Other means of identification : Expanding Cement.

Product type : Powder.

Relevant identified uses of the substance or mixture and uses advised against

Identified uses : For controlled demolition, reinforced concrete cutting, rock breaking, quarrying, stone dimension, mining, excavating...

Manufacturer :
Archer Company USA, Inc.
2031 Appaloosa Dr.
Sunland Park, NM 88063
Tel: 575-528-5454
Fax: 575-528-5458
Toll Free: 866-272-4378

Distributor/Canada :

Emergency telephone number (with hours of operation) : +1-575-528-5454 (24/7)

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture :
SKIN CORROSION/IRRITATION - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3

GHS label elements

Hazard pictograms :

Signal word : Danger

Section 2. Hazards identification

Hazard statements : H318 - Causes serious eye damage.
H315 - Causes skin irritation.
H335 - May cause respiratory irritation.

Precautionary statements

Prevention : P280 - Wear protective gloves. Wear eye or face protection.
P271 - Use only outdoors or in a well-ventilated area.
P261 - Avoid breathing dust.
P264 - Wash hands thoroughly after handling.

Response : P304 + P340 + P312 - IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER or physician if you feel unwell.
P302 + P352 + P362+P364 - IF ON SKIN: Wash with plenty of soap and water. Take off contaminated clothing and wash it before reuse.
P332 + P313 - If skin irritation occurs: Get medical attention.
P305 + P351 + P338 + P310 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or physician.

Storage : P405 - Store locked up.

Disposal : P501 - Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : Not applicable.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Expanding Cement.

Ingredient name	%	CAS number
Calcium dihydroxide	≥75 - ≤90	1305-62-0

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Chemical burns must be treated promptly by a physician.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Section 4. First aid measures

Skin contact : Get medical attention immediately. Call a poison center or physician. Flush contaminated skin with plenty of water. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 20 minutes. Chemical burns must be treated promptly by a physician. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Get medical attention immediately. Call a poison center or physician. Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Chemical burns must be treated promptly by a physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye damage.

Inhalation : May cause respiratory irritation.

Skin contact : Causes skin irritation.

Ingestion : No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain
watering
redness

Inhalation : Adverse symptoms may include the following:
respiratory tract irritation
coughing

Skin contact : Adverse symptoms may include the following:
pain or irritation
redness
blistering may occur

Ingestion : Adverse symptoms may include the following:
stomach pains

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : No specific fire or explosion hazard.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
metal oxide/oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Do not breathe dust. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Avoid dust generation. Do not dry sweep. Vacuum dust with equipment fitted with a HEPA filter and place in a closed, labeled waste container. Avoid creating dusty conditions and prevent wind dispersal. Dispose of via a licensed waste disposal contractor. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not get in eyes or on skin or clothing. Do not breathe dust. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Section 7. Handling and storage

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

United States

Occupational exposure limits

Ingredient name	Exposure limits
Calcium dihydroxide	**ACGIH TLV (United States, 3/2017).** TWA: 5 mg/m³ 8 hours. **NIOSH REL (United States, 10/2016).** TWA: 5 mg/m³ 10 hours. **OSHA PEL (United States, 6/2016).** TWA: 5 mg/m³ 8 hours. Form: Respirable fraction TWA: 15 mg/m³ 8 hours. Form: Total dust

Canada

Occupational exposure limits

Ingredient name	Exposure limits
Calcium dihydroxide	**CA Alberta Provincial (Canada, 4/2009).** 8 hrs OEL: 5 mg/m³ 8 hours. **CA British Columbia Provincial (Canada, 7/2016).** TWA: 5 mg/m³ 8 hours. **CA Ontario Provincial (Canada, 7/2015).** TWA: 5 mg/m³ 8 hours. **CA Quebec Provincial (Canada, 1/2014).** TWAEV: 5 mg/m³ 8 hours. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 10 mg/m³ 15 minutes. TWA: 5 mg/m³ 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls : In some cases, dust collection, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Section 8. Exposure controls/personal protection

Eye/face protection	Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles and/or face shield. If inhalation hazards exist, a full-face respirator may be required instead.
Skin protection	
Hand protection	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.
Body protection	Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection	Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory protection	Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.

Section 9. Physical and chemical properties

Appearance	
Physical state	Solid. [Powder.]
Color	Gray.
Odor	Odorless.
Odor threshold	Not available.
pH	Not available.
Melting point	1000°C (1832°F)
Boiling point	Not available.
Flash point	Not available.
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Lower and upper explosive (flammable) limits	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	3.2
Solubility	Very slightly soluble in the following materials: cold water.
Partition coefficient: n-octanol/water	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.
Flow time (ISO 2431)	Not available.

Section 10. Stability and reactivity

Reactivity	No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	The product is stable.
Possibility of hazardous reactions	Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	No specific data.
Incompatible materials	Reactive or incompatible with the following materials: moisture.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Calcium dihydroxide	LD50 Oral	Rat	7340 mg/kg	-

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
Calcium dihydroxide	Eyes - Severe irritant	Rabbit	-	10 mg	-

Sensitization

There is no data available.

Mutagenicity

There is no data available.

Carcinogenicity

There is no data available.

Reproductive toxicity

There is no data available.

Teratogenicity

There is no data available.

Specific target organ toxicity (single exposure)

Name	Category	Target organs
Calcium dihydroxide	Category 3	Respiratory tract irritation

Specific target organ toxicity (repeated exposure)

There is no data available.

Aspiration hazard

There is no data available.

Information on the likely routes of exposure	Dermal contact. Eye contact. Inhalation. Ingestion.

Potential acute health effects

Section 11. Toxicological information

Eye contact : Causes serious eye damage.

Inhalation : May cause respiratory irritation.

Skin contact : Causes skin irritation.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain
watering
redness

Inhalation : Adverse symptoms may include the following:
respiratory tract irritation
coughing

Skin contact : Adverse symptoms may include the following:
pain or irritation
redness
blistering may occur

Ingestion : Adverse symptoms may include the following:
stomach pains

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : No known significant effects or critical hazards.

Potential delayed effects : No known significant effects or critical hazards.

Long term exposure

Potential immediate effects : No known significant effects or critical hazards.

Potential delayed effects : No known significant effects or critical hazards.

Potential chronic health effects

General : Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

There is no data available.

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
Calcium dihydroxide	Acute LC50 33884.4 µg/L Fresh water	Fish - Clarias gariepinus - Fingerling	96 hours

Persistence and degradability

There is no data available.

Bioaccumulative potential

There is no data available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	TDG Classification	IMDG	IATA
UN number	Not regulated.	Not regulated.	Not regulated.	Not regulated.
UN proper shipping name	-	-	-	-
Transport hazard class(es)	-	-	-	-
Packing group	-	-	-	-
Environmental hazards	No.	No.	No.	No.

AERG : Not applicable.

Section 14. Transport information

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : SKIN CORROSION/IRRITATION - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3

Composition/information on ingredients

Name	Classification
Calcium dihydroxide	SKIN CORROSION/IRRITATION - Category 2 SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1 SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3

SARA 313

There is no data available.

State regulations

Massachusetts : The following components are listed: Calcium dihydroxide; Silica, vitreous; Diiron trioxide; Aluminium oxide

New York : None of the components are listed.

New Jersey : The following components are listed: Calcium dihydroxide; Silica, vitreous; Diiron trioxide; Aluminium oxide

Pennsylvania : The following components are listed: Calcium dihydroxide; Diiron trioxide; Aluminium oxide

California Prop. 65

This product does not require a Safe Harbor warning under California Prop. 65.

Section 15. Regulatory information

Canada

Canadian lists

Canadian NPRI : None of the components are listed.

CEPA Toxic substances : None of the components are listed.

Canada inventory (DSL NDSL) : All components are listed or exempted.

Section 16. Other information

Procedure used to derive the classification

Classification	Justification
SKIN CORROSION/IRRITATION - Category 2	Calculation method
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 1	Calculation method
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Respiratory tract irritation) - Category 3	Calculation method

History

Date of issue mm/dd/yyyy : 04/30/2019

Date of previous issue : 04/15/2015

Version : 7

Prepared by : KMK Regulatory Services Inc.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

LAFARGE
CEMENT

eco
80 % reduction in CO_2
65 % recycled materials

TerraFlow® Mill Test Report

Month of Issue: July 2022

Plant:	**Seattle, Washington**
Product:	**TerraFlow 75**
Manufactured:	**June 2022**
Mill Test Report Number:	**TerraFlow75_July2022**

ASTM C 1157 Standard Requirements

CHEMICAL ANALYSIS

Item	Spec limit	Test Result
Slag, %	---	75
Type IL, %	---	25

PHYSICAL ANALYSIS

Item	Spec limit	Test Result
Passing 325 Sieve (%)	---	96.8
Autoclave expansion (%)	0.8	-0.05
Compressive strength (MPa)		
3 days	5.0 min	15.1
7 days	11.0 min	23.1
28 days	--	36.4

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirements of applicable Specifications for Type MH

Certified By:

Robert D. Shogren

Rob Shogren Technical Director

July 1, 2022

Seattle Plant
5400 W. Marginal Way SW, Seattle, WA 98106
Phone: 206-937-8025

LAFARGE
CEMENT

eco
45% reduction in CO_2

MaxCem® Mill Test Report

Month of Issue: July 2022

Plant:	**Seattle, Washington**
Product:	**MaxCem® - Type IT(L11)(S30)MS**
Month of Production:	**June of 2022**
Mill Test Report Number:	**SEA_MAXCEM_July2022**

ASTM C 595 and AASHTO M 240 Standard Requirements

CHEMICAL ANALYSIS

Item	Spec limit	Test Result
Rapid Method, X-Ray *(C 114)*		
SiO2 (%)	---	25.8
Al2O3 (%)	---	8.7
Fe2O3 (%)	---	2.1
CaO (%)	---	56.2
MgO (%)	---	3.0
Sulphate as SO3 (%)	3.0 max*	3.4
Loss on ignition (%)	10.0 max	4.0
Total Alkalis (Type IL)	---	0.37
Slag addition (%)		30
Richmond Type IL (%)		70

PHYSICAL ANALYSIS

Item	Spec limit	Test Result
Air content of mortar (%) *(C 185)*	12 max	5
Blaine Fineness (m2/kg) *(C 204)*	---	488
Fineness, Residue retained on a 45 um sieve (%)	---	3.6
Autoclave expansion (%) *(C 151)*	0.80 max -0.20 min	-0.02
Compressive strength ([PSI]) *(C 109)*		
3 days	1890 min	3440
7 days	2900 min	4670
28 days Previous Month	3620 min	5710
Time of setting (minutes)		
Vicat Initial *(C 191)*	45 - 420	153
C-1038 Expansion 14-day (%) (C 1038)*	0.020	0.005

*Table 1 chemical requirements states that SO3 content above 3.0 is permissible if the C1038 expansion is below 0.020% at 14 days.

We certify that the above described cement, at the time of shipment, meets the chemical and physical ASTM C595 Standard Requirements and AASHTO M 240.

Certified By:

Robert G. Shogren

Rob Shogren - Techincal Director

July 1, 2022

Lafarge PNW, Inc - Seattle Plant
5400 W. Marginal Way SW, Seattle, WA 98106
Phone: 206-937-8025