Public Works and Government Services Canada

Requisition No.: EZ897-180975/A

Buy and Sell ID No.: _____

Specifications for

LIF and Hydraulic Profiling Survey

Muncho Lake Maintenance Camp, KM 698, Alaska Highway, BC and Fireside Maintenance Camp, KM 839, Alaska Highway, BC

Project No. R.016701.006/007 and R.018388.006/007

APPROVED BY:

Regional Manager ES — Date: 3 Aug 2017

Construction Safety Coordinator — Date: 17.08.03

TENDER:

Project Manager — Date: 2017-08-03

Real Property Services Branch, Professional and Technical Services, Pacific Region
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Canada

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1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. Pre-mobilization Submittals will be paid in accordance with lump sum price established for all Preconstruction Meetings, planning, health and safety, and other Submittals in accordance with the Contract or required and accepted by the Departmental Representative as in accordance with the Contract prior to mobilization to Site.

1.1.2. Mobilization/Demobilization to Muncho Lake / Fireside will be paid in accordance with lump sum price established for mobilizing all necessary equipment, materials, supplies, facilities, and personnel associated with the Works to the Site. Includes initial insurance and permits. Additional insurance and permits due to changes in scope, cost, and schedule as accepted by the Departmental Representative will be included in Contract amendments. Initial mobilization will be to Muncho Lake. Demobilization will take place from Fireside. Includes utility location and protection at each of the sites.

1.1.3. Laser-Induced Fluorescence (LIF) Survey (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance LIF tool for subsurface evaluation of hydrocarbon concentrations in accordance with the Contract. Measurement per metre LIF tool advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the LIF survey. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Muncho Lake not included in Mobilization/Demobilization.

1.1.4. LIF Survey (Fireside) will be paid in accordance with unit rate price established per metre to advance LIF tool for subsurface evaluation of hydrocarbon concentrations in accordance with the Contract. Measurement per metre LIF tool advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the LIF survey. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.1.5. Hydraulic Profiling Survey (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance the Hydraulic Profiling probe for subsurface evaluation of hydrostatic pressure in accordance with the Contract. Measurement per metre probe advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the Hydraulic Profiling Survey. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Muncho Lake not included in Mobilization/Demobilization.

1.1.6. Hydraulic Profiling Survey (Fireside) will be paid in accordance with unit rate price established per metre to advance the Hydraulic Profiling probe for subsurface evaluation of hydrostatic pressure with the Contract. Measurement per metre probe advanced as recorded time by the Departmental Representative.

Includes all equipment, machinery, consumables and labour required to undertake the Hydraulic Profiling Survey. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.1.7. "Pre-probing" (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance the drill tooling to necessary depths prior to data collection or deploying the LIF or Hydraulic Profiling probes in accordance with the Contract. Measurement per metre tooling advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the "Pre-probing". Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Muncho Lake not included in Mobilization/Demobilization.

1.1.8. "Pre-probing" (Fireside) will be paid in accordance with unit rate price established per metre to advance drill tooling to necessary depths prior to data collection or deploying the LIF or Hydraulic Profiling probes in accordance with the Contract. Measurement per metre tooling advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the "Pre-probing". Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.1.9. Soil Sample Collection (Muncho Lake) will be paid in accordance with unit rate price established per soil sample to collect soil samples at the prescribed locations and depth as directed by the Departmental Representative and in accordance with the Contract. Measurement per sample as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to collect the representative soil samples. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Muncho Lake not included in Mobilization/Demobilization. Includes supplying sufficient number of drums for placement and on-site storage of soil cuttings as directed by the Departmental Representative.

1.1.10. Soil Sample Collection (Fireside) will be paid in accordance with unit rate price established per soil sample to collect soil samples at the prescribed locations and depth as directed by the Departmental Representative and in accordance with the Contract. Measurement per sample as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to collect the representative soil samples. Includes wear and tear and damage to equipment and tooling. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization. Includes supplying sufficient number of drums for placement and on-site storage of soil cuttings as directed by the Departmental Representative.

1.1.11. Closeout Submittals will be paid in accordance with lump sum price established for all data and reports generated for the LIF and Hydraulic Profiling Survey as instructed by the Departmental Representative.

1.2. Measurement Procedures (Optional Items)

1.2.1. Optional LIF Survey (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance the LIF tool for subsurface evaluation of hydrocarbon concentrations in accordance with the Contract. Measurement per metre LIF tool advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the LIF survey. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.2.2. Optional LIF Survey (Fireside) will be paid in accordance with unit rate price established per metre to advance LIF tool for subsurface evaluation of hydrocarbon concentrations in accordance with the Contract. Measurement per metre LIF tool advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the LIF survey. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.2.3. Optional Hydraulic Profiling Survey (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance the Downhole Pressure Transducer probe for subsurface evaluation of hydrostatic pressure in accordance with the Contract. Measurement per metre probe advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the Hydraulic Profiling Survey. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.2.4. Optional Hydraulic Profiling Survey (Fireside) will be paid in accordance with unit rate price established per metre to advance the Downhole Pressure Transducer probe for subsurface evaluation of hydrostatic pressure in accordance with the Contract. Measurement per metre probe advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the Hydraulic Profiling Survey. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.2.5. Optional “Pre-probing” (Muncho Lake) will be paid in accordance with unit rate price established per metre to advance drill tooling to necessary depths prior to data collection or deploying the LIF or Hydraulic Profiling probes in accordance with the Contract. Measurement per metre tooling advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to undertake the “Pre-probing”. Includes accommodation and travel time to and from Muncho Lake not included in Mobilization/Demobilization.

1.2.6. Optional “Pre-probing” (Fireside) will be paid in accordance with unit rate price established per metre to advance drill tooling to necessary depths prior to data collection or deploying the LIF or hydraulic profiling probes in accordance with the Contract. Measurement per metre tooling advanced as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and

labour required to undertake the "Pre-probing". Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization.

1.2.7. Optional Soil Sample Collection (Muncho Lake) will be paid in accordance with unit rate price established per soil sample to collect soil samples at the prescribed locations and depth as directed by the Departmental Representative and in accordance with the Contract. Measurement per sample as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to collect the representative soil samples. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization. Includes supplying sufficient number of drums for placement and on-site storage of soil cuttings as directed by the Departmental Representative.

1.2.8. Optional Soil Sample Collection (Fireside) will be paid in accordance with unit rate price established per soil sample to collect soil samples at the prescribed locations and depth as directed by the Departmental Representative and in accordance with the Contract. Measurement per sample as recorded by the Departmental Representative. Includes all equipment, machinery, consumables and labour required to collect the representative soil samples. Includes accommodation and travel time to and from Fireside not included in Mobilization/Demobilization. Includes supplying sufficient number of drums for placement and on-site storage of soil cuttings as directed by the Departmental Representative.

1.3. Definitions

1.3.1. Certificate of Completion: see General Conditions.

1.3.2. Change Order: PWGSC form issued by the Departmental Representative to the Contractor as per the relevant Contemplated Change Notice.

1.3.3. Soil Samples: soil samples collected by the Departmental Representative.

1.3.4. Contaminated Material: soil, sediment, and other solid material where substances occur at concentrations that: (i) are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment, or (ii) exceed the levels specified in policies and regulations. Includes Hazardous Waste and Waste Quality; does not include Non-Contaminated Material or Waste. Relevant regulations, unless otherwise in accordance with the Contract or as directed by the Departmental Representative, include:

1.3.4.1. For all sites: Canadian Council of Ministers of the Environment (CCME) *Canadian Environmental Quality Guidelines* and CCME *Canada-Wide Standards*.

1.3.4.2. For sites in BC: BC *Hazardous Waste Regulations*, BC *Approved Water Quality Guidelines*, BC *Contaminated Sites Regulation*.

1.3.5. Contaminated Water: liquid material where substances occur at concentrations that: (i) are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment, or (ii) meet or exceed the levels specified in policies and regulations. Includes Hazardous Waste and Waste Quality Water; does not include Non-Contaminated Water or Sewage Wastewater. Relevant regulations, unless otherwise in accordance with the Contract or as directed by the Departmental Representative, include:

1.3.5.1. For all sites: Canadian Council of Ministers of the Environment (CCME) *Canadian Environmental Quality Guideline*s and CCME *Canada-Wide Standards*.

1.3.5.2. For sites in BC: BC *Hazardous Waste Regulations*, BC *Approved Water Quality Guidelines*.

1.3.6. Contemplated Change Notice: PWGSC form issued by the Departmental Representative to the Contractor requesting Contractor to provide a quote, which may result in a Change Order.

1.3.7. Contract: see General Conditions.

1.3.8. Contract Amount: see General Conditions.

1.3.9. Contractor: see General Conditions.

1.3.10. Departmental Representative: see General Conditions.

1.3.11. Environmental Pollution and Damage: presence of chemical, physical, biological elements or agents which adversely affect human health and welfare; unfavourably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade environment aesthetically, culturally and/or historically.

1.3.12. Environmental Protection: prevention, control, mitigation, and restoration of pollution and habitat or environmental disruption during construction. Control of Environmental Pollution and Damage requires consideration of land, water, and air; biological and cultural resources; and includes management of visual aesthetics; vibrations; noise; solid, chemical, gaseous, and liquid waste; radiant energy and radioactive material as well as other pollutants.

1.3.13. Environmental Protection Plan: plan developed by the Contractor to ensure Environmental Protection and prevent Environmental Pollution and Damage identifying all environmental risks and mitigation measures, including: personnel requirements, emergency contacts, Environmental Protection methods, procedures, and equipment, and emergency response including a Spill Control Plan.

1.3.14. Extension of Time: see General Conditions.

1.3.15. Extension of Time on Contracts: PWGSC form requesting an Extension of Time.

1.3.16. Final Completion: see General Conditions.

1.3.17. Hazardous Waste: Contaminated Material which meets the regulatory definition of Hazardous Waste.

1.3.18. Laser-induced fluorescence (LIF): a survey technique uses laser light to excite fluorescent molecules including PAHs that exist in the vast majority of hydrocarbons including petroleum fuels/oils. The LIF survey is intended to provide a continual proportional representation (i.e., semi-quantitative) of the hydrocarbon concentrations present with depth.

1.3.19. Hydraulic profiling: a survey technique that measures the pressure required to inject a flow of water into the soil profile. Measurement of the injection and hydrostatic pressures are made using a downhole pressure transducer within a hydraulic profiling probe as it is advanced into the subsurface.

1.3.20. Land Surveyor: a person working for the Contractor who is a qualified, registered land surveyor licensed to practice in relevant jurisdiction.

1.3.21. Landfill Facility: an existing offsite facility located in Canada that is designed, constructed and operated to prevent any pollution from being caused by the facility outside the area of the facility from waste placed in or on land within the facility.

1.3.22. Materials Source Separation Program: consists of a series of ongoing activities to separate reusable and recyclable waste into categories from other types of waste at point of generation.

1.3.23. Non-Contaminated Material: soil, sediment, and other solid material excavated incidentally which meets the BC Contaminated Sites Regulation Schedule 7 Column IV.

1.3.24. Non-Contaminated Water: liquids which are suitable for direct discharge to the environment after removal of sediment, and which is not Contaminated Water or Sewage Wastewater. Includes surface runoff, stormwater, and groundwater which have not come into contact with Contaminated Material.

1.3.25. On Site Instruction: notices, instructions, or directions issued by the Departmental Representative to the Contractor.

1.3.26. On Site Notice: notice or other communication issued by the Contractor to the Departmental Representative.

1.3.27. Overburden: Non-Contaminated Material excavated incidentally above Contaminated Material Extents that is not Topsoil or Contaminated Material.

1.3.28. Progress Payment: see General Conditions.

1.3.29. PWGSC: Public Works and Government Services Canada. Representative of Canada with control of the Site.

1.3.30. Qualified Professional: a person working for the Contractor who is registered in relevant jurisdiction with his or her appropriate professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association, and through suitable education, experience, accreditation and knowledge can be reasonably relied on to provide advice within his or her area of expertise. Includes Geotechnical Engineers and Environmental Consultants.

1.3.31. Quote: Contractor's cost estimate issued to the Departmental Representative as per the relevant Contemplated Change Notice via an On Site Notice.

1.3.32. Sewage Wastewater: liquid waste which is not suitable for direct discharge to the environment, and which must be either treated offsite or discharged to a sanitary sewer. Includes water from hand basin, shower, personal hygiene facilities, or other liquid waste from sanitary facilities.
1.3.33. Site: work area available to Contractor according to Drawings. Does not include shared or public areas, including common roads.
1.3.34. Subcontractor: see General Conditions.
1.3.35. Submit/Submittals: documents from the Contractor to the Departmental Representative as: required by Contract; stipulated in permit, certificate, approval, or any other form of authorization; by convention or industry practice. Submittals are final only after review and accepted in writing by the Departmental Representative.
1.3.36. Substantial Performance: see General Conditions.
1.3.37. Superintendent: see General Conditions.
1.3.38. Supplier: see General Conditions.
1.3.39. Transfer/Interim Storage Facility: a facility specifically used to transfer or short term storage Contaminated Material during offsite transport.
1.3.40. Treatment Facility: a facility specifically used to treat Contaminated Material. May be Onsite or Offsite. Onsite facility is located on property under PWGSC control, but may be located at a different location than where construction work occurs.
1.3.41. Waste: Non-Contaminated Material that is not soil. Includes cleared and grubbed vegetation, litter, rubbish, debris, cobbles, boulders, excess construction material, lumber, steel, plastic, concrete, and asphalt.
1.3.42. Waste Quality: soil or other material that is not suitable for industrial, commercial, urban park, residential, agricultural, wildlands or any other land use specified in the BC Contaminated Sites Regulation.
1.3.43. Waste Reduction Plan: a written report which addresses opportunities for reduction, reuse or recycling of materials.
1.3.44. Work: see General Conditions.
1.3.45. Working Day: see General Conditions.

1.4. Action and Informational Submittals

1.4.1. After hours work: at least 5 Working Days prior to commencing after hours work Submit a schedule showing requested dates, times, and reasons for after hours work. Approval will only be granted for reasons valid in the opinion of the Departmental Representative and if request can be reasonably accommodated by other contracts.

1.5. Work Covered by Contract

1.5.1. Work under the Contract covers the LIF and Hydraulic Profiling survey at Muncho Lake and Fireside.

1.5.2. Work to be performed under the Contract includes, but is not limited to, the following items covered further in the Contract:

1.5.2.1. Prime Contractor for health and safety and environmental protection at Site. Contractor is responsible for utility location and protection at Muncho Lake and Fireside for the work.

1.5.2.2. Pre-mobilization Submittals.

1.5.2.3. Progress Submittals, including cash flow and forecasting.

1.5.2.4. Complete the LIF Survey at Muncho Lake at the locations and to the depths specified by the Departmental Representative.

1.5.2.5. Complete the LIF Survey at Fireside at the locations and to the depths specified by the Departmental Representative.

1.5.2.6. Complete the Hydraulic Profiling Survey at Muncho Lake at the locations and to the depths specified by the Departmental Representative.

1.5.2.7. Complete the Hydraulic Profiling Survey at Fireside at the locations and to the depths specified by the Departmental Representative.

1.5.2.8. Complete “Pre-probing” at Muncho Lake at the locations and depths specified by the Departmental Representative.

1.5.2.9. Complete “Pre-probing” at Fireside at the locations and depths specified by the Departmental Representative.

1.5.2.10. Collect representative subsurface soil samples at Muncho Lake suitable for analytical testing at the locations and to the depths specified by the Departmental Representative.

1.5.2.11. Collect representative subsurface soil samples at Fireside suitable for analytical testing at the locations and to the depths specified by the Departmental Representative.

1.5.2.12. Capture and collect all waste soil generated to complete the work into drums or other containers as approved by the Departmental Representative for long-term storage on each of the respective work sites (Muncho Lake / Fireside). Sufficient number of drums to be supplied by the contractor for both the work and optional work.

1.5.2.13. Closure Submittals.

1.5.2.14. All ancillary activities required to complete Work.

1.5.3. Green Requirements:

1.5.3.1. Use only environmentally responsible green materials/products with no Volatile Organic Compounds (VOC) emissions or minimum VOC emissions of indoor off-gassing contaminants for improved indoor air quality – subject of acceptance of Submittal of Materials Safety Data Sheet (MSDS) Product Data.

1.5.3.2. Use materials/products containing highest percentage of recycled and recovered materials practicable – consistent with maintaining cost effective satisfactory levels of competition.

1.5.3.3. Adhere to waste reduction requirement for reuse or recycling of waste materials, thus diverting materials from any landfill.

1.5.4. Work not included in the Contract comprises such work and services specifically listed as:
1.5.4.1. Not Used.

1.6. Location
1.6.1. The Site location is shown on Drawings.
1.6.2. There is no civic street address or PIN for the Sites.

1.7. Project/Site Conditions
1.7.1. Work at Site will involve contact with contaminated materials, requiring appropriate health and safety and environmental protection procedures.
1.7.2. Complete list of anticipated contaminants and concentration levels on the Site available separately in assessment reports.
1.7.3. Existing condition on the Site identified according to Drawings. Surface cover consists of gravel.

1.8. Other Contracts
1.8.1. Other contracts are currently in progress at Site.
1.8.2. Other contracts are:
1.8.2.1. Environmental and other consultants.
1.8.2.2. Site users as identified in Contract Documents.
1.8.3. Further contracts may be awarded while the Contract is in progress.
1.8.4. Cooperate with other contractors in carrying out their respective works and carry out directions from Departmental Representative.
1.8.5. Coordinate Work with that of other contractors. If any part of Work under the Contract depends for its proper execution or result upon Work of another contractor, report promptly to Departmental Representative, in writing, any defects which can interfere with proper execution of this Work.

1.9. Products Supplied by the Departmental Representative
1.9.1. Not Used.

1.10. Contractor's Use of Site
1.10.1. Use of Site:
1.10.1.1. For the sole benefit of Canada.
1.10.1.2. Exclusive and only for completion of the execution of Work.
1.10.1.3. Assume responsibility for assigned premises for performance of this Work.
1.10.2. Be responsible for coordination of all Work activities onsite, including the Work of other contractors engaged by the Departmental Representative.
1.10.3. There are no pre-existing arrangements for encroachment on the neighbouring properties. Shoring designs accommodating no offsite encroachment, or arrangements for offsite encroachment, are the responsibility of the Contractor.
1.10.4. Perform Work in accordance with Contract. Ensure Work is carried out in accordance with schedule accepted by the Departmental Representative.

1.10.5. Do not unreasonably encumber Site with material or equipment.
1.10.6. Accommodate common areas with other Site users, including roadways.
1.10.7. Segregate Contractor's work area from common areas to prevent unintentional multiple employer worksite, as required.

1.11. Existing Permits
1.11.1. Existing permits are:
1.11.1.1. None.

1.12. Schedule Requirements
1.12.1. Work to be initiated: within 5 Working Days of Contract Award.
1.12.2. Pre-Mobilization Submittals: within 5 Working Days of Contract Award.
1.12.3. Site Works: Final Completion no later than November 17, 2017.
1.12.4. Completion of the Work: no later than December 15, 2017. Includes all final Submittals.

1.13. Hours of Work
1.13.1. Restrictive as follows:
1.13.1.1. Maximum Working Day work hours including travel to and from Site from accommodation are 07:00 to 19:00 Monday to Saturday.
1.13.2. Obtain consent from Departmental Representative for all after hours Work, including Sundays and holidays.
1.13.2.1. Proceed only as directed by the Departmental Representative.

1.14. Security Clearances
1.14.1. Not Used.

1. PART 2 - PRODUCTS

1.1. Not Used
1.1.1. Not Used.

2. PART 3 - EXECUTION

2.1. Not Used
2.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Utility Locations: Prior to commencing any subsurface disturbance, Submit drawings identifying all utilities on the Site. Update drawings as directed by the Departmental Representative.

1.3.2. Breakdown of Lump Sum Prices: at least 5 Working Days prior to submitting the first Progress Payment, Submit a breakdown of the Contract lump sum prices including labour, material and time, in detail as directed by the Departmental Representative and aggregating Contract Amount.

1.3.3. Daily Work Records: at the end of each shift Submit daily Work records, during onsite Work. Include:

1.3.3.1. Quantities for each Description of Work identified in the Unit Price Table and Change Orders.

1.3.3.2. Description of Work performed.

1.3.3.3. Current Site conditions.

1.3.3.4. General information including: date, time shift started and ended, Subcontractor(s) onsite, Health and Safety items, and Environmental Protection items.

1.3.3.5. Signature of Superintendent.

1.3.4. Cash Flow: with each Progress Payment, Submit a cash flow forecast. Include:

1.3.4.1. Calculation of planned cost versus actual cost and schedule forecasting and cash flow projections on a monthly basis, indicating anticipated value of future Progress Payments, for each Description of Work identified in the Unit Price Table.

1.3.4.2. Progress Payments will not be processed until cash flow has been accepted by the Departmental Representative.

1.3.5. Coordination Meeting Minutes and Drawings: at least 5 Working Days prior to relevant Work commencing, Submit final meeting minutes and drawings from coordination with Subcontractors.

1.3.6. Quality Management Plan: within 5 Working Days after Contract award, submit a quality management plan. Include:

1.3.6.1. Details on planned review, inspection and testing to provide Quality Assurance and Quality Control for the Work.

1.3.6.2. Subcontractors responsible for review, inspection and testing.

1.3.6.3. Schedule of submittals of review, inspection and testing results.

1.3.7. Review, Inspection, and Testing Results: within 5 Working Days of receipt, Submit all results of reviews, inspection, and testing performed as part of the Work, including laboratory reports and sampling chains of custody.

1.4. Division of Specifications

1.4.1. This specification is subdivided into Divisions and Sections in accordance with the six digit National Master Specifications System.

1.4.2. A Division or Section may consist of the Work of more than one Subcontractor. Responsibility for determining which Subcontractor provides the labour, material, equipment and services required to complete the Work rests solely with the Contractor.

1.5. Documents Required

1.5.1. Maintain 1 copy each of the following posted at the job Site:

1.5.1.1. General Conditions.
1.5.1.2. Drawings.
1.5.1.3. Specifications.
1.5.1.4. Addenda or other modifications to Contract.
1.5.1.5. Change orders.
1.5.1.6. Copy of current Work schedule.
1.5.1.7. Reviewed and final Shop Drawings Submittals.
1.5.1.8. One set of record Shop Drawings and Specifications for “as-built” purposes.
1.5.1.9. Field and laboratory test reports.
1.5.1.10. Reviewed and accepted Submittals.
1.5.1.11. Manufacturers’ installation and application instructions (as appropriate).
1.5.1.12. *National Building Code of Canada* (as appropriate).
1.5.1.13. Current construction standards of workmanship listed in technical Sections (as appropriate).
1.5.1.14. Health and Safety documents, including all daily toolbox meetings, Notice of Project and utility clearances.
1.5.1.15. Environmental Protection Plan.
1.5.1.16. Quality Management Plan.
1.5.1.17. Final Meeting Minutes, Agendas and associated attachments.
1.5.1.18. Permits and other approvals (as appropriate).

1.6. Setting out of Work

1.6.1. Assume full responsibility for and execute complete layout of Work to locations, lines and elevations according to Drawings.

1.6.2. Provide devices needed to layout and construct Work.

1.6.3. Supply such services and devices in accordance with the Contract to facilitate Departmental Representative’s inspection of Work.

1.7. Acceptance of Substrates

1.7.1. Each trade must examine surfaces prepared by others and job conditions which can affect his work, and must report defects to the Departmental Representative. Commencement of Work will imply acceptance of prepared Work or substrate surfaces.

1.8. Works Coordination

1.8.1. Coordinate Work of Subcontractors.

1.8.1.1. Designate one person to be responsible for review of Contract and Shop Drawings and managing coordination of Work.

1.8.2. Convene meetings between Subcontractors whose Work interfaces and ensure awareness of areas and extent of interface required.

1.8.2.1. Provide each Subcontractor with complete Drawings and Specifications for Contract as required, to assist them in planning and carrying out their respective work.

1.8.2.2. Develop coordination drawings when required, illustrating potential interference between Work of various trades and distribute to affected parties.

1.8.2.3. Facilitate meeting and review coordination drawings. Ensure Subcontractors agree and sign off on coordination drawings.

1.8.2.4. Publish minutes of each meeting.

1.8.2.5. Submit a copy of coordination drawings and meeting minutes as directed by the Departmental Representative.

1.8.3. Submit Shop Drawings and order of prefabricated equipment or rebuilt components as required only after coordination meeting for such items has taken place.

1.8.4. Work coordination:

1.8.4.1. Ensure cooperation between trades in order to facilitate general progress of Work and avoid situations of spatial interference.

1.8.4.2. Ensure that each trade provides all other trades reasonable opportunity for Final Completion of Work and in such a way as to prevent unnecessary delays, cutting, patching and removal or replacement of completed Work.

1.8.4.3. Ensure disputes between Subcontractors are resolved.

1.8.5. Failure to coordinate Work is responsibility of Contractor.

1.9. Approvals of Shop Drawings, Product Data and Samples

1.9.1. Submit as directed by the Departmental Representative the requested Shop Drawings, product data, MSDS sheets and samples in accordance with the Contract.

1.9.2. Allow sufficient time for the following:

1.9.2.1. Review of product data.

1.9.2.2. Acceptance of Shop Drawings.

1.9.2.3. Review of re-submission.

1.9.2.4. Ordering of accepted material and/or products.

1.10. Relics and Antiquities

1.10.1. See General Conditions.

1.11. Additional Drawings

1.11.1. The Departmental Representative may furnish additional Drawings for clarification. These additional Drawings have the same meaning and intent as if they were included with Drawings referred to in the Contract.

1.11.2. Upon request, Departmental Representative may furnish up to a maximum of 2 sets of Drawings for use by the Contractor at no additional cost. Should more than 2 sets of documents be required the Departmental Representative will provide them at additional cost.

1.12. Record Keeping

1.12.1. On Site Instruction: Contractual correspondence from the Departmental Representative to the Contractor. Does not include Contemplated Change Notices, Change Orders, and Extension of Time on Contracts. Sequentially numbered On Site Instructions. Include cross references to applicable On Site Notifications. The status of the Contractor, including the function of Prime Contractor, must not change by reason of any On Site Instructions.

1.12.2. On Site Notifications: Contractual correspondence from Contractor to the Departmental Representative. Includes Submittals. Does not include Quotes, and Extension Of Time On Contracts. Must be as a sequentially numbered On Site Notifications. Include cross references to applicable On Site Instructions. The status of the Contractor, including the function of Prime Contractor, must not change by reason of any On Site Notifications.

1.12.3. Maintain adequate records to support information provided to Departmental Representative.

1.12.4. Maintain bills of ladings for minimum of 300 Working Days from date of shipment or longer period required by applicable law or regulation.

1.13. Change Documents

1.13.1. Change Documents do not relieve Contractor of any obligation.

1.13.2. Change Documents do not change the Contractor's responsibility for sequencing, methods and means.

1.13.3. Change Documents do not change by any reason the status of the Contractor, including the function of Prime Contractor or as supervisor.

1.13.4. Change Documents include:

1.13.4.1. Change Order: There may be a change to the Contract Amount by reason of any Change Order. No Extension of Time for completion of the Work by reason of any Change Order.

1.13.4.2. Contemplated Change Notice: No increase to the Contract Amount by reason of any Contemplated Change Notice. No Extension of Time for completion of the Work by reason of any Contemplated Change Notice.

1.13.4.3. Extension of Time on Contracts: No increase to the Contract Amount by reason of any Extension of Time on Contracts. There may be an Extension of Time for completion of the Work by reason of an Extension of Time on Contracts.

1.13.4.4. Quote: No increase to the Contract Amount by reason of any Quote. No Extension of Time for completion of the Work by reason of any Quote. The status of the Contractor, including the function of Prime Contractor, must not change by reason of any Quote.

1.14. System of Measurement

1.14.1. The metric system of measurement (SI) will be employed on the Contract.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Preconstruction Meeting Minutes: within 2 Working Days of the Preconstruction Meeting, Submit meeting minutes.

1.3.2. Progress Meeting Minutes: within 2 Working Days of a Progress Meeting, Submit meeting minutes. Submit revised minutes within 2 Working Days of receiving comments by Departmental Representative.

1.3.3. Information for Progress Meetings: at least 2 Working Days prior to scheduled Progress Meetings, Submit all information in accordance with the Contract for Progress Meetings. Include:

1.3.3.1. Agenda for the proposed Progress Meeting.

1.3.3.2. Updated Project Schedule.

1.3.3.3. Copies of transport manifests and disposal receipts for all materials removed from Site.

1.3.3.4. Other information as directed by the Departmental Representative or relevant to agenda for upcoming progress meeting.

1.3.4. Final Site Inspection: within 2 Working Days of the Final Site Inspection, Submit meeting minutes.

1.3.5. Closeout Meetings: within 2 Working Days of the Closeout Meeting, Submit meeting minutes.

1.4. Administrative

1.4.1. Schedule and administer project meetings throughout the progress of the Work weekly and at the call of the Departmental Representative.

1.4.2. Prepare agenda for meetings.

1.4.3. Submit written notice with agenda of each meeting 2 Working Days in advance of meeting date as directed by the Departmental Representative.

1.4.4. Provide physical space and make arrangements for meetings, or arrange for teleconference meetings, as directed by Departmental Representative.

1.4.5. Preside at meetings.

1.4.6. Record the meeting minutes. Include significant proceedings and decisions. Identify actions by parties.

1.4.7. Maintain records of meeting minutes for a minimum of 2 years after Work is completed.

1.4.8. Representative of Contractor, Subcontractor(s) and Supplier(s) attending meetings must be qualified and authorized to act on behalf of party each represents.

1.5. Preconstruction Meeting

1.5.1. Within 5 Working Days after award of Contract, request a meeting of parties in Contract to discuss and resolve administrative procedures and responsibilities.

1.5.2. Departmental Representative, Contractor, Superintendent, major Subcontractor(s), field inspectors and supervisors must be in attendance.

1.5.3. Establish time and location of meeting subject to approval by Departmental Representative and notify parties concerned at least 3 Working Days before meeting.

1.5.4. Agenda to include:

1.5.4.1. Appointment of official representative of participants in the Work, including Contractor's Superintendent and Departmental Representative.

1.5.4.2. Schedule of Work.

1.5.4.3. Schedule of Submittals.

1.5.4.4. Requirements for temporary facilities.

1.5.4.5. Site security.

1.5.4.6. Change orders, procedures, approvals required, administrative requirements.

1.5.4.7. Monthly Progress Payments, administrative procedures, hold backs.

1.5.4.8. Appointment of inspection and testing agencies or firms.

1.5.4.9. List of Subcontractor(s).

1.6. Progress Meetings

1.6.1. During course of Work schedule progress meetings weekly subject to approval by Departmental Representative.

1.6.2. Contractor, Superintendent, major Subcontractor(s) involved in Work, and Departmental Representative are to be in attendance.

1.6.3. Agenda to include:

1.6.3.1. Review and acceptance of minutes of previous meeting.

1.6.3.2. Review health and safety, including incidents, near misses, and corrective measures.

1.6.3.3. Review Environmental Protection, including incidents, near misses, and corrective measures.

1.6.3.4. Review contractual compliance.

1.6.3.5. Review regulatory compliance.

1.6.3.6. Review communications, problems or concerns with community.

1.6.3.7. Review of Work progress since previous meeting.

1.6.3.8. Field observations, problems, conflicts.

1.6.3.9. Updated progress schedule detailing activities planned over next 2 week period. Include review of progress with respect to previously established dates for starting and stopping various stages of Work.

1.6.3.10. Problems which impede construction schedule.

1.6.3.11. Corrective measures and procedures to regain projected schedule.

1.6.3.12. Revision to construction schedule.

1.6.3.13. Progress schedule, during succeeding Work period.

1.6.3.14. Review submittal schedules: expedite as required.

1.6.3.15. Maintenance of quality standards.
1.6.3.16. Quantities of material transported, treated, and disposed.
1.6.3.17. Review proposed changes for effect on construction schedule and on Final Completion date.
1.6.3.18. Other business.
1.6.4. Submit draft Progress Meeting Minutes for review and comment by Departmental Representative. Incorporate comments into final Progress Meeting Minutes.

1.7. Toolbox Meetings

1.7.1. During the course of the Work, schedule daily toolbox meetings at the start of each Work shift. Multiple meetings are required if the Contractor works multiple shifts within a 24-hour period.
1.7.2. All on Site workers to attend, including Contractor, Superintendent, major Subcontractor(s), and environmental consultants. Departmental Representative may attend.
1.7.3. Agenda to include:
1.7.3.1. Planned Work activities and environmental considerations for that shift.
1.7.3.2. Coordination activities required between Contractor, Subcontractor(s), Departmental Representative, and other contractor(s) including environmental consultant.
1.7.3.3. Health and Safety items.
1.7.3.4. Environmental Protection items.

1.8. Final Site Inspection

1.8.1. Within 5 Working Days of completion of Site Works but prior to Demobilization, request a meeting on Site to review the Site.
1.8.2. Departmental Representative, Contractor, Superintendent, major Subcontractor(s), field inspectors and supervisors must be in attendance.
1.8.3. Establish time and location of meeting subject to approval by Departmental Representative and notify parties concerned at least 3 Working Days before meeting.
1.8.4. Agenda to include:
1.8.4.1. Inspect removal of all temporary equipment, materials, supplies, and facilities.
1.8.4.2. Inspect final surface grades.
1.8.4.3. Inspect final vegetation.
1.8.4.4. Inspect permanent facilities for performance and damage.
1.8.4.5. Document all damage, deficiencies, missing items, and non-conformance.
1.8.5. If required, and in the opinion of the Departmental Representative, perform another Final Site Inspection after resolving all documented damage, deficiencies, missing items, and non-conformance.

1.9. Closeout Meeting

1.9.1. Within 10 Working Days of completion of the Work, request a meeting to review the project.

1.9.2. Departmental Representative, Contractor, Superintendent, major Subcontractor(s), field inspectors and supervisors must be in attendance.

1.9.3. Establish time and location of meeting subject to approval by Departmental Representative and notify parties concerned at least 3 Working Days before meeting.

1.9.4. Agenda to include:

1.9.4.1. Review Certificate of Completion.

1.9.4.2. Review final payment.

1.9.4.3. Identify lessons learned.

1.9.4.4. Perform Contractor Performance Evaluation Report Form.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Schedule: within 5 Working Days after Contract award, Submit a Master Plan.

1.3.2. Schedule of Interruption of Services: at least 5 Working Days prior to any shutdown or closure of active utilities or facilities Submit a schedule identifying type of service and dates of shutdown or closure.

1.3.3. Project Schedule and Updates: with Progress Payment, Submit a Project Schedule updated as appropriate. Progress Payment submission is incomplete without an updated Project Schedule acceptable to Departmental Representative.

1.4. Requirements

1.4.1. Ensure Master Plan and detail Project Schedules are practical and remain within specified Contract duration.

1.4.2. Plan to complete Work in accordance with prescribed milestones and time frame.

1.4.3. Limit activity durations to maximum of approximately 10 Working Days, to allow for progress reporting.

1.4.4. Ensure that it is understood that Award of Contract or time of beginning, rate of progress, Interim Certificate and Final Certificate as defined times of completion are of essence of this contract.

1.4.5. Include Work sequencing description and schedule:

1.4.5.1. Work Sequencing description must describe sequence, methods and means to perform each major task.

1.4.5.2. Work Sequencing schedule must show on a Gantt chart, start, end and dependencies of each major task and also indicates Work to be performed in sequence and in parallel.

1.4.5.3. Major tasks includes all items identified on Unit Price Table.

1.5. Master Plan

1.5.1. Structure schedule to allow orderly planning, organizing and execution of Work as Bar Chart (GANTT).

1.5.2. Departmental Representative will review and return revised schedules within 5 Working Days.

1.5.3. Revise impractical schedule and resubmit within 5 Working Days.

1.5.4. Accepted revised schedule will become Master Plan and be used as baseline for updates.

1.6. Project Schedule

1.6.1. Develop detailed Project Schedule derived from Master Plan.

1.6.2. Ensure detailed Project Schedule includes as minimum milestone and activity types as follows:

1.6.2.1. Dates of commencement and completion of Work for each Description of Work identified on the Unit Price Table.

1.6.2.2. Dates of Submittals including Shop Drawings, product data, MSDS sheets and samples.

1.6.2.3. Dates of inspection and testing.

1.6.2.4. Final Completion date within the time period in accordance with the Contract, including Amendments.

1.7. Project Schedule Reporting

1.7.1. Update Project Schedule on monthly basis reflecting activity changes and completions, as well as activities in progress.

1.7.2. Include as part of Project Schedule, narrative report identifying Work status to date, comparing current progress to baseline, presenting current forecasts, defining problem areas, anticipated delays and impact with possible mitigation.

1.8. Project Meetings

1.8.1. Discuss Project Schedule at regular site meetings, identify activities that are behind schedule and provide measures to regain slippage. Activities considered behind schedule are those with projected start or completion dates later than current approved dates shown on baseline schedule.

1.8.2. Weather related delays with their remedial measures will be discussed and negotiated.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Shop Drawings: at least 5 Working Days prior to commencing applicable Work, Submit Shop Drawings signed by a Qualified Professional.

1.4. General

1.4.1. Submission details to be commensurate for type of Work and Site conditions. Details depend on Work performed and Contractor's sequence, methods and means.

1.4.2. This section specifies general requirements and procedures for the Contractor's Submittals of Shop Drawings, product data, samples and other submittals in accordance with the Contract to Departmental Representative. Additional specific requirements for Submittals are identified in individual technical sections.

1.4.3. Present Shop Drawings, product data and samples in SI Metric units.

1.4.4. Where items or information is not produced in SI Metric units, converted values are acceptable.

1.4.5. Contractor's responsibility for errors and omissions in Submittals is not relieved by the Departmental Representative's review of Submittals.

1.4.6. Notify Departmental Representative in writing at time of Submittals, identifying deviations from requirements of Contract and stating reasons for deviations.

1.4.7. Contractor's responsibility for deviations in Submittals from requirements of Contract is not relieved by the Departmental Representative's review of Submittals unless Departmental Representative gives written acceptance of specific deviations.

1.4.8. Make any changes in Submittals which Departmental Representative requires to be in accordance with the Contract and resubmit as directed by the Departmental Representative.

1.4.9. Notify Departmental Representative in writing, when resubmitting, of any revisions other than those directed by the Departmental Representative.

1.4.10. Do not proceed with Work until relevant Submittals are finalized and have been accepted.

1.4.11. Submit to Departmental Representative submittals listed for review. Submit promptly and in orderly sequence to not cause delay in Work. Failure to Submit in ample time is responsibility of Contractor.

1.4.12. Review Submittals prior to submission to Departmental Representative. This review represents that necessary requirements have been determined and verified, or will be, and that each Submittal has been checked and coordinated with requirements of Work and Contract. Submittals not stamped, signed, dated and identified as to specific project will be returned without being examined and considered rejected.
1.4.13. Verify field measurements and affected adjacent Work are coordinated.
1.4.14. Adjustments made on Submittals by the Departmental Representative will not result in an increase the Contract Amount nor an Extension of Time for completion of the Work. If adjustments result in an increase to the Contract Amount or an Extension of Time for completion of the Work, notify Departmental Representative and receive approval prior to proceeding with Work.
1.4.15. Keep one final copy of each Submittal onsite.

1.5. Submission Requirements

1.5.1. Coordinate each Submittal with the requirements of the Work and the Contract. Individual Submittals will not be reviewed until:
1.5.1.1. Submittals are complete.
1.5.1.2. All related information is available.
1.5.2. Allow 5 Working Days for Departmental Representative's review of each Submittal, unless otherwise specified.
1.5.3. All Submittals are to be sent to Departmental Representative in duplicate as a hardcopy and in electronic format compatible with Departmental Representative's software.
1.5.4. Accompany Submittals with On Site Notification:
1.5.4.1. Date.
1.5.4.2. Project title and number.
1.5.4.3. Contractor's name and address.
1.5.4.4. Identification and quantity of each Shop Drawing, product data and sample.
1.5.4.5. Other pertinent data.
1.5.5. Submittals must include:
1.5.5.1. Date and revision dates.
1.5.5.2. Project title and number.
1.5.5.3. Name and address of:
1.5.5.3.1. Subcontractor.
1.5.5.3.2. Supplier.
1.5.5.3.3. Manufacturer.
1.5.5.4. Signature of Superintendent, certifying approval of Submittals, verification of field measurements and in accordance with the Contract.
1.5.5.5. Qualified Professional to sign and seal Submittals in accordance with the Contract. Submittals to include at a minimum 1 hard copy of original ink sealed document.
1.5.5.6. Details of appropriate portions of Work as applicable.

1.6. Shop Drawings

1.6.1. Shop Drawings are designs, drawings, figures, diagrams, illustrations, schedules, performance charts, brochures and other data intended to illustrate details of a portion of the Work which are provided by the Qualified Professional of record.

1.6.2. Maximum sheet size: ANSI E (864 x 1118 mm).

1.6.3. Submit, as directed by the Departmental Representative, electronic and 2 hard copies of Shop Drawings for each requirement requested in the specification sections and/or as directed by the Departmental Representative.

1.6.4. Cross-reference Shop Drawing information to applicable portions of the Contract.

1.6.5. Qualified Professional to sign and seal each individual Shop Drawing.

1.6.6. Qualified Professional to sign and seal final Shop Drawings and submit as directed by the Departmental Representative upon Final Completion of the construction project. Final Shop Drawings are prepared by a Qualified Professional to reflect design changes made during the construction of the Remediation by Excavation project. Final Shop Drawings are intended to incorporate addenda, change orders and other significant design changes, but not necessarily Site directions.

1.6.7. Shop Drawings must include:

1.6.7.1. The original date of issue.

1.6.7.2. The dates of all applicable revisions.

1.6.7.3. The project title.

1.6.7.4. The project address.

1.6.7.5. The project number.

1.6.7.6. Wherever applicable, the name(s) of the: Contractor, Subcontractor(s), Supplier(s), manufacturers, and separate detailers.

1.6.7.7. The sequence number for each Shop Drawing.

1.6.7.8. Identifications of all products and materials.

1.6.7.9. Relation to adjacent structures or materials.

1.6.7.10. Clearly identified field dimensions.

1.6.7.11. Applicable standards.

1.7. Shop Drawings Review

1.7.1. Departmental Representative's review of Shop Drawings is to determine if Shop Drawings are consistent with the general intent of the Contract and are in accordance with the Contract.

1.7.2. This review will not mean that Departmental Representative approves the detail design inherent in the Shop Drawings, responsibility for which will remain with Contractor submitting same.

1.7.3. This review will not relieve the Contractor of responsibility for errors or omissions in the Shop Drawings or of responsibility for meeting all requirements of the Contract.

1.7.4. Without restricting the generality of the foregoing, be responsible for:

1.7.4.1. Dimensions to be confirmed and correlated at the Site.

1.7.4.2. Information that pertains solely to fabrication processes or to techniques of construction and installation.
1.7.4.3. Coordination of the Work of all sub-trades.

2. PART 2 - PRODUCTS

2.1. Not Used
2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used
3.1.1. Not Used.

END OF SECTION

4. PART 1 - GENERAL

4.1. Measurement Procedures

4.1.1. See 01 11 00.

4.2. Definitions

4.2.1. See 01 11 00.

4.3. Action and Informational Submittals

4.3.1. List of Signs and Devices: within 5 Working Days after Contract award and prior to mobilization to Site Submit a list of signs and other devices required for the project.

4.4. Protection of Public Traffic

4.4.1. Comply with requirements of acts, regulations and bylaws in force for regulation of traffic or use of roadways upon or over which it is necessary to carry out Work or haul materials or equipment.

4.4.2. Comply with current version of BC Ministry of Transportation and Infrastructure *Traffic Control Manual for Work on Roadways*.

4.4.3. Provide and maintain road access and egress to property fronting Site and in other areas in accordance with the Contract, except where other means of road access exist that are accepted.

4.5. Informational and Warning Devices

4.5.1. Provide and maintain signs, flashing warning lights, and other devices required to indicate construction activities or other temporary and unusual conditions resulting from Work which requires road user response.

4.5.2. Supply and erect signs, delineators, barricades and miscellaneous warning devices to comply with current version of BC Ministry of Transportation and Infrastructure *Traffic Control Manual for Work on Roadways*.

4.5.3. Place signs and other devices in locations recommended in current version of BC Ministry of Transportation and Infrastructure *Traffic Control Manual for Work on Roadways*.

4.5.4. Meet with Departmental Representative prior to commencement of Work to prepare list of signs and other devices required for project. If situation onsite changes, revise list for approval.

4.5.5. Continually maintain traffic control devices in use:

4.5.5.1. Check signs daily for legibility, damage, suitability and location. Clean, repair or replace to ensure clarity and reflectance.

4.5.5.2. Remove or cover signs which do not apply to conditions existing from day to day.

4.6. Control of Public Traffic

4.6.1. Provide competent flag personnel, trained in accordance with, and properly equipped to, current version of BC Ministry of Transportation and Infrastructure *Traffic Control Manual for Work on Roadways* for situations as follows:

4.6.1.1. When public traffic is required to pass working vehicles or equipment that block all or part of travelled roadway.

4.6.1.2. In situations where complete protection for workers, working equipment and public traffic is not provided by other traffic control devices.

4.7. Operational Requirements

4.7.1. Maintain existing conditions for traffic throughout period of Contract except that, when required for construction in accordance with the Contract and when measures have been taken in accordance with the Contract and accepted by Departmental Representative to protect and control public traffic, existing conditions for traffic to be restricted as follows:

4.7.1.1. Maintain existing conditions for traffic crossing right-of-way.

5. PART 2 - PRODUCTS

5.1. Not Used

5.1.1. Not Used.

6. PART 3 - EXECUTION

6.1. Not Used

6.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Contaminated Material and Non-Contaminated Material Management Plan: within 5 Working Days after Contract award and prior to mobilization to Site, Submit plan detailing management of Contaminated Material and Non-Contaminated Material. Include:

1.3.1.1. Sequence, methods and means to ensure different categories of waste are segregated.

1.3.1.2. Sequence, methods and means to transport and store Contaminated Material and Non-Contaminated Material onsite.

1.3.1.3. Sequence, methods and means to transport Contaminated Material and Non-Contaminated Material offsite. Include name, vehicle type, and licenses of transporters. For all transfer stations and interim storage facilities include name of facility; location of facility; copy of valid and subsisting permit, certificate, approval, or other required form of authorization issued by a Facility Regulator for the facility; and evidence of compliance with municipal zoning and bylaws of facility.

1.3.2. Transport Manifests: within 5 Working Days of offsite transport, Submit documentation verifying that material has been transported appropriately. Include:

1.3.2.1. Method of transport.

1.3.2.2. Name of transport company.

1.3.2.3. Weigh scale receipt including location, date, and weight of loading, as appropriate.

1.3.2.4. Weigh scale receipt including location, date, and weight of unloading.

1.4. Sequencing and Scheduling

1.4.1. Commence Work involving contact with Contaminated or potentially Contaminated Material or Wastewater after all applicable Environmental Protection procedures (including those identified in Contaminated Material and Non-Contaminated Material Management Plan and Environmental Protection Plan) and facilities (including those identified in Site Layout) are operational and accepted by Departmental Representative.

1.4.2. Plan work sequencing and traffic patterns to prevent contamination of clean areas due to traffic or debris.

1.5. Equipment Decontamination Facility

1.5.1. Prior to commencing Work involving equipment contact with potentially Contaminated Material, construct equipment decontamination facilities to accommodate the largest potentially contaminated equipment onsite.

1.5.2. Collect and contain equipment decontamination wastewater and sediment. Transfer collected wastewater and sediment to treatment facilities accepted by Departmental Representative.

1.6. Personnel Decontamination Facility

1.6.1. Provide an area or areas close to the workers' changing facilities to enable workers and other personnel leaving areas such as exclusion area to remove deleterious and contaminated materials from boots, clothing and skin surfaces.

1.6.2. Be responsible for ensuring that all materials, chemicals, protective clothing, wash water and deleterious materials are collected, treated and disposed of in accordance with applicable environmental standards and regulations.

1.6.3. Personnel Decontamination Facility to be available for use by persons other than the Contractor's workers and Subcontractors, including federal employees, other contractor(s), and environmental agencies. Provide use of facilities to other persons.

1.7. Equipment Decontamination

1.7.1. At minimum, perform following steps during equipment decontamination: mechanically remove packed dirt, grit, and debris by scraping and brushing without using steam or high-pressure water to reduce amount of water needed and to reduce amount of contaminated rinsate generated.

1.7.2. If required, as directed by the Departmental Representative, use high-pressure, low-volume, hot water or steam supplemented by detergents or solvents as appropriate. Pay particular attention to tire treads, equipment tracks, springs, joints, sprockets, and undercarriages. Scrub surfaces with long handle scrub brushes and cleaning agent. Rinse off and collect cleaning agent. Air dry equipment in clean area before removing from Site or travelling on clean areas. Perform assessment as directed by the Departmental Representative to determine effectiveness of decontamination.

1.7.2.1. Take appropriate measures necessary to minimize drift of mist and spray during decontamination including provision of wind screens.

1.7.2.2. Collect decontamination wastewater and sediment which accumulate in decontamination location. Treat collected wastewater as Contaminated Water. Manage decontamination sediment as Hazardous Waste.

1.7.3. In the opinion of the Departmental Representative, each piece of equipment must be inspected by the Departmental Representative after decontamination and prior to travel on clean areas or demobilization from Site. Perform additional decontamination as required in the opinion of the Departmental Representative.

1.7.4. Furnish and equip personnel engaged in equipment decontamination with protective equipment including suitable disposable clothing, respiratory protection, and face shields.

1.8. Progress Decontamination

1.8.1. Decontaminate equipment after working in potentially contaminated Work areas and prior to subsequent Work or travel on clean areas.

1.9. Final Decontamination

1.9.1. Perform final decontamination of construction facilities, equipment, and materials which may have come in contact with potentially Contaminated Material prior to demobilization from Site.

1.10. Drums

1.10.1. Storage of liquid waste: 200 L steel drums meeting Transportation and Dangerous Goods Act, closable lids, complete with labels for marking contents and date filled.

1.10.2. Storage of solid waste: 200 L steel drums meeting Transportation and Dangerous Goods Act, closable lids, complete with labels for marking contents and date filled.

1.11. Contaminated Material Management

1.11.1. Remove all Contaminated Material within Work areas in accordance with the Contract and as directed by the Departmental Representative.

1.11.2. Minimize generation of Contaminated Material to greatest extent practicable. Take necessary precautions to avoid mixing during excavation, handling, loading, stockpiling, and transport of Non-Contaminated Material with Contaminated Material, and Waste Quality with Hazardous Waste.

1.11.3. Segregate, excavate, handle, stockpile, load, unload, haul, interim storage, treat, and dispose Contaminated Material separately into the following classifications in accordance with the Contract or as directed by the Departmental Representative based on insitu results, field observations, field measurements, and/or ex-situ characterization:

1.11.3.1. Hazardous Waste.

1.11.3.2. Waste Quality.

1.11.4. Handle, stockpile, load, unload, haul, and interim store Contaminated Material from the Site separately from material from other sites.

1.11.5. Treat and dispose Contaminated Material from the Site separately from material from other sites to the extent practicable as acceptable to the Departmental Representative.

1.11.6. Material characterization additional to information provided in Contract required by transport, Treatment Facility or Disposal Facility responsibility of Contractor.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Submit to Departmental Representative Submittals listed for review.
1.3.2. Work affected by Submittal must not proceed until review is complete.
1.3.3. Submit the following:
1.3.3.1. Health and Safety Plan.
1.3.3.2. Copies of reports or directions issued by federal and provincial health and safety inspectors.
1.3.3.3. Copies of incident and accident reports.
1.3.3.4. Complete set of Material Safety Data Sheets (MSDS), and all other documentation required by Workplace Hazardous Materials Information System (WHMIS) requirements.
1.3.3.5. Emergency Procedures.
1.3.3.6. Notice of Project.
1.3.4. The Departmental Representative will review the Contractor's site-specific project Health and Safety Plan and emergency procedures, and provide comments to the Contractor within 5 Working Days after receipt of the plan.
1.3.5. If changes are required, revise the plan as appropriate and resubmit to Departmental Representative within 5 Working Days.
1.3.6. Submittal of the Health and Safety Plan, and any revised version, to the Departmental Representative is for information and reference purposes only. It will not:
1.3.6.1. Be construed to imply approval by the Departmental Representative.
1.3.6.2. Be interpreted as a warranty of being complete, accurate and legislatively compliant.
1.3.6.3. Relieve the Contractor of his legal obligations for the provision of health and safety on the project.

1.4. References

1.4.1. Government of Canada:
1.4.1.1. Canada Labour Code - Part II.
1.4.1.2. Canada Occupational Health and Safety Regulations.
1.4.2. National Building Code of Canada (NBC):
1.4.2.1. Part 8, Safety Measures at Construction and Demolition Sites.
1.4.3. Canadian Standards Association (CSA) as amended:
1.4.3.1. CSA Z797-2009 Code of Practice for Access Scaffold.
1.4.3.2. CSA S269.1-1975 (R2003) Falsework for Construction Purposes.

1.4.3.3. CSA S350-M1980 (R2003) Code of Practice for Safety in Demolition of Structures.
1.4.4. National Fire Code of Canada 2010 (as amended):
1.4.4.1. Part 5 – Hazardous Processes and Operations and Division B as applicable and required.
1.4.4.2. FCC No. 302, Standard for Welding and Cutting.
1.4.5. American National Standards Institute (ANSI):
1.4.5.1. ANSI A10.3, Operations – Safety Requirements for Powder-Actuated Fastening Systems.
1.4.6. Province of British Columbia:
1.4.6.1. Workers Compensation Act Part 3-Occupational Health and Safety.
1.4.6.2. Occupational Health and Safety Regulation.

1.5. Regulatory Requirements

1.5.1. Comply with codes, acts, bylaws, standards and regulations applicable to the performance of the Work in accordance with the Contract to ensure safe operations at Site.
1.5.2. In event of conflict between any provision of the above authorities, the most stringent provision will apply. Should a dispute arise in determining the most stringent requirement, the Departmental Representative will direct on the course of action to be followed.

1.6. Worker’s Coverage

1.6.1. Comply fully with the relevant Workers' Compensation Act, regulations and orders made pursuant thereto, and any amendments up to the Final Completion of the Work.
1.6.2. Maintain Workers coverage as required by relevant acts and regulations during the term of the Contract, until and including the date that the Certificate of Final Completion is issued.

1.7. Compliance with Regulations

1.7.1. PWGSC may terminate the Contract without liability to PWGSC where the Contractor, in the opinion of PWGSC, refuses to comply with a requirement of the Workers' Compensation Act or the Occupational Health and Safety Regulations.
1.7.2. It is the Contractor's responsibility to ensure that all workers are qualified, competent and certified to perform the Work as required by the Workers' Compensation Act or the Occupational Health and Safety Regulations.

1.8. Responsibility

1.8.1. Assume responsibility as the Prime Contractor for Work under this Contract.
1.8.1.1. Be responsible for health and safety of person’s onsite, safety of property onsite and for protection of persons adjacent to Site and environment to extent that they may be affected by conduct of Work.

1.8.1.2. Comply with and enforce compliance by employees with safety requirements of Contract, applicable federal, provincial, territorial and local statutes, regulations, and ordinances, and with site-specific Health and Safety Plan.

1.9. Health and Safety Coordinator

1.9.1. The Health and Safety Coordinator must:

1.9.1.1. Be responsible for completing all health and safety training, and ensuring that personnel that do not successfully complete the required training are not permitted to enter the Site to perform Work.

1.9.1.2. Be responsible for implementing, daily enforcing, and monitoring the site-specific Health and Safety Plan.

1.9.1.3. Be on Site during execution of Work.

1.10. General Conditions

1.10.1. Provide safety barricades and lights around Site as required to provide a safe working environment for workers and protection for pedestrian and vehicular traffic.

1.10.2. Ensure that non-authorized persons are not allowed to circulate in designated construction areas of the Site:

1.10.2.1. Provide appropriate means by use of barricades, fences, warning signs, traffic control personnel, and temporary lighting as required.

1.11. Project/Site Conditions

1.11.1. Work at Site will involve contact with contaminants identified in Specifications and environmental reports.

1.12. Work Permits

1.12.1. Obtain specialty permits related to project before start of Work.

1.13. Filing of Notice

1.13.1. The Prime Contractor is to complete and submit a Notice of Project as required by Provincial or Territorial authorities.

1.13.2. Provide copies of all notices to the Departmental Representative.

1.14. Health and Safety Plan

1.14.1. Conduct a site-specific hazard assessment based on review of Contract, required Work, and project Site. Identify any known and potential health risks and safety hazards.

1.14.2. Prepare and comply with a site-specific project Health and Safety Plan based on hazard assessment, including, but not limited to, the following:

1.14.2.1. Primary requirements:

1.14.2.1.1. Contractor's safety policy.

1.14.2.1.2. Identification of applicable compliance obligations.

1.14.2.1.3. Definition of responsibilities for project safety/organization chart for project.
1.14.2.1.4. General safety rules for project.
1.14.2.1.5. Job-specific safe work, procedures.
1.14.2.1.6. Inspection policy and procedures.
1.14.2.1.7. Incident reporting and investigation policy and procedures.
1.14.2.1.8. Occupational Health and Safety Committee/Representative procedures.
1.14.2.1.9. Occupational Health and Safety meetings.
1.14.2.1.10. Occupational Health and Safety communications and record keeping procedures.
1.14.2.2. Summary of health risks and safety hazards resulting from analysis of hazard assessment, with respect to site tasks and operations which must be performed as part of the Work.
1.14.2.3. List hazardous materials to be brought onsite as required by Work.
1.14.2.4. Indicate engineering and administrative control measures to be implemented at the Site for managing identified risks and hazards.
1.14.2.5. Identify personal protective equipment (PPE) to be used by workers.
1.14.2.6. Identify personnel and alternates responsible for site safety and health.
1.14.2.7. Identify personnel training requirements and training plan, including site orientation for new workers.
1.14.3. Develop the plan in collaboration with all Subcontractors. Ensure that work/activities of Subcontractors are included in the hazard assessment and are reflected in the plan.
1.14.4. Revise and update Health and Safety Plan as required, and re-submit to the Departmental Representative.
1.14.5. Departmental Representative's review: the review of Health and Safety Plan by Public Service and Procurement Canada (PWGSC) will not relieve the Contractor of responsibility for errors or omissions in final Health and Safety Plan or of responsibility for meeting all requirements of construction and Contract.

1.15. Emergency Procedures

1.15.1. List standard operating procedures and measures to be taken in emergency situations. Include an evacuation plan and emergency contacts (i.e., names/telephone numbers) of:
1.15.1.1. Designated personnel from own company.
1.15.1.2. Regulatory agencies applicable to Work and as per legislated regulations.
1.15.1.3. Local emergency resources.
1.15.1.4. Departmental Representative and site staff.
1.15.2. Include the following provisions in the emergency procedures:
1.15.2.1. Notify workers and the first-aid attendant, of the nature and location of the emergency.
1.15.2.2. Evacuate all workers safely.
1.15.2.3. Check and confirm the safe evacuation of all workers.

1.15.2.4. Notify the fire department or other emergency responders.
1.15.2.5. Notify adjacent workplaces or residences which may be affected if the risk extends beyond the workplace.
1.15.2.6. Notify Departmental Representative and Site staff.
1.15.3. Provide written rescue/evacuation procedures as required for, but not limited to:
1.15.3.1. Work at high angles.
1.15.3.2. Work in confined spaces or where there is a risk of entrapment.
1.15.3.3. Work with hazardous substances.
1.15.3.4. Underground work.
1.15.3.5. Work on, over, under and adjacent to water.
1.15.3.6. Workplaces where there are persons who require physical assistance to be moved.
1.15.4. Design and mark emergency exit routes to provide quick and unimpeded exit.
1.15.5. Revise and update emergency procedures as required, and re-submit to the Departmental Representative.

1.16. Hazardous Products

1.16.1. Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage and disposal of hazardous materials, and regarding labelling and provision of Material Safety Data Sheets (MSDS) acceptable to the Departmental Representative and in accordance with the Canada Labour Code.
1.16.2. Where use of hazardous and toxic products cannot be avoided:
1.16.2.1. Notify Departmental Representative beforehand of the product(s) intended for use. Submit applicable MSDS and WHMIS documents as required.
1.16.2.2. As required, in conjunction with Departmental Representative, schedule to carry out Work during "off hours" when tenants have left the building.
1.16.2.3. Provide adequate means of ventilation as required.

1.17. Unforeseen Hazards

1.17.1. Should any unforeseen or peculiar safety-related factor, hazard or condition become evident during performance of the Work, immediately stop Work and notify the Departmental Representative verbally and in writing.

1.18. Posted Documents

1.18.1. Post legible versions of the following documents onsite:
1.18.1.1. Health and Safety Plan.
1.18.1.2. Sequence of Work.
1.18.1.3. Emergency procedures.
1.18.1.4. Site drawing showing project layout, locations of the first-aid station, evacuation route and marshalling station, and the emergency transportation provisions.
1.18.1.5. Notice of Project.
1.18.1.6. Floor plans or Site plans.

1.18.1.7. Notice as to where a copy of the Workers' Compensation Act and Regulations are available on the Site for review by employees and workers.
1.18.1.8. Workplace Hazardous Materials Information System (WHMIS) documents.
1.18.1.9. Material Safety Data Sheets (MSDS).
1.18.1.10. List of names of Joint Health and Safety Committee members, or Health and Safety Representative, as applicable.
1.18.2. Post all Material Safety Data Sheets (MSDS) onsite, in a common area, visible to all workers and in locations accessible to tenants when Work of this Contract includes construction activities adjacent to occupied areas.
1.18.3. Postings should be protected from the weather, and visible from the street or the exterior of the principal construction site shelter provided for workers and equipment, or as accepted by the Departmental Representative.

1.19. Meetings
1.19.1. Attend health and safety preconstruction meeting and all subsequent meetings called by the Departmental Representative.
1.19.2. Ensure all site personnel attend a health and safety toolbox meeting at the beginning of each shift, which must include:
1.19.2.1. Sign-in of all attendees.
1.19.2.2. Planned Work activities and environmental considerations for that shift.
1.19.2.3. Hazards associated with these Work activities, including environmental hazards (e.g., potential for hypothermia, heat exhaustion, heat stroke).
1.19.2.4. Appropriate job-specific safe work procedures.
1.19.2.5. Required personal protective equipment (PPE).
1.19.2.6. Appropriate emergency procedures.
1.19.2.7. Review recent accidents on Site, including near misses.
1.19.3. Retain records of all health and safety meetings onsite during Work, and retain as corporate records for a minimum of 7 years after Work is completed.

1.20. Correction of Non-Compliance
1.20.1. Immediately address health and safety non-compliance issues identified by the Departmental Representative.
1.20.2. Provide Departmental Representative with written report of action taken to correct non-compliance with health and safety issues identified.
1.20.3. The Departmental Representative may issue a "stop work order" if non-compliance of health and safety regulations is not corrected immediately or within posted time.
1.20.4. Correct non-compliance.

1.21. Hazardous Occurrence Investigation and Reporting
1.21.1. Hazard includes:
1.21.1.1. Any source of potential damage, harm or adverse effects on life, health, property or environment at work. It refers to any biological, chemical, ergonomic, physical, psychosocial and safety factor that is reasonably likely

to cause harm or damage to humans, other organisms, or the environment in the absence of its control. Sometimes a hazard is referred to as being the actual harm or the health effect it caused rather than the hazard. For example the disease tuberculosis might be called a hazard by some but in general the tuberculosis-causing bacteria would be considered the “hazard” or “hazardous biological agent”. Exposure to tuberculosis would be the hazardous incident. For types of Hazards refer to Annex 3 of the Standard on Hazard Prevention Program.

1.21.2. Hazardous Occurrence includes:

1.21.2.1. An event occurring at a PWGSC managed building or worksite, or through the course of an employee's work that results in, or has the potential to result in, a fatality, injury, illness, exposure to a hazardous substance or property damage or an escapement of a hazardous material. For the purpose of investigating, recording and reporting hazardous occurrences, the following are included under this term: disabling injuries, minor injuries and near-misses.

1.21.3. Hazardous Occurrence Investigation and Reporting Procedures:

1.21.3.1. Includes information regarding the person involved and the basic circumstances surrounding the hazardous occurrence.

1.21.3.2. Provides a detailed and thorough description of the hazardous occurrence and the sequence of events.

1.21.3.3. Indicates corrective measures that have been taken since the occurrence.

1.21.3.4. Requires the appointment of a qualified investigator.

1.21.3.5. Provides recommendations for additional corrective measures, if required.

1.21.4. Fatal or Serious Accidents Procedures:

1.21.4.1. Call emergency number to advise the police organization having jurisdiction to secure the scene and investigate the matter.

1.21.4.2. Advise the Departmental Representative of the fatality or serious accident within 1 hour.

1.21.4.3. No investigation will be conducted at the scene until the police service having jurisdiction has released the scene.

1.21.4.4. No person shall, unless authorized to do so, remove or in any way interfere with or disturb any wreckage, article or thing related to the incident except to the extent necessary to: save a life, prevent injury or relieve human suffering in the vicinity; maintain an essential public service; or prevent unnecessary damage to or loss of property.

1.22. Utility Clearance

1.22.1. Contractor is solely responsible for utility clearance.

1.22.2. Contractor will not rely upon Drawings or other information provided with utility locations.

1.23. Personal Protective Equipment Program

1.23.1. Submit Personal Protective Equipment (PPE) program to the Departmental Representative addressing:

1.23.1.1. Donning and doffing procedures.

1.23.1.2. PPE selection based upon Site hazards.

1.23.1.3. PPE use and limitations of equipment.

1.23.1.4. Work mission duration, PPE maintenance and storage.

1.23.1.5. PPE decontamination and disposal.

1.23.1.6. PPE inspection procedures prior to, during, and after use.

1.23.1.7. Evaluation of effectiveness of PPE program, and limitations during temperature extremes, and other appropriate medical considerations.

1.23.1.8. Medical surveillance requirements for personnel assigned to work at Site.

1.23.1.9. Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment.

1.23.1.10. Site control measures employed at Site including site map, site work zones, use of 'buddy system', site communications including site security, alerting means for emergencies, standard operating procedures or safe work practices, and identification of nearest medical assistance.

1.23.1.11. Decontamination procedures for both personnel and equipment.

1.23.1.12. Emergency response requirements addressing: pre-emergency planning, personnel roles, lines of authority and communication, emergency recognition and prevention, safe distances and places of refuge, site security and control, evacuation routes and procedures, decontamination procedures not covered under decontamination section, emergency medical treatment and first aid, emergency alerting and response procedures, critique of response and follow-up, PPE and emergency equipment, site topography, layout, prevailing weather conditions, and procedures for reporting incidents to local, provincial, or federal agencies.

1.23.1.13. Written respiratory protection program for project activities.

1.23.1.14. Procedures dealing with heat and/or cold stress.

1.23.1.15. Spill containment program if waste material is generated, excavated, stored, or managed onsite.

1.24. Offsite Contingency and Emergency Response Plan

1.24.1. Prior to commencing Work involving handling of hazardous materials, develop offsite Contingency and Emergency Response Plan.

1.24.2. Plan must provide immediate response to serious site occurrence such as explosion, fire, or migration of significant quantities of toxic or hazardous material from Site.

1.25. Personnel Health, Safety, and Hygiene

1.25.1. Training: ensure personnel entering Site are trained in accordance with specified personnel training requirements. Training session must be completed by Health and Safety Officer.

1.25.2. Levels of Protection: establish levels of protection for each Work area based on planned activity and location of activity.

1.25.3. Personal Protective Equipment:

1.25.3.1. Furnish site personnel with appropriate PPE as specified above. Ensure that safety equipment and protective clothing is kept clean and maintained.

1.25.4. Develop protective equipment usage procedures and ensure that procedures are strictly followed by site personnel; include following procedures as minimum:

1.25.4.1. Ensure prescription eyeglasses worn are safety glasses.

1.25.4.2. Ensure footwear is steel-toed safety shoes or boots.

1.25.4.3. Dispose of or decontaminate PPE worn onsite at end of each workday.

1.25.4.4. Decontaminate reusable PPE before reissuing.

1.25.4.5. Ensure site personnel have passed respirator fit test prior to entering potentially contaminated work areas.

1.25.4.6. Ensure facial hair does not interfere with proper respirator fit.

1.25.5. Respiratory Protection:

1.25.5.1. Provide site personnel with extensive training in usage and limitations of, and qualitative fit testing for, air purifying and supplied-air respirators in accordance with specified regulations.

1.25.5.2. Develop, implement, and maintain respirator program.

1.25.5.3. Monitor, evaluate, and provide respiratory protection for site personnel.

1.25.5.4. Ensure levels of protection as listed have been chosen consistent with site-specific potential airborne hazards associated with major contaminants identified onsite.

1.25.5.5. In absence of additional air monitoring information or substance identification, retain an industrial hygiene specialist to determine minimum levels of respiratory protection required.

1.25.5.6. Immediately notify Departmental Representative when level of respiratory protection required increases.

1.25.5.7. Ensure appropriate respiratory protection during Work activities. As minimum requirement, ensure that persons entering potentially contaminated work areas are supplied with and use appropriate respiratory protection.

1.25.6. Heat Stress/Cold Stress: implement heat stress or cold stress monitoring program as applicable and include in site-specific Health and Safety Plan.

1.25.7. Personnel Hygiene and Personnel Decontamination Procedures. Provide minimum as follows:

1.25.7.1. Suitable containers for storage and disposal of used disposable PPE.

1.25.7.2. Potable water and suitable sanitation facility.

1.25.8. Emergency and First-Aid Equipment:

1.25.8.1. Locate and maintain emergency and first-aid equipment in appropriate location onsite including first-aid kit to accommodate number of site personnel; portable emergency eye wash; two 9 kg ABC type dry chemical fire extinguishers.

1.25.9. Site Communications:

1.25.9.1. Identify, supply and implement appropriate dedicated communication devices for Site and post emergency numbers near dedicated devices.

1.25.9.2. Ensure personnel use of "buddy" system and develop hand signal system appropriate for site activities.

1.25.9.3. Provide employee alarm system to notify employees of site emergency situations or to stop Work activities if necessary.

1.25.9.4. Furnish selected personnel with 2-way radios.

1.25.9.5. Safety Meetings: conduct mandatory daily safety meetings for personnel, and additionally as required by special or Work-related conditions; include refresher training for existing equipment and protocols, review ongoing safety issues and protocols, and examine new site conditions as encountered. Hold additional safety meetings on as-needed basis.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Environmental Protection Plan: within 5 Working Days after Contract award and prior to mobilization to Site, Submit a plan detailing protection of the environment. Include:

1.3.1.1. Comprehensive overview of known or potential environmental issues to be addressed during Work.

1.3.1.2. Identify requirements that plan complies with. Includes: permits, certificates, approvals, or any other form of authorizations; other federal, provincial, or municipal requirements; and in accordance with the Contract.

1.3.1.3. Names and qualifications of persons responsible for ensuring adherence to Environmental Protection Plan.

1.3.1.4. Names and qualifications of persons responsible for manifesting material to be removed from Site.

1.3.1.5. Names and qualifications of persons responsible for training Site personnel.

1.3.1.6. Description of Environmental Protection personnel training program.

1.3.1.7. Work Area Plan showing proposed activity in each portion of areas, such as exclusion zone(s), decontamination zone(s) and clean zone(s), and identifying areas of limited use or non-use. Ensure plan includes measures for marking limits of use areas and methods for protection of features to be preserved within authorized Work areas.

1.3.1.8. Drawings showing locations of proposed temporary excavations or embankments for haul roads, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials onsite.

1.3.1.9. Historical, Archaeological, Cultural Resources, Biological Resources and Wetlands Plan that defines procedures for identifying and protecting historical, archaeological, cultural resources, biological resources and wetlands. Include procedures if previously unknown historical, archaeological, cultural, and biological resources are discovered during Work.

1.3.1.10. Noise Control Plan identifying methods and procedures for preventing, monitoring, and controlling noise for compliance with: applicable permits, certificates, approvals, or any other form of authorizations; other federal, provincial, or municipal requirements; and in accordance with the Contract. Include thresholds and procedures if: noise does not comply with appropriate levels, or if there are public complaints. Plan to be for type of Work and Site conditions.

1.3.1.11. Contamination Prevention Plan identifying hazardous, deleterious or regulated substances to be used onsite; intended actions to prevent introduction of such materials into air, water, or ground; and detailing provisions for compliance with federal, provincial, and municipal laws and regulations for storage and handling of these materials.

1.3.1.12. Spill Control Plan including procedures, instructions, and reports to be used in event of spill of hazardous, deleterious or regulated substances. Identify locations and contents of spill kits.

1.3.1.13. Communications Plan identifying emergency contact list and conditions for implementing emergency contact. Emergency contact to include: Contractor emergency response team including Superintendent; Departmental Representative and alternate, and other contractor(s) and individuals as directed by the Departmental Representative; and federal, provincial, and municipal emergency contacts.

1.3.1.14. Air Pollution Control Plan detailing provisions to assure that contaminants, dust, debris, materials, and trash, are contained onsite. Include procedures, in accordance with the Contract, if air pollution does not comply with appropriate levels, there are public complaints, or if onsite or offsite damage occurs.

1.3.1.15. Non-Contaminated Material Disposal Plan identifying methods and locations for solid waste disposal including clearing waste. Include name, location, provincial or territorial authorizations, and evidence of compliance with municipal zoning and bylaws of Landfill Facility.

1.3.1.16. Wastewater Management Plan identifying methods and procedures for management and discharge of Contaminated and Non-Contaminated Water including surface waters and wastewater which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of groundwater, disinfection water, hydrostatic test water, and water used in flushing of lines. Include method of treatment and disposal.

1.3.1.17. Wastewater Disposal Plan identifying methods and locations for solid waste disposal including clearing waste. Include name, location, provincial or territorial authorizations, and evidence of compliance with Municipal zoning and bylaws of Disposal Facility and/or copy of municipal permit to discharge to sewer system.

1.3.1.18. Erosion and Sediment Control Plan identifying type and location of erosion and sediment controls to be provided including monitoring and reporting requirements to assure that control measures are in compliance with erosion and sediment control plan, federal, provincial, and municipal laws and regulations.

1.3.2. Pollution Control Procedures Modification: immediately when pollution control procedures are inadequate, as directed by the Departmental Representative, Submit modified procedures to resolve problem.

1.3.3. Pollution Control Remediation: immediately when soil, sediment or water contaminated by Contractor's activities are inadequate as directed by the Departmental Representative, Submit remediation procedures.
1.3.4. Dust and Particulate Control Procedures Modification: immediately when dust and particulate control measures are inadequate as directed by the Departmental Representative, Submit modified procedures to resolve problem.

1.4. Fires
1.4.1. Fires and burning of rubbish onsite not permitted.

1.5. Cleaning
1.5.1. Maintain cleanliness of Work and surrounding Site to comply with federal, provincial, and municipal fire and safety laws, ordinances, codes, and regulations applicable to the performance of the Work.
1.5.2. Coordinate cleaning operations with disposal operations to prevent accumulation of dust, dirt, debris, rubbish, and waste materials.
1.5.3. Ensure cleanup of the Work areas each day after Final Completion of Work.

1.6. Site Clearing and Plant Protection
1.6.1. Minimize stripping of Topsoil and vegetation.
1.6.2. Restrict tree and plant removal to areas in accordance with the Contract or as directed by the Departmental Representative. Protect all other trees and plants onsite and offsite.

1.7. Vibration
1.7.1. Maintain acceptable vibration levels not injurious to public health or safety, to the environment, to onsite or offsite property, or to any part of Work completed or under construction.

1.8. Noise
1.8.1. Maintain acceptable noise levels not injurious to public health or safety or to the environment.

1.9. Maintenance of Public Roads
1.9.1. Prevent tracking or spilling of debris or material onto public roads.
1.9.2. Immediately sweep or scrape up debris or material on public roads.
1.9.3. Clean public roads within a 200 m radius of the Site entrance at least once per shift.

1.10. Pollution Control
1.10.1. Pollution includes spills or other releases from Contractor's activities that could potentially contaminate soil, sediment, water, and atmosphere from discharge of hazardous, deleterious or regulated substances, including from equipment and material handling.

1.10.2. Provide sequence, methods and means, and facilities to prevent spills or releases.
1.10.2.1. Maintain temporary erosion and pollution control features.
1.10.2.2. Do not store fuel onsite other than tanks forming part of the equipment.
1.10.2.3. Control emissions from equipment and plant to meet applicable authorities' emission requirements.
1.10.2.4. Contractor to regularly inspect all machinery on the Site to ensure it is in good repair and free of leaks.
1.10.3. Inadequate procedures:
1.10.3.1. Stop relevant Work if procedures are inadequate to prevent spills or other releases, or when monitoring indicates that release equals or exceeds regulated or levels in accordance with the Contract.
1.10.3.2. Submit procedures proposed to resolve problem.
1.10.3.3. Make necessary changes to operations prior to resuming excavation, handling, processing, or other Work that can cause spills or other releases.
1.10.3.4. Departmental Representative can stop relevant Work at any time when Contractor's Work procedures are inadequate to prevent spills or other releases, or when monitoring indicates that release equals or exceeds regulated quantities or levels in accordance with the Contract. Do not proceed with stopped Work until corrections accepted by Departmental Representative.
1.10.4. Be prepared to intercept, cleanup, and dispose of spills or other releases that can occur whether on land or water.
1.10.5. Spill kits and containment are to be maintained onsite and ready for deployment in the event of spills or other releases.
1.10.5.1. Spill kits are to include sufficient quantities of absorbent material, containers, booms, shovels and other tools, and personal protective equipment.
1.10.5.2. Spill response materials must be compatible with type of equipment being used or type of material being handled.
1.10.5.3. Spill kits are to be in close proximity to machinery.
1.10.5.4. During the Work there are to be trained and qualified personnel available that are ready to deploy spill kits when necessary.
1.10.6. Take immediate action using available resources to contain and mitigate effects on environment and persons from spill or release.
1.10.7. Promptly report spills and releases potentially causing damage to environment to:
1.10.7.1. Authority having jurisdiction or interest in spill or other release including conservation authority, water supply authorities, drainage authority, road authority, and fire department.
1.10.7.2. Contractor emergency response team including Superintendent.
1.10.7.3. Departmental Representative and other contractor(s) and individuals as directed by the Departmental Representative.

1.10.8. Departmental Representative can collect samples for chemical analyses prior to, during, and upon Final Completion of Work to monitor potential pollution caused by Contractor's activities. Assist Departmental Representative in collection of samples.
1.10.9. Remediation of soil, sediment or water contaminated by Contractor's activities.
1.10.9.1. Remediate all soil, sediment or water contaminated by Contractor's activities associated with the Work onsite and offsite.
1.10.9.2. Remediation includes excavation, pumping, testing, transport, treatment and disposal as appropriate for the type of contamination incurred, and at a minimum in accordance with the Contract.
1.10.9.3. Submit procedures for remediating soil, sediment or water contaminated by Contractor's activities.
1.10.9.4. Remediate as directed by the Departmental Representative.
1.10.9.5. Contractor is responsible for any additional investigation, testing, and assessments required as acceptable to the Departmental Representative.

1.11. Dust and Particulate Control

1.11.1. Execute Work by methods to minimize raising dust from construction operations.
1.11.2. Prevent fugitive dust from the Site from interfering with onsite and offsite uses.
1.11.3. Prevent dust from spreading to neighbouring properties.
1.11.4. Cover or wet down dry materials and rubbish to prevent blowing dust and debris. Provide dust control for temporary roads, excavations, and stockpiles.
1.11.5. Implement and maintain dust and particulate control measures immediately as directed by the Departmental Representative during Work and in accordance with regulations and in accordance with the Contract.
1.11.6. Provide positive means to prevent airborne dust from dispersing into atmosphere. Use fresh (non-saline) water for dust and particulate control.
1.11.7. As minimum, use appropriate covers on vehicles, including trucks, barges, and trains, hauling fine or dusty material. Use watertight vehicles to haul wet materials.
1.11.8. Inadequate procedures:
1.11.8.1. Stop relevant Work if dust and particulate control is not sufficient for controlling dusts and particulates into atmosphere, or when monitoring indicates that dust or particulate levels equal or exceed regulated or levels in accordance with the Contract.
1.11.8.2. Submit procedures proposed to resolve problem.
1.11.8.3. Make necessary changes to operations prior to resuming excavation, handling, processing, or other Work that can cause release of dusts or particulates.

1.11.8.4. Departmental Representative can stop relevant Work at any time when Contractor's Work procedures are inadequate to prevent release of dusts or particulates, or when monitoring indicates that dust or particulate levels equal or exceed regulated or levels in accordance with the Contract. Do not proceed with stopped Work until corrections accepted by Departmental Representative.

1.12. Non-Contaminated Material Removal

1.12.1. Remove all Non-Contaminated Material within Work areas in accordance with the Contract and as directed by the Departmental Representative.
1.12.2. Remove surplus materials and temporary facilities from Site.
1.12.3. Dispose waste offsite.
1.12.4. Do not burn or bury any waste onsite.
1.12.5. Do not discharge wastes into streams or waterways.
1.12.6. Do not dispose of volatile or hazardous materials such as mineral spirits, oil, or paint thinner in storm or sanitary drains.

1.13. Sewage Wastewater

1.13.1. Store Sewage Wastewater from toilet facilities with wastewater from handbasins, and/or showers, for ultimate disposal.
1.13.2. Provide, operate, and maintain Sewage Wastewater storage tanks to store Sewage Wastewater.
1.13.3. Transport and dispose of Sewage Wastewater at a Disposal Facility, or discharge to municipal sanitary sewer system in compliance with Municipal requirements, as accepted by Departmental Representative.
1.13.4. Discharges: comply with applicable discharge limitations and requirements; do not discharge Sewage Wastewater to Site sewer systems that do not conform to or are in violation of such limitations or requirements; and obtain approval prior to discharge of Sewage Wastewater.

1.14. Wastewater Control

1.14.1. Dewater various parts of Work including, without limitation, excavations, structures, foundations, and Work areas.
1.14.2. Employ construction methods, plant procedures, and precautions that ensure Work, including excavations, are stable, free from disturbance, and dry.
1.14.3. Direct surface waters that have not contacted potentially Contaminated Materials to surface drainage systems.
1.14.4. Control surface drainage including ensuring that gutters are kept open, wastewater is not allowed across or over pavements or sidewalks except through accepted pipes or properly constructed troughs, and runoff from unstabilized areas is intercepted and diverted to suitable outlet.

1.15. Non-Contaminated Water Disposal

1.15.1. Dispose of Non-Contaminated Water in manner not injurious to public health or safety, to the environment, to onsite or offsite property, or to any part of Work completed or under construction.

1.15.2. Control disposal or runoff of Non-Contaminated Water containing suspended materials or other harmful substances in accordance with local authority requirements.

1.15.3. Ensure pumped Non-Contaminated Water into waterways, sewer or drainage systems is free of suspended materials. Provide flocculation tanks, settling basins, or other treatment facilities to remove suspended solids or other materials before discharging to storm sewers, watercourses or drainage areas.

1.15.4. Obtain permits to discharge Non-Contaminated Water to environment or Municipal sewers.

1.15.5. Do not discharge water which may have come in contact with potentially Contaminated Material or otherwise be Contaminated directly offsite to the environment or to municipal sewers.

1.16. Erosion and Sediment Control

1.16.1. Plan and execute construction by methods to control surface drainage from cuts and fills, from borrow and waste disposal areas, from stockpiles, staging areas, and other Work areas. Prevent erosion and sedimentation.

1.16.2. Minimize amount of bare soil or sediment exposed at one time. Stabilize disturbed soil or sediment as quickly as practical. Strip vegetation, regrade, or otherwise develop to minimize erosion. Remove accumulated sediment resulting from construction activity from adjoining surfaces, drainage systems, and water courses, and repair damage caused by soil erosion and sedimentation as directed by the Departmental Representative.

1.16.3. Provide and maintain temporary erosion and sediment control measures.

1.16.3.1. Temporary erosion and sediment control measures are required to prevent erosion and migration of silt, mud, sediment, and other debris offsite or to other areas of Site where damage might result, or that might otherwise be required by laws and regulations.

1.16.3.2. Temporary erosion and sediment control measures include: silt fences, hay or straw bales, ditches, geotextiles, drains, berms, terracing, riprap, temporary drainage piping, vegetative cover, dikes, mulching, sediment traps, detention and retention basins, grading, planting, retaining walls, culverts, pipes, guardrails, temporary roads, and other measures appropriate to specific condition.

1.16.3.3. Temporary improvements must remain in place and in operation as necessary or until otherwise directed by the Departmental Representative.

1.16.3.4. Place silt fences and/or hay or straw bales in ditches to prevent sediment from escaping from ditch terminations.

1.16.3.5. Do not construct bale barriers and silt fence in flowing streams or in swales.

1.16.3.6. Check erosion and sediment control measures weekly after each rainfall; during prolonged rainfall check daily.
1.16.3.7. Bales and/or silt fence can be removed at beginning of Working Day, replace at end of Working Day.
1.16.3.8. Repair damaged bales, end runs, and undercutting beneath bales.
1.16.3.9. Unless directed by the Departmental Representative, remove temporary erosion and sediment control devices upon Final Completion of Work. Temporary erosion and sediment control devices once removed become property of Contractor.
1.16.4. Whenever sedimentation is caused by stripping vegetation, regrading, or other development, remove it from adjoining surfaces, drainage systems, and watercourses, and repair damage as quickly as possible.
1.16.5. Construct fill areas to prevent erosion.
1.16.6. Do not disturb existing embankments or embankment protection in accordance with the Contract.
1.16.7. Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.
1.16.8. If soil, sediment and debris from Site accumulate in low areas, storm sewers, roadways, gutters, ditches, or other areas where it is undesirable, remove accumulation and restore area to original condition, as directed by the Departmental Representative.

1.17. Work In or Adjacent to Waterways

1.17.1. Approvals and Practices:
1.17.1.1. Obtain Discharge Approval prior to commencing work which may impact waterways.
1.17.1.2. As required, comply with Fisheries Act Authorization and other relevant authorizations and in accordance with the Contract.
1.17.1.3. Follow practices described in Fisheries and Oceans Canada (September 1993) *Land Development Guidelines for the Protection of Aquatic Habitat*.
1.17.1.4. Follow practices described in BC Ministry of Environment (March 2004) *Standards and Best Practices for Instream Works*.
1.17.2. Timing:
1.17.2.1. Time work in water to respect timing windows to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.
1.17.2.2. Minimize duration of in-water work.
1.17.2.3. Conduct instream work during periods of low flow, or at low tide, to further reduce the risk to fish and their habitat or to allow work in water to be isolated from flows.
1.17.2.4. Schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation.

1.17.3. Site Selection:

1.17.3.1. Design and plan activities and works in waterbody such that loss or disturbance to aquatic habitat is minimized and sensitive spawning habitats are avoided.

1.17.3.2. Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.

1.17.3.3. Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.

1.17.3.4. Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.

1.17.4. Contaminant and Spill Management:

1.17.4.1. Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, poured concrete or other chemicals do not enter the watercourse.

1.17.4.2. Develop a response plan that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.

1.17.4.3. Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

1.17.5. Erosion and Sediment Control:

1.17.5.1. Develop and implement an Erosion and Sediment Control Plan for the site that minimizes risk of sedimentation of the waterbody during all phases of the project. Maintain erosion and sediment control measures until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the waterbody or settling basin and runoff water is clear.

1.17.6. Erosion and Sediment Control Plan includes:

1.17.6.1. Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the water body.

1.17.6.2. Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site such that sediment is filtered out prior to the water entering a waterbody. This includes pumping/diversion of water to a vegetated area, construction of a settling basin or other filtration system.

1.17.6.3. Site isolation measures (e.g., silt boom or silt curtain) for containing suspended sediment where in-water work is required (e.g., dredging, underwater cable installation).

1.17.6.4. Measures for containing and stabilizing waste material (e.g., dredging spoils, construction waste and materials, commercial logging waste, uprooted or cut aquatic plants, accumulated debris) above the high water mark of nearby waterbodies to prevent re-entry.

1.17.6.5. Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction.
1.17.6.6. Repairs to erosion and sediment control measures and structures if damage occurs.
1.17.6.7. Removal of non-biodegradable erosion and sediment control materials once site is stabilized.
1.17.7. Shoreline/Bank Re-vegetation and Stabilization:
1.17.7.1. Clearing of riparian vegetation should be kept to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction.
1.17.7.2. When practicable, prune or top the vegetation instead of grubbing/uprooting.
1.17.7.3. Minimize the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the waterbody below the ordinary high water mark. If material is removed from the waterbody, set it aside and return it to the original location once construction activities are completed.
1.17.7.4. Immediately stabilize shoreline or banks disturbed by any activity associated with the project to prevent erosion and/or sedimentation, preferably through re-vegetation with native species suitable for the site.
1.17.7.5. Restore bed and banks of the waterbody to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage should be restored.
1.17.7.6. If replacement rock reinforcement/armouring is required to stabilize eroding or exposed areas, then ensure that appropriately-sized, clean rock is used; and that rock is installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.
1.17.7.7. Remove all construction materials from site upon project completion.
1.17.8. Aquatic Life Protection:
1.17.8.1. Ensure that all in-water activities, or associated in-water structures, do not interfere with aquatic life passage, constrict the channel width, or reduce flows.
1.17.8.2. Retain a qualified environmental professional to ensure applicable permits for relocating fish are obtained and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters. Fish may need to be relocated again, should flooding occur on the site.
1.17.8.3. Screen any water intakes or outlet pipes to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.
1.17.8.4. Avoid using explosives in or near water. Use of explosives in or near water produces shock waves that can damage a fish swim bladder and rupture internal organs. Blasting vibrations may also kill or damage fish eggs or larvae.

1.17.9. Operation of Machinery:

1.17.9.1. Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.

1.17.9.2. Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbance to the banks and bed of the waterbody.

1.17.9.3. Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.

1.17.9.4. Use temporary crossing structures or other practices to cross streams or waterbodies with steep and highly erodible (e.g., dominated by organic materials and silts) banks and beds. For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g., swamp mats, pads) if minor rutting is likely to occur during fording.

1.17.9.5. Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.

1.18. Noncompliance

1.18.1. Departmental Representative will inform Contractor in writing of observed noncompliance with federal, provincial or municipal environmental laws, regulations, permits, or other environmental procedure violations.

1.18.2. After receipt of notice, inform the Departmental Representative of the proposed corrective action. Corrective action will be subject to acceptance of Departmental Representative.

1.18.2.1. Do not take action until after receipt of written acceptance.

1.18.3. Departmental Representative will issue stop order of Work until satisfactory corrective action has been taken.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Not Used.

1.4. Laws, Regulations, Permits

1.4.1. Generally, provincial and municipal laws, regulations, bylaws and other requirements do not apply on federal lands, activities or undertakings. Soil and other materials that are removed from federal lands may become subject to provincial or municipal laws and regulations.

1.4.2. Provincial or municipal standards may be used in relation to federal lands only as guidelines for the purpose of establishing remediation goals and objectives. The term "standards" is used in this part in order to maintain consistency in terminology throughout this document, and does not imply that standards contained in provincial or municipal laws and regulations apply on Federal lands, activities or undertakings.

1.4.3. Comply with certificates, licenses and other permits enforced at the location concerned required by regulatory federal, provincial or municipal authorities to complete the Work that have already been obtained.

1.4.4. Obtain and pay for certificates, licenses and other permits enforced at the location concerned required by regulatory federal, provincial or municipal authorities to complete the Work that have not already been obtained or that are required to be amended.

1.4.5. Provide applicable authorities with plans and information required for issue of acceptance certificates.

1.4.6. Furnish inspection certificates in evidence that the Work installed conforms with the requirements of the authority having jurisdiction.

1.5. Codes, Bylaws, Standards

1.5.1. Meet or exceed requirements of Contract, standards, and codes applicable to the performance of the Work and referenced documents.

1.5.2. In any case of conflict or discrepancy, the most stringent requirements will apply.

1.5.3. Perform Work in accordance with the *National Building Code* of Canada (NBC), and other requirements or codes in accordance with the Contract, construction standards and/or any other code or bylaw applicable to the performance of the Work.

1.5.4. Certificates, licenses and other permits enforced at the location concerned required by regulatory federal, provincial or municipal authorities to complete the Work: see 01 11 00.

1.5.5. Comply with all attachments, references, and reports relevant to Work, including environmental protection.

1.6. Smoking Environment

1.6.1. Smoking on the Site is not permitted.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Not Used.

1.4. Quality of Work

1.4.1. Ensure that quality workmanship is performed through use of skilled tradesmen, under supervision of qualified journeyman, or Qualified Professional.

1.4.2. Meet or exceed standards set out in the National Building Code of Canada as applicable for workmanship, erection methods and procedures.

1.4.3. In cases of dispute, perform Work to standard or quality in accordance with any decisions by the Departmental Representative.

1.4.4. Follow Departmental Representative's directions to meet the Quality of Work in accordance with the Contract at no increase to the Contract Amount and no increase to Extension of Time for completion of the Work. Quality of Work includes addressing comments on Submittals, modifying environmental procedures, and preventing or remediating contaminated material spills.

1.5. Quality Management

1.5.1. Be responsible for all Quality Assurance and Quality Control during the performance of the Work.

1.5.2. Quality Assurance and Quality Control includes monitoring, inspecting, testing, documenting and reporting the means, methods, materials, workmanship, processes, and products of all aspects of the Work, including design, construction, and management as necessary to ensure conformance with the Contract.

1.5.3. Assist Departmental Representative in quality audit inspections and submit all indicated information within 5 Working Days of collection or as directed.

1.6. Inspection

1.6.1. Allow Departmental Representative access to Work. If part of Work is in preparation at locations other than Site, allow access to such Work whenever it is in progress. Work at locations other than Site includes offsite Transportation (e.g., transfer stations), Treatment, and Disposal Facilities.

1.6.2. Give timely notice requesting inspection if Work is designated for special tests, inspections or approvals by Departmental Representative directions, or law of Site.

1.6.3. If Contractor covers or permits to be covered Work that has been designated for special tests, inspections or approvals before such is made, uncover such Work, have inspections or tests satisfactorily completed and make good such Work.

1.6.4. Departmental Representative will order part of Work to be examined if Work is suspected to be not in accordance with Contract Documents. If, upon examination such work is found not in accordance with Contract Documents, correct such Work and pay cost of examination and correction.

1.7. Independent Inspection Agencies

1.7.1. Independent Inspection/Testing Agencies may be engaged by Departmental Representative for purpose of inspecting and/or testing portions of Work. Cost of such services will be borne by Departmental Representative.

1.7.2. Provide equipment required for executing inspection and testing by appointed agencies.

1.7.3. Employment of inspection/testing agencies does not relax responsibility to perform Work in accordance with Contract Documents.

1.7.4. If defects are revealed during inspection and/or testing, appointed agency will request additional inspection and/or testing to ascertain full degree of defect. Correct defect and irregularities as advised by Departmental Representative at no cost to Departmental Representative. Pay costs for retesting and reinspection.

1.8. Access to Work

1.8.1. Allow inspection/testing agencies access to Work, off site manufacturing and fabrication plants.

1.8.2. Co-operate to provide reasonable facilities for such access.

1.9. Procedures

1.9.1. Notify appropriate agency and Departmental Representative in advance of requirement for tests, in order that attendance arrangements can be made.

1.9.2. Submit samples and/or materials required for testing, as specifically requested in specifications. Submit with reasonable promptness and in orderly sequence to not cause delays in Work.

1.9.3. Provide labour and facilities to obtain and handle samples and materials on site. Provide sufficient space to store and cure test samples.

1.10. Rejected Work

1.10.1. Remove defective Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by Departmental Representative as failing to conform to Contract Documents. Replace or re-execute in accordance with Contract Documents.

1.10.2. Make good other Contractor's work damaged by such removals or replacements promptly.

1.10.3. If in opinion of Departmental Representative it is not expedient to correct defective Work or Work not performed in accordance with Contract Documents, PWGSC will deduct from Contract Price difference in value between Work performed and that called for by Contract Documents, amount of which will be determined by Departmental Representative.

1.11. Reports

1.11.1. Submit 2 copies of inspection and test reports to [Departmental Representative.

1.11.2. Provide copies to subcontractor of work being inspected or tested.

1.12. Tests and Mix Designs

1.12.1. Furnish test results and mix designs as requested.

1.12.2. Test results must be signed by Qualified Professional.

1.12.3. The Departmental Representative may require, and pay for, additional inspection and testing services not included above.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Site Layout: Prior to mobilization to Site, Submit Site Layout drawings showing existing conditions and facilities, construction facilities and temporary controls provided by Contractor. Include:

1.3.1.1. Equipment and personnel decontamination areas.

1.3.1.2. Means of ingress, egress and temporary traffic control.

1.3.1.3. Equipment and material staging areas.

1.3.1.4. Stockpile areas and construction details, including base preparation and water control features.

1.3.1.5. Exclusion areas, contaminant handling areas, and other areas identified in Contractor's site-specific Health and Safety Plan and Environmental Protection Plan.

1.3.1.6. Grading, including contours, required to construct temporary facilities.

1.3.1.7. Location of all temporary facilities including: Contaminated Water Treatment Plant, truck wash and decontamination units, office trailers, modular camp structures, parking, storage, environmental monitoring stations, above ground and underground utilities, and temporary facilities and roads.

1.3.2. Signs: at least 5 Working Days prior to posting, Submit any required signs viewable by public.

1.4. Utilities

1.4.1. Power is not available at existing Site and must be supplied at the Contractor’s expense. Provide power for work force.

1.4.2. Water supply is not available at existing Site and must be supplied at the Contractor’s expense. Provide water for work force.

1.5. Fire Protection

1.5.1. Provide and maintain temporary fire protection equipment during performance of Work required by governing codes, regulations and bylaws.

1.6. Access and Delivery

1.6.1. Only the designated entrance in accordance with the Contract can be used for access to Site.

1.6.1.1. Maintain for duration of Contract.

1.6.1.2. Make good damage resulting from Contractor’s use.

1.6.2. Use of the Site will be granted to the Contractor through the Departmental Representative.

1.7. Installation and Removal

1.7.1. Prepare site plan indicating proposed location and dimensions of area to be fenced and used by Contractor, number of trailers to be used, avenues of ingress/egress to fenced area and details of fence installation.
1.7.2. Identify areas which have to be graveled or otherwise treated to prevent tracking of mud.
1.7.3. Indicate use of supplemental or other staging area.
1.7.4. Provide construction facilities in order to execute work expeditiously.
1.7.5. Provide temporary utilities in order to execute Work expeditiously.
1.7.6. Remove from Site all such Work after use.

1.8. Site Storage/Loading

1.8.1. Confine work and operations of employees in accordance with the Contract. Do not unreasonably encumber premises with products.
1.8.2. Storage space must be limited to the Site.
1.8.3. Do not load or permit to load any part of Work with weight or force that will endanger Work.

1.9. Construction Parking

1.9.1. Parking of private vehicles will not be permitted on Site.
1.9.2. Provide and maintain adequate access to project site.

1.10. Security

1.10.1. As needed, provide and pay for responsible security personnel to guard site and contents of site after working hours and during holidays.
1.10.2. Control access to Site and maintain a log of all personnel onsite. No non-Work visitors allowed without prior written consent of Departmental Representative.

1.11. Equipment, Tools and Materials Storage

1.11.1. Provide and maintain, in clean and orderly condition, lockable weatherproof sheds for storage of tools, equipment and materials.
1.11.2. Locate materials not required to be stored in weatherproof sheds on site in manner to cause least interference with work activities.

1.12. Sanitary Facilities

1.12.1. Provide sanitary facilities for work force in accordance with governing regulations and ordinances.
1.12.2. Post notices and take precautions as required by local health authorities. Keep area and premises in sanitary condition.

1.13. Protection and Maintenance of Traffic

1.13.1. Provide access and temporary relocated roads as necessary to maintain traffic.
1.13.2. Maintain and protect traffic on affected roads during construction period except as otherwise specifically directed by Departmental Representative.
1.13.3. Provide measures for protection and diversion of traffic, including provision of watch-persons and flag-persons, erection of barricades, placing of lights around and in front of equipment and work, and erection and maintenance of adequate warning, danger, and direction signs.
1.13.4. Protect travelling public from damage to person and property.
1.13.5. Contractor's traffic on roads selected for hauling material to and from site to interfere as little as possible with public traffic.
1.13.6. Verify adequacy of existing roads and allowable load limit on these roads. Contractor: responsible for repair of damage to roads caused by construction operations.
1.13.7. Construct access and haul roads necessary.
1.13.8. Haul roads: constructed with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic shall be avoided.
1.13.9. Provide necessary lighting, signs, barricades, and distinctive markings for safe movement of traffic.
1.13.10. Dust control: adequate to ensure safe operation at all times.
1.13.11. Location, grade, width, and alignment of construction and hauling roads: subject to approval by Departmental Representative.
1.13.12. Lighting: to assure full and clear visibility for full width of haul road and work areas during night work operations.
1.13.13. Provide snow removal during period of Work.
1.13.14. Remove, upon completion of work, haul roads designated by Departmental Representative.

1.14. Rig Wash and Decontamination

1.14.1. Wash and decontaminate the rig as needed, including the supply of potable water.

1.15. Clean-Up

1.15.1. Remove construction debris, waste materials, packaging material from work site daily.
1.15.2. Clean dirt or mud tracked onto paved or surfaced roadways.
1.15.3. Store materials resulting from demolition activities that are salvageable.
1.15.4. Stack stored new or salvaged material not in construction facilities.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Product Data: at least 5 Working Days prior to use, Submit data on products to be used in Work. Include:

1.3.1.1. Manufacturers' catalogue sheets, MSDS sheets, brochures, literature, performance charts and diagrams, used to illustrate standard manufactured products or any other information in accordance with the Contract.

1.3.1.2. Delete information not applicable to project.

1.3.1.3. Supplement standard information to provide details applicable to project.

1.3.1.4. Cross-reference product data information to applicable portions of Contract.

1.3.2. Substitution: at least 5 Working Days prior to use and after Contract award, Submit proposals for substituting products, if required. Include statements of respective costs of items originally in accordance with the Contract and the proposed substitution.

1.3.3. Quality of Work: at least 5 Working Days prior to Work, Submit alternate means to meet or correct quality of work, if required.

1.4. Products, Material and Equipment

1.4.1. Use new products, material and equipment in accordance with the Contract. The term "products" is referred to throughout the specifications.

1.4.2. Use products of one manufacturer for material and equipment of the same type or classification in accordance with the Contract.

1.4.3. Unless otherwise specified, comply with manufacturer's latest printed instructions for materials and installation method in accordance with the Contracts.

1.4.4. Notify Departmental Representative in writing of any conflict between Contract and manufacturer's instructions. Departmental Representative will instruct which document is to be followed.

1.4.5. Deliver, store and maintain packaged material and equipment with manufacturer's seals and labels intact.

1.4.6. Prevent damage, adulteration and soiling of products during delivery, handling and storage. Immediately remove rejected products from Site.

1.4.7. Store products in accordance with Suppliers' instructions.

1.5. Quality of Products

1.5.1. Products, materials and equipment (referred to as products) incorporated into Work must be new, not damaged or defective, and of the best quality (compatible with the specifications) for the purpose intended. As directed by the Departmental Representative, furnish evidence as to type, source, and quality of the products provided.

1.5.2. Defective products will be rejected regardless of previous inspections.

1.5.2.1. Inspection does not relieve responsibility, but is precaution against oversight or error.

1.5.2.2. Remove and replace defective products.

1.5.3. Retain purchase orders, invoices and other documents to prove that all products utilized in the Work meet the requirements of the Contract. Produce documents as directed by the Departmental Representative.

1.5.4. Should any dispute arise as to quality or fitness of products, the decision rests strictly with the Departmental Representative in accordance with the Contract.

1.5.5. Permanent labels, trademarks and nameplates on products are not acceptable in prominent locations, except where required for operating instructions, or when located in mechanical or electrical rooms.

1.6. Availability of Products

1.6.1. Immediately upon signing the Contract, review product delivery requirements and anticipate foreseeable supply delays for any items.

1.6.2. If delays in supply of products are foreseeable, Notify Departmental Representative of such in order that substitutions or other remedial action may be authorized in ample time to prevent delay in performance of the Work.

1.6.3. In event of failure to Notify Departmental Representative at the start of Work and should it subsequently appear that the Work may be delayed for such reason, the Departmental Representative reserves the right to substitute more readily available products of similar character.

1.7. Manufacturer’s Instructions

1.7.1. Install or erect products in accordance with the manufacturer’s instructions in accordance with the Contract.

1.7.1.1. Do not rely on labels or enclosures provided with products.

1.7.1.2. Obtain written instructions directly from the manufacturer.

1.7.2. Notify Departmental Representative in writing of any conflict between Contract and manufacturer’s instructions. Departmental Representative will instruct which document is to be followed.

1.7.3. Improper installation or erection of products, due to failure in complying with these requirements, authorizes the Departmental Representative to instruct the removal and re-installation.

1.8. Contractor's Options for Selection of Products for Tendering

1.8.1. Products specified by "Prescriptive" specifications: select any product meeting or exceeding requirements in accordance with the Contract.

1.8.2. Products specified by performance and referenced standard: select any product meeting or exceeding the referenced standard.

1.8.3. Products specified to meet particular design requirements or to match existing materials: use only material in accordance with the Contract.

1.8.4. When products are specified by a referenced standard or by performance specifications, as directed by the Departmental Representative obtain from manufacturer and independent laboratory report showing that the product meets or exceeds the requirements in accordance with the Contract.

1.9. Storage, Handling and Protection

1.9.1. Handle and store products in manner to prevent damage, adulteration, deterioration and soiling and in accordance with manufacturer's instructions.

1.9.2. Store packaged or bundled products in original and undamaged condition with manufacturer's seals and labels intact. Do not remove from packaging or bundling until required in Work.

1.9.3. Store products subject to damage from weather in weatherproof enclosures.

1.9.4. Remove and replace damaged products as directed by the Departmental Representative.

1.10. Transportation

1.10.1. Pay costs of transportation of products required in performance of Work.

1.10.2. Transport products in manner to prevent damage, adulteration, deterioration and soiling and in accordance with manufacturer's instructions when applicable.

1.10.3. Transport products subject to damage from weather in weatherproof enclosures.

1.10.4. Transport in an efficient manner that does not cause delays to the Work schedule.

1.11. Quality of Work

1.11.1. Ensure quality of Work is of highest standard, executed by workers experienced and skilled in respective duties for which they are employed. Immediately Notify Departmental Representative if required Work is such as to make it impractical to produce results in accordance with the Contract. Provide alternate means to meet or correct quality of work, as accepted by the Departmental Representative.

1.11.2. Do not employ anyone unskilled in their required duties.

1.11.3. Perform Work to standard of fitness of Quality of Work in accordance with any decision by the Departmental Representative.

1.12. Coordination

1.12.1. Ensure cooperation of workers in laying out Work. Maintain efficient and continuous supervision.

1.13. Remedial Work

1.13.1. Perform remedial Work required to repair or replace parts or portions of Work as directed by the Departmental Representative as defective or unacceptable. Coordinate adjacent affected Work as required.

1.13.2. Perform remedial Work by specialists familiar with materials affected. Perform in a manner to neither damage nor put at risk any portion of Work.

1.14. Storage Tanks

1.14.1. Abide by the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations* for stored petroleum products and allied petroleum products tank system located on federal or Aboriginal land, or within federal jurisdiction as described in the regulations.

1.14.2. Temporary storage tanks subject to the regulations must be registered with Environment Canada.

1.14.3. Mobile tanks subject to the regulations must be certified to be mobile.

1.14.4. Storage tanks to meet the following minimum requirements:

1.14.4.1. Corrosion protection.

1.14.4.2. Secondary containment.

1.14.4.3. Containment sumps, if applicable.

1.14.4.4. Overfill protection.

1.14.5. All components of tank system must bear certification marks indicating that they conform to the standards set out in the regulations.

1.14.6. Product transfer area must be designed to contain spills.

1.14.7. Prepare an emergency plan.

1.14.8. Prior to first filling, storage tanks must:

1.14.8.1. Be registered.

1.14.8.2. Be certified and marked.

1.14.8.3. Transfer area be constructed.

1.14.8.4. Emergency plan in place.

2. PART 2 - PRODUCTS

2.1. Asbestos Containing Materials Prohibition

2.1.1. Any material containing any degree of asbestos is banned from use in any and all sites, designs and projects.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Preconstruction Condition Survey: Prior to mobilization to Site, Submit Preconstruction Condition Survey of existing structures, utilities and surface features.

1.4. Qualifications of Surveyor

1.4.1. A Land Surveyor, acceptable to Departmental Representative.

1.5. Survey Reference Points

1.5.1. Locate, confirm and protect control points prior to starting site work. Preserve permanent reference points during construction.

1.5.2. Make no changes or relocations without prior written notice to Departmental Representative.

1.5.3. Report to Departmental Representative when reference point is lost or destroyed, or requires relocation because of necessary changes in grades or locations.

1.5.4. Require surveyor to replace control points in accordance with original survey control.

1.6. Survey Requirements

1.6.1. Establish permanent bench marks on site, referenced to established bench marks by survey control points. Record locations, with horizontal and vertical data in Project Record Documents.

1.6.2. Establish lines and levels, locate and lay out.

1.7. Existing Services

1.7.1. Size, depth and location of existing utilities and structures as specified are for guidance only. Completeness and accuracy are not guaranteed.

1.7.2. Before commencing work, establish location and extent of service lines in area of Work and notify Departmental Representative. All utilities entering Site must be confirmed prior to subsurface disturbance (i.e., do not rely on as-built documents). As appropriate, confirm locations of buried utilities by independent utility locator and using hand test excavations or hydrovac methods.

1.7.3. Remove abandoned service lines within 2 m of structures. Cap or otherwise seal lines at cut-off points as directed by Departmental Representative.

1.7.4. Maintain and protect from damage all utilities and structures encountered, unless Work involves temporarily breaking, rerouting, or connecting into existing utilities.
1.7.5. Where Work involves temporarily breaking, rerouting, or connecting into existing utilities, obtain permission from utility companies of intended interruption of services, and carry out Work at times determined by the authorities having jurisdiction.
1.7.6. Submit schedule to and obtain approval for any shutdown or closure of active service. Adhere to schedule accepted by Departmental Representative and provide notice to affected parties.
1.7.7. Provide temporary services as required to maintain critical building and tenant systems.
1.7.8. Where unknown utilities are encountered, immediately verbally notify Departmental Representative and confirm findings in writing.

1.8. Examination

1.8.1. Examine Site and Contract and be familiar and conversant with existing conditions likely to affect Work, including Contaminated Material.

1.9. Records

1.9.1. Contractor to prepare preconstruction as-built Shop Drawings of all utilities.
1.9.2. Contractor or to prepare post construction as-built Shop Drawings of all utilities, including existing, reinstated, rerouted, and abandoned.
1.9.3. Maintain a complete, accurate log of control and survey work as it progresses.
1.9.4. Preconstruction Condition Survey:
1.9.4.1. Conduct Preconstruction Condition Survey of existing structures and other features which can be affected by Work, both onsite and offsite. Includes: buildings, trees and other plants, lawns, fencing, service poles, wires, rail tracks, pavement, roads, survey bench marks, monuments and other features.
1.9.4.2. Survey to include detailed photographic documentation of any preconstruction damage, and measurements where appropriate, including crack width and length, angles out of true. Record written notices to owners of features that have existing damage.
1.9.4.3. Record written notices of offsite owners which refused entry to conduct Preconstruction Condition Survey.

2. PART 2 - PRODUCTS

2.1. Not Used

2.1.1. Not Used.

3. PART 3 - EXECUTION

3.1. Not Used

3.1.1. Not Used.

END OF SECTION

1. PART 1 - GENERAL

1.1. Measurement Procedures

1.1.1. See 01 11 00.

1.2. Definitions

1.2.1. See 01 11 00.

1.3. Action and Informational Submittals

1.3.1. Profiling Data Logs: within 20 Working Days of completion of the work, submit all final borehole data logs for the LIF Survey and Hydraulic Profiling in both hard and electronic copy form. Include all technical information and data including procedures, equipment used, Quality Assurance and Quality Control testing, and generated data logs. Include:

1.3.1.1. LIF Survey borehole data logs.

1.3.1.2. Hydraulic Profiling borehole data logs.

1.3.2. Draft electronic copies of each log to be provided to the Departmental Representative at the conclusion of each field day.

2. PART 2 - PRODUCTS

2.1. Equipment

2.1.1. Drill rig supplied for advancing probe rods can advance via direct push, has a minimum weight of 7,900 kgs, can generate a down force of 262 kN, and can generate a retraction force of 356 kN.

2.1.2. LIF survey equipment to suitable to carry out the work as defined.

2.1.3. Hydraulic Profiling probe suitable to carry out the work as defined.

2.1.4. Representative Soil Sampling Equipment to carry out the work as defined.

3. PART 3 - EXECUTION

3.1. Site Review

3.1.1. Departmental Representative to be present on Site for the Duration of the Work, and will review progress daily.

3.2. LIF Survey

3.2.1. The Laser-induced fluorescence (LIF) survey technique uses laser light to excite fluorescent molecules including PAHs that exist in the vast majority of hydrocarbons including petroleum fuels/oils. The LIF survey is intended to provide a continual proportional representation (i.e., semi-quantitative) of the hydrocarbon concentrations present with depth.

3.2.2. The LIF probe is advanced into the subsurface at a rate not greater than 2.0 cm/sec using a direct push technology drill which relies on static weight of the carrier vehicle combined with percussion as the energy for advancement of a tool string.

3.2.3. Probe calibration is performed prior to initiating the LIF probe advance at each survey location. Calibration details to be reviewed with the Departmental Representative at each sample location.

3.2.4. Electrical conductivity (EC) measurements are to be collected during advancement of the LIF probe at each survey location.

3.2.5. At Muncho Lake, the LIF survey will be carried out at 50 locations to a depth of 15 m below grade within the location grid shown on the Drawings or at the direction of the Departmental Representative. Two rounds of characterization for the LIF survey are planned. The first round will generally consist of advancing survey holes across a 15 m by 15 m grid at each site. The second survey round will consist of providing further data characterization within the 15 m by 15 m grid with locations to be determined by the Departmental Representative based on data review.

3.2.6. Optional LIF Survey may be undertaken at the direction of the Departmental Representative at Muncho Lake. The optional LIF Survey would be carried out at 25 locations to a depth of 15 m below grade within the location grid shown on the Drawings or at the direction of the Departmental Representative. The optional work would be carried out as part of the second round of characterization.

3.2.7. At Fireside, the LIF survey will be carried out at 90 locations within the location grid shown on the Drawings and at the direction of the Departmental Representative. Two rounds of characterization for the LIF survey are planned. The first round will generally consist of advancing survey holes across a 15 m by 15 m grid at each site. The second survey round will consist of providing further data characterization within the 15 m by 15 m grid with locations to be determined by the Departmental Representative based on data review. Anticipated LIF survey depths are provided in 3.2.7.1 to 3.2.7.5.

3.2.7.1. 20 locations to 15 m below grade.

3.2.7.2. 10 locations to 20 m below grade.

3.2.7.3. 15 locations to 25 m below grade.

3.2.7.4. 20 locations to 30 m below grade.

3.2.7.5. 25 locations to 35 m below grade.

3.2.8. Optional LIF Survey may be undertaken at the direction of the Departmental Representative at Fireside. The optional LIF Survey would be carried out at 40 locations within the location grid shown on the Drawings or at the direction of the Departmental Representative. The optional work would be carried out as part of the second round of characterization. Anticipated optional LIF survey depths are provided in 3.2.8.1 to 3.2.8.5.

3.2.8.1. 10 locations to 15 m below grade.
3.2.8.2. 5 locations to 20 m below grade.
3.2.8.3. 5 locations to 25 m below grade.
3.2.8.4. 10 locations to 30 m below grade.
3.2.8.5. 10 locations to 35 m below grade.

3.2.9. At both Muncho Lake and Fireside, no LIF survey data is required for the top 8 metres at any location. Therefore, the Contractor will employ a "Pre-probing" strategy which can consist either of advancing the drill tooling and LIF probe directly to 8 metres below grade prior to initiating data collection, or advancing drill tooling without the LIF probe to 8 metres, withdrawing the drill tooling and subsequent advancement of the drill tooling with the LIF probe within the "Pre-probed" hole and initiating data collection at 8 metres below grade.

3.2.10. "Pre-probed" holes may be filled with filter sand at the Contractor's discretion prior to deployment of the LIF probe.

3.2.11. To achieve continuous data collection with depth , the "Pre-probing" strategy will also be used at a hole location where subsurface conditions are difficult and could result in potential damage to drill tooling, or in areas where refusal is encountered. In these circumstances, a slightly offset step out at the survey location can be used and "Pre-probed" by advancing drill tooling without the LIF probe to the depths already achieved in the original location with redeployment of the LIF probe for data collection beyond to the target depth. This approach is subject to approval by the Departmental Representative on a per location basis. Also, based on data review during the program, the Departmental Representative may identify depth intervals where data is not required allowing for this "Pre-probed" approach to be utilized for efficiency within a borehole location if desired during the work.

3.2.12. Following completion at each LIF Survey location, holes will be backfilled with bentonite chips and the ground surface will be restored to ensure no hole or depression remains.

3.3. Hydraulic Profiling

3.3.1. The Hydraulic Profiling technique measures the pressure required to inject a flow of water into the soil profile. Measurement of the injection pressure is to be made using a downhole pressure transducer within a hydraulic profiling probe as it is advanced into the subsurface.

3.3.2. Hydrostatic pressure measurements are to be made using the downhole pressure transducer within the probe. Logs are to be produced at each survey location illustrating injection pressure with depth. The injection pressure log is intended to indicate formation permeability with depth.

3.3.3. EC measurements are to be collected during advancement of the hydraulic profiling probe at each location.

3.3.4. At Muncho Lake, the Hydraulic Profiling will be carried out at 8 locations to a depth of 15 m below grade within the location grid shown on the Drawings or at the direction of the Departmental Representative.

3.3.5. Optional Hydraulic Profiling Survey may be undertaken at the direction of the Departmental Representative at Muncho Lake. The optional Hydraulic Profiling Survey would be carried out at 4 locations to a depth of 15 m below grade within the location grid shown on the Drawings or at the direction of the Departmental Representative. The optional work would be carried out as part of the second round of characterization.

3.3.6. At Fireside, the Hydraulic Profiling will be carried out at 15 locations within the location grid shown on the Drawings or at the direction of the Departmental Representative. Anticipated Hydraulic Profiling survey depths are provided in 3.3.6.1 to 3.3.6.4.

3.3.6.1. 3 locations to 20 m below grade.

3.3.6.2. 4 locations to 25 m below grade.

3.3.6.3. 4 locations to 30 m below grade.

3.3.6.4. 4 locations to 35 m below grade.

3.3.7. Optional Hydraulic Profiling Survey may be undertaken at the direction of the Departmental Representative at Fireside. The optional Hydraulic Profiling Survey would be carried out at 7 locations within the location grid shown on the Drawings or at the direction of the Departmental Representative. The optional work would be carried out as part of the second round of characterization. Anticipated optional Hydraulic Profiling survey depths are provided in 3.3.7.1 to 3.3.7.4.

3.3.7.1. 1 location to 20 m below grade.

3.3.7.2. 2 locations to 25 m below grade.

3.3.7.3. 2 locations to 30 m below grade.

3.3.7.4. 2 locations to 35 m below grade.

3.3.8. At both Muncho Lake and Fireside, no Hydraulic Profiling data is required for the top 8 metres at any location. Therefore, the Contractor will employ a “Pre-probing” strategy which can consist either of advancing the drill tooling and Hydraulic Profiling probe directly to 8 metres below grade prior to initiating data collection, or advancing drill tooling without the Hydraulic Profiling probe to 8 metres, withdrawing the drill tooling and subsequent advancement of the drill tooling with the Hydraulic Profiling probe within the “Pre-probed” hole and initiating data collection at 8 metres below grade.

3.3.9. “Pre-probed” holes may be filled with filter sand at the Contractor’s discretion prior to deployment of the Hydraulic Profiling probe.

3.3.10. To achieve continuous data collection with depth , the “Pre-probing” strategy will also be used at a hole location where subsurface conditions are difficult and could result in potential damage to drill tooling, or in areas where refusal is encountered. In these circumstances, a slightly offset step out at the survey location can be used and “Pre-probed” by advancing drill tooling without the Hydraulic Profiling probe to the depths already achieved in the original location with redeployment of the Hydraulic Profiling probe for data collection beyond to the target depth. This approach is subject to approval by the Departmental Representative on a per location basis. Also, based on data review during the program, the Departmental Representative may identify depth intervals where data is not required allowing for this “Pre-probed” approach to be utilized for efficiency within a borehole location if desired during the work.

3.3.11. Following completion at each Hydraulic Profiling location, holes will be backfilled with bentonite chips and the ground surface will be restored to ensure no hole or depression remains.

3.4. Soil Sampling

3.4.1. At Muncho Lake, representative soil samples suitable for analytical testing of petroleum hydrocarbons and PAHs to be collected from 20 locations at specific depth intervals as directed by the Departmental Representative. A suitable core sampler will be used, and samples will collection depths are not expected to exceed approximately 15 m below ground surface.

3.4.2. Optional soil sampling may be undertaken at the direction of the Departmental Representative at Muncho Lake. The optional soil sampling would consist of the collection of representative soil samples suitable for analytical testing of petroleum hydrocarbons and PAHs from 10 locations at specific depth intervals as directed by the Departmental Representative. A suitable core sampler will be used, and samples will collection depths are not expected to exceed approximately 15 m below ground surface.

3.4.3. At Fireside, representative soil samples suitable for analytical testing of petroleum hydrocarbons and PAHs to be collected from 30 locations at specific depth intervals as directed by the Departmental Representative. A suitable core sampler will be used, and samples will collection depths are not expected to exceed approximately 35 m below ground surface.

3.4.4. Optional soil sampling may be undertaken at the direction of the Departmental Representative at Fireside. The optional soil sampling would consist of the collection of representative soil samples suitable for analytical testing of petroleum hydrocarbons and PAHs from 15 locations at specific depth intervals as directed by the Departmental Representative. A suitable core sampler will be used, and samples will collection depths are not expected to exceed approximately 35 m below ground surface.

END OF SECTION

APPENDIX A

In-Situ Pilot Testing and Laser-induced Fluorescence Evaluation

In-Situ Pilot Testing and Laser-induced Fluorescence Evaluation

Muncho Lake and Fireside Maintenance Camps, Alaska Highway, BC (PWGSC-Project # R. 016701.004/005)

Prepared for:

Public Works and Government Services Canada - Pacific Region

March 31, 2017

Project No. :635031/636200

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Executive Summary

On behalf of Public Works and Government Services Canada (PWGSC), SNC-Lavalin Inc. (SNC-Lavalin), has prepared this report for the pilot testing of in-situ chemical oxidant injection and surfactant application, as well as an evaluation into the feasibility of using a laser induced fluorescence (LIF) tool to further characterize and delineate petroleum hydrocarbon (PHC) concentrations at the Muncho Lake Maintenance Camp, kilometre 698, Alaska Highway, BC and Fireside Maintenance Camp, kilometre 839, Alaska Highway, BC (the Sites).

Pilot testing was completed in early Q4 2016 and identified that technical challenges associated with the in-situ application of oxidants and surfactants were easily overcome. Similarly it was identified that advancement of the LIF device was possible and could be considered for characterization of the deep petroleum hydrocarbon impacts at each yard.

Results from the initial in-situ chemical oxidation application suggest favourable conditions for larger scale remediation using this approach. Probe rods for the direct injection of hydrogen peroxide were advanced quickly and easily to target deep contaminated soil zones associated with the smear zone. Hydrogen peroxide was injected at flow rates, pressures, and concentrations that is expected to allow for remediation.

The application of surfactants was also successful in solubilising petroleum hydrocarbon impacts for subsequent recovery and remediation. However the increase in the concentration of dissolved phase PHCs is not sufficient to affect remediation without the recovery of a significant groundwater volume, and is not considered to be practical.

For the LIF evaluation probe rods with a solid point were advanced to simulate the advancement of the LIF tool at the Sites. It was observed that soil conditions were very tight for this type of advancement to the target depths required. However a “pre-probing” strategy in which a larger bore probe rod is advanced prior to deploying the LIF device was identified as a suitable approach for characterizing the plume at depth while minimizing the potential for any tooling damage.

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1 Introduction

On behalf of Public Works and Government Services Canada (PWGSC), SNC-Lavalin Inc. (SNC-Lavalin), has prepared this report for the pilot testing of in-situ chemical oxidant injection and surfactant application, as well as an evaluation into the feasibility of using a laser induced fluorescence (LIF) tool to further characterize and delineate petroleum hydrocarbon (PHC) concentrations at the Muncho Lake Maintenance Camp, kilometre 698, Alaska Highway, BC and Fireside Maintenance Camp, kilometre 839, Alaska Highway, BC (the Sites). All proposed work was completed under the Human Health and Ecological R.A.C.S. Contract with task Authorizations (CTA) No. EZ897-161534/003/VAN and PWGSC Project No. R.016701.004/005 and specific Task Authorization (TA) number 700362482.

The field work for in-situ chemical oxidant injection, surfactant application, and the LIF evaluation was completed from October 3, 2016 to October 14, 2016. The pilot test and LIF evaluation was completed in accordance with the Azimuth/SNC-Lavalin workplan, *FY 2016/2017 Work Plan for Limited In-Situ Pilot Testing Muncho Lake and Fireside Maintenance Camps, Alaska Highway, BC (PWGSC Project # R. 016701.004/005)*, provided to PWGSC on August 31, 2016.

SNC-Lavalin understands that PWGSC's remediation objectives for the Sites are to reduce PHC impacts utilizing a suitable remediation technology with a reasonable effort and cost, within the Federal Contaminated Sites Action Plan (FCSAP) funding window. The objectives of the pilot test and LIF evaluation were to:

- Evaluate the potential to complete in-situ remediation of deep PHC impacts through in-situ chemical oxidation or surfactant application;
- Collect data and information for designing and planning a larger scale in-situ chemical oxidation program or surfactant application;
- Evaluate the option for site wide characterization of PHC impacts through advancement of the LIF device with direct push technology; and
- Develop recommendations for the in-situ remediation of deep PHC impacts at both Muncho Lake and Fireside maintenance camps.

The report format is as follows:

- Section 1 -- introduction and background;
- Section 2 -- scope of work, results and interpretations for the Muncho Lake Maintenance Camp;
- Section 3 -- scope of work, results and interpretations for the Fireside Maintenance Camp;
- Section 4 -- closure section; and
- Section 5 -- notice to reader.

1.1 Background

1.1.1 Muncho Lake Maintenance Camp

The Muncho Lake Maintenance Camp is located approximately 240 km west of Fort Nelson, BC, on the west side of the Alaska Highway. As outlined in previous environmental investigation reports residual PHC contamination greater than the applicable Canadian Council of Ministers of the Environment (CCME) and *Contaminated Sites Regulation*[1] (CSR) standards/guidelines for soil, groundwater, and soil vapour remains on the Site. Salt and metals impacts were also identified, however for the purposes of this letter report only PHC contamination is considered.

Shallow PHC impacts (from ground surface to the water table) at Muncho Lake were excavated in seven areas and moved to an off site PWGSC managed soil treatment facility in Q4 2016.

Deep PHC impacts targeted for in-situ remediation pilot testing are primarily within the groundwater smear zone (approximately 8 metres to 15 metres below ground [mbg]). The source of PHC impacts at the Site is considered to be fuel oil and possibly limited quantities of used oil. Soils in the smear zone are primarily sand and gravel with some silt.

Generally low dissolved hydrocarbon concentrations have been detected and no light non-aqueous phase liquid (LNAPL) has been encountered in monitoring wells at the site. The contaminants of concern are primarily F2 and light extractable petroleum hydrocarbon (LEPH) for soil. F1 and benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations have also been identified as contaminants of concern.

There are three areas currently identified that have deep PHC impacts at the Muncho Lake Maintenance Camp. The following areas of environmental concern (AEC) with deep PHC impacts were previously identified:

- AEC 1 – **SW Portion of Maintenance Yard**: Residual soil contamination was identified to be present within and adjacent to a previous remedial excavation in the southwest portion of the operational area on the Site;
- AEC 2 – **Northwest of Maintenance Garage**: The deep PHC plume in soil within the groundwater smear zone extends to the northwest from the maintenance garage. PHC contamination in soil within this area exceeds the applicable guidelines. A second PHC plume to the north and west of this area appears to be separate, however deep impacts appear to be similar in nature and vertical extent (i.e., elevated F2 concentrations in soil at the smear zone). The full extent of the deep PHC impacts in soil and groundwater in these areas has not been delineated; and

[1] *Contaminated Sites Regulation* (CSR), B.C. Reg. 375/96, includes amendments up to B.C. Reg. 184/2016, July 19, 2016.

- AEC 7 – **South of Salt Shed**: PHC contamination in soil was identified in the groundwater smear zone (i.e., 8 m to 15 mbg) adjacent to the salt storage shed area. A contaminant plume in the smear zone extends to the northwest from the apparent source area.

Additional investigation activities were undertaken by SNC-Lavalin in 2016 to further delineate the PHC plume within the smear zone to the northwest of the maintenance garage. The full extent of deep PHC impacts associated with the smear zone, and primarily associated with the AEC 2 – Northwest of Maintenance Garage remains undelineated. Refer to the attached Drawing 635031-501 for a site plan outlining Site features and historic investigation locations.

1.1.2 Fireside Maintenance Camp

The Fireside Maintenance Camp is located approximately 378 km northwest of Fort Nelson, BC, and 150 km southeast of Watson Lake, YT, on the northeast side of the Alaska Highway. Residual PHC exists below the active maintenance yard, likely related to aboveground releases from aboveground fuel storage tanks (ASTs) and site maintenance activities. The following AECs were previously identified:

- AEC 1 – **Northwest Portion of Yard**: PHC contamination in soil was identified in this area over 2,400 m^2;
- AEC 2 – **North Portion of Yard**: PHC contamination in soil was identified in this area over 150 m^2; and
- AEC 3 – **Central Portion of Yard**: PHC contamination in soil was identified in this area over 5,150 m^2.

Shallow PHC impacts (from ground surface to the water table) at Fireside were excavated in four areas and moved to an off site PWGSC managed soil treatment facility in Q4 2016.

In addition to shallow PHC impacts identified at these AECs, deeper PHC impacts are coincident with two perched water tables and the regional aquifer. The upper perched water table is at a depth of 10 m to 14 mbg. PHC impacts associated with this water table are considered to extend over an area of 500 m^2 and are primarily coincident with AEC 3. The lower perched water table is at a depth of 19 m to 23 mbg and PHC impacts associated with this water table are considered to extend over an area of 5,600 m^2. The regional aquifer is at a depth of 26 m to 32.5 mbg and PHC impacts associated with this water table are considered to extend over an area of 2,300 m^2.

The source of PHC impacts at the Site is considered to be fuel oil and possibly limited quantities of used oil. Deep PHC impacts targeted for in-situ remediation pilot testing are associated with perched water tables and the regional aquifer. Soils associated with these PHC impacts are primarily sand and gravel with some silty layers. The contaminants of concern are primarily F2 and LEPH for soil. F1 and BTEX concentrations have also been identified as contaminants of concern. Generally low dissolved hydrocarbon concentrations have been detected and no LNAPL has been encountered in monitoring wells at the site.

The full extent of deep PHC soil impacts associated with the perched water tables and regional aquifer remain undelineated in portions of these plumes. Refer to the attached Drawing 636200-501 for a site plan outlining Site features and historic investigation locations.

1.2 Remediation Options Overview

1.2.1 In-situ Remediation Technologies

SNC-Lavalin reviewed in-situ remediation technologies in consideration of site applicability, contaminant type, total costs, time frame to affect remediation, regulatory compliance, stakeholder considerations, and impacts to future operations at the site. Preferred technologies were required to achieve meaningful reduction in hydrocarbons within the 4 year FCSAP funding window with reasonable costs.

The two technologies that were selected for testing and further evaluation were chemical oxidation and surfactant flushing. Air sparging and nutrient addition were rejected since these technologies are expected to require a significant time frame (15+ years) to achieve a meaningful reduction in hydrocarbons. Pump and treat, multiphase extraction, and vapour extraction were discounted given that the PHC impacts have low solubility and volatility.

With respect to chemical oxidation, the oxidizer persulfate was not considered for further evaluation due to the potential for significant sulfate addition to groundwater at the site, and as sulfate is a regulated parameter in British Columbia. Given this consideration, the oxidizer hydrogen peroxide was selected for further evaluation.

In conjunction with hydrogen peroxide, SNC-Lavalin also considered the injection of a catalyst to enhance the performance of the hydrogen peroxide through the formation of hydroxyl and other free radicals. Additional hydroxyl and free radical production can significantly improve both the rate and overall efficiency of the oxidation treatment. VTX Catalyst 4.4 (VTX), an organo-metallic catalyst was selected, as it is designed to enhance the performance of hydrogen peroxide.

For surfactant application, two surfactants were considered for further evaluation. Iveysol 106 was selected as it has been used successfully at another maintenance yard site along the Alaska Highway. It is a proprietary, non-ionic surfactant formulated for solubilising and mobilizing fuel oil based contaminants, manufactured by Ivey International Inc. SNC-Lavalin also selected the ionic surfactant Task, manufactured by Tersus Environmental LLC (Tersus). It is a proprietary surfactant that is mixed with an electrolyte, which in turn provides a cation to optimize the effectiveness of the surfactant. Task was selected as a surfactant to allow for comparing the performance of non-ionic (Iveysol 106) versus ionic surfactants. The ratio of Task to electrolyte can also be varied when applied to optimize the degree of solubilisation or mobilization of PHC contaminants.

In addition to evaluating in-situ chemical oxidation and surfactant application, an evaluation of hydraulic conductivity in the regional aquifers at these Sites through pumping and slug testing was also completed. This was done to provide supporting information for the larger scale application of surfactants, should this approach to in-situ remediation be selected.

1.2.2 Characterization of PHC Impacts

As part of the evaluation of options for in-situ remediation, SNC-Lavalin identified that further characterization of the extent and degree of deeper PHC impacts will improve the targeting of the selected remedial technology and provide more certainty on the lateral and vertical extent of impacted areas. Further delineation of the deep PHC impacts is also required to close data gaps identified in the conceptual site models (CSMs) for these Sites.

SNC-Lavalin identified LIF as a tool that may allow for more rapid and cost-effective delineation of the deep PHC impacts, as compared to conventional drilling and soil sampling, provided it could be advanced via direct push technology. Therefore, an evaluation of the advancement of direct push tooling at forces compatible with the device was completed. Soil samples were also collected for off-site testing with the tool to confirm that it would respond to the type of hydrocarbons encountered. This evaluation is intended to assist with the development of a suitable program for further delineation and characterization of deep PHC impacts at the Sites.

2 Muncho Lake Maintenance Camp Testing

In advance of ground disturbance activities BC One Call was contacted and members were requested to locate and mark utilities subject to encroachment. Additionally a utility survey was completed in the areas where ground disturbance was planned. Utilities or buried lines were marked by the utility survey contractor. Following the completion of the utility survey, SNC-Lavalin's ground disturbance checklist was reviewed and completed.

To allow for the collection and temporary storage of recovered liquids during the pilot test, an open top steel tank was supplied and delivered to the Site.

Work at the Muncho Lake Maintenance Camp included:

- Borehole advancement and well installation;
- Hydrogen peroxide injection into dedicated wells and injection points;
- Monitoring well response evaluation;
- Pump testing;
- Surfactant application (push/pull) test; and
- LIF evaluation.

Refer to the attached Drawings 635031-801 and 635031-802 showing the locations of the test areas, boreholes, and monitoring wells.

2.1 Borehole Advancement and Well Installation

2.1.1 Methodology and Observations

To allow for surfactant and chemical oxidizer application (injection) as well as to provide pre and post in-situ treatment soil characterization, five boreholes (i.e., 16-116 to 16-120) were advanced with three of the boreholes (i.e., 16-116 to 16-118) completed as monitoring wells. Boreholes and soil samples were collected using the DT45 soil sampling system which was advanced with the Geoprobe 8040DT direct push and rotary rig.

Monitoring wells 16-116 and 16-117 were constructed as injection wells to allow for targeting the injection of surfactants and hydrogen peroxide into PHC impacted soils. As such these wells were screened across PHC impacts at depth. The injection wells were also completed with a cement/bentonite grout to minimize the potential for bypass. Monitoring well 16-118 was constructed to allow for monitoring across the water table to evaluate the potential for mobilizing PHC impacts (i.e., light non-aqueous phase liquid)

to the water table adjacent the surfactant injection well. Borehole 16-119 was advanced to evaluate soil quality post surfactant application at monitoring well 16-116. Borehole 16-120 was advanced to evaluate soil quality post hydrogen peroxide treatment.

Borehole logs are provided in Appendix I.

2.1.2 Results and Discussion

It took approximately 1.5 hours to advance the DT45 soil sampling system to a depth of 13.0 m. Following the advancement of boreholes 16-116 and 16-117 it took approximately 2.5 hours to complete the well as an injection well with a cement/bentonite grout from above the screen to near ground surface. Sample collection beyond a depth of 12.2 m was challenging due to the loss of sample. This is likely the result of the loss of loose saturated soils from the end of the sampling tube at depth. It is likely that injection well installation time can be reduced through refinements to the cement/bentonite grout mixing and placement process, such as the use of a cement mixer and a tremie pipe.

Soil samples were collected from boreholes 16-116, 16-117, 16-119, and 16-120. Analytical results indicated that soil exceeded Canadian Council of Ministers of the Environment (CCME) Canadian Wide Standards for Petroleum Hydrocarbons (PHC CWS) for F1 (C6-C10) and F2 (>C10-C16) petroleum hydrocarbons at depths between 10.2 m and 12.3 m. PHC concentrations within this interval consisted of F2 (>C10-C16) in the range of 220 µg/g to 4,300 µg/g and F1-BTEX in the range of 22 µg/g to 130 µg/g. Dark grey and black staining and a slight hydrocarbon odour were observed in soil samples collected at these depths. PHC impacts were noted to be below the water table. Analytical results from the soil sampling are presented in Table 1. Analytical reports are provided in Appendix III.

Soils at these boreholes were generally comprised of fine and coarse grained sands with gravel. Some siltier layers were observed at varying depths as were larger cobbles or rocks. Soil stratigraphy was similar to previous boreholes advanced in this area. These results were in general accordance with soil sample observations from nearby monitoring wells 16-100 and 16-102.

2.2 Hydrogen Peroxide Injection

2.2.1 Methodology and Observations

In-situ chemical injections were completed at five locations using hydrogen peroxide. 50% (m/m) hydrogen peroxide was mixed with water to concentrations between 11.5% and 20% (m/m). Hydrogen peroxide was directly injected through 2.25” (57 mm) probe rods advanced to a target depth of 12.2 m. Probe rods for direct injection were advanced with the Geoprobe 8040DT direct push and rotary rig. The injection probe rods were advanced with a standard expendable 2.45 inch (62 mm) outer diameter drive point. Following advancement of the probe rods to the target depth, compatible fittings were connected to the top of the probe rod to allow for injection through the inner diameter of the probe rod. A flow meter and pressure gauge were connected so that total volume, flow rate, and injection pressure could be monitored during injection. Following advancement to 12.2 m the probe rods were raised approximately

0.2 m to cause the expendable drive point to come off of the bottom of the probe rods and to ease the injection of hydrogen peroxide.

Hydrogen peroxide was injected at four direct injection locations (IP1, IP2, IP3, and IP4) and at the one dedicated hydrogen peroxide injection well (16-117). Drawing 635031-801 shows the injection locations. VTX was injected into IP2 to enhance the action of hydrogen peroxide. VTX was mixed with water at a ratio 1 L VTX : 3 L H2O prior to injecting. A total VTX mixed volume of 160 L was injected into IP2.

The injection of hydrogen peroxide was completed as indicated in Table A.

Table A: Summary of Hydrogen Peroxide Injections – Muncho Lake

Injection Locations	Flow (L/min)	Pressure (psi)	Hydrogen Peroxide Injection Concentration (% m/m)	Volume (L)	Duration (hrs)	Comments
IP1	7-22	0-30	11.5	3440	5	-
IP2	3-6	35-50	11.5	177	0.75	160 L of VTX mixture added. IP2 had soil blockage at tip of probe rod
IP3	21	10	11.5	900	0.7	-
IP4	22	10	11.5	2070	2	-
16-117	8-21	4-20	11.5 and 20	304 and 1833	0.3 and 2	-

In conjunction with the hydrogen peroxide injections, groundwater was monitored at monitoring well 16-100 before, during, and after the hydrogen peroxide injections at the direct injection points and dedicated injection well. Groundwater was monitored for temperature, pH, dissolved oxygen (DO), oxidation/reduction potential (ORP), salinity, and electrical conductivity (EC).

IP1 Injection Observations and Monitoring:

- Limited bypass of hydrogen peroxide at ground surface was observed.
- It was observed that the injection rate increased and injection pressure dropped following the raising of the injection rod. An increase in the injection flowrate was also observed when the injection hose was changed from 0.75” (19 mm) to 1” (25 mm).

Groundwater was monitored at monitoring well 16-100 approximately 3.0 m away from IP1. The following observations at monitoring well 16-100 during injection at IP1 were made:

- Conductivity, pH, and temperature remained steady throughout the injection with pre-injection measured values.

- Dissolved oxygen concentrations increased from less than 5 mg/L to greater than 15 mg/L after the injection of approximately 1,000 L of hydrogen peroxide. Dissolved oxygen concentrations increased up to 65 mg/L during the injection.
- A doubling in the ORP value from approximately 40 mV to 80 mV after the injection of approximately 1,000 L of hydrogen peroxide.

Results from the monitoring at 16-100 are presented in Table 2.

IP2, IP3 and IP4 Injection Observations and Monitoring:

Similar to the advancement of IP1, the probe rods for IP2 were raised to cause the expendable drive point to come off of the bottom. When injecting VTX into IP2 the back pressure was notably higher than at IP1 and the flow rate correspondingly lower. Also, VTX would not flow freely when poured into the probe rod. Injection at IP2 was stopped after 45 minutes to inspect the probe tip. Following the removal of the probe rods at IP2 residual liquid remained in the rods during removal. Soil was also found in the bottom portion of the rod causing the backpressure and reduced flow.

IP3 was advanced 1.0 m away from IP2. Pressure and flow rate during the injections at IP3 followed a similar pattern to IP1 and remained relatively steady during the injection. In general, a higher injection flowrate corresponded with a higher pressure.

IP4 was advanced 0.15 m away from IP2 to allow for injection adjacent the VTX application point. Pressure and flow rate during the injections at IP4 did not change substantially over the course of injections. Gurgling was heard at 16-117 during injection at IP4.

Groundwater was monitored at monitoring well 16-100 and 16-117 approximately 4 m away and 4.7 m away from IP2, respectively. The following was noted at monitoring well 16-100 during injection at IP2, IP3, and IP4:

- Similar to observations made during injection at IP1, conductivity, pH, temperature remained at pre-injection levels throughout the injection;
- Dissolved oxygen concentrations remained greater than 25 mg/L; and
- ORP remained above 125 mV.
- 16-117 Injection Observations and Monitoring:

Monitoring well 16-117 was developed prior to the start of injection at IP2, IP3, and IP4 and after injection at IP1. The following was noted at monitoring well 16-117 during injection at IP2, IP3, and IP4:

- Dissolved oxygen concentrations were approximately 10 mg/L after development, and rose to approximately 30 mg/L after the completion of injections; and
- Post development and post injection ORP ranged between 110 mV and 131 mV.

No bypass of hydrogen peroxide at ground surface was observed during the subsequent injection at 16-117. Pressure did not change substantially over the course of injections and in general a higher injection flowrate corresponded with a higher injection pressure.

Groundwater was monitored at monitoring well 16-100 during injection at 16-117 approximately 2.5 m away. The following was noted at monitoring well 16-100 during injection at 16-117:

- Similar to observations made during injection at the direct injection points, conductivity, pH, temperature remained at pre-injection levels;
- Dissolved oxygen concentrations at 16-100 ranged from 9 mg/L to 44 mg/L; and
- ORP at 16-100 ranged from 126 mV to 190 mV.

Post-Injection Monitoring:

Groundwater was monitored at 16-100 and 16-117 following the completion of injections. 2 hours after the completion of injection at 16-117 the groundwater temperature in 16-117 was measured to be 15 °C. The temperature at 16-117 remained above pre-injection levels 40 hours after the completion of injections, but decreased to pre-injection levels after 7 days. The temperature at 16-100 increased above pre-injection levels approximately 40 hours after injection. Temperature at 16-100 remained above pre-injection levels 8 days after the completion of injections. There was evidence of stratification in temperature at 16-100 with a decrease in groundwater temperature at a greater depth in the monitoring well. Post injection measurements were continued at monitoring wells 16-100 and 16-117 and the results are summarized as following:

- Dissolved oxygen concentrations ranged from 20 mg/L to 50 mg/L at 16-100, and remained above pre-injection levels for at least 8 days;
- ORP remained above pre-injection levels at 16-100 for at least 8 days and ranged from 115 mV to 177 mV;
- Similarly, following the injections dissolved oxygen concentrations ranged from 23 mg/L to 43 mg/L at 16-117, and remained above pre-injection levels for at least 8 days; and
- ORP remained above pre-injection levels at 16-117 for at least 8 days and ranged from 106 to 129 mV.

Figures 1 and 2 present temperature, dissolved oxygen concentrations and ORP response over the course of hydrogen peroxide injections at Muncho Lake.

F1 and F2 (>C_{10}-C_{16}) concentrations at target zone soils collected at 16-117 (pre-injection) and from the adjacent borehole location 16-120 (post injection) did not identify a notable change in F1 or F2 concentrations post injection 0.8 m away. Analytical results from the soil sampling are presented in Table 1.

2.2.2 Results and Discussion

Hydrogen peroxide injections were completed at Muncho Lake Maintenance Camp with relative ease. Hydrogen peroxide was injected at direct injection points (through probe rods) and at a dedicated

injection well at concentrations of 11.5% - 20% (m/m), flow rates up to 25 L/min, and pressures less than 30 psi. This suggests the larger scale application of this in-situ remediation option could be completed with few technical limitations.

Installation

Advancement of the 2.25" diameter direct injection probe rods to the target depth of 12 m was fast (less than 15 minutes) indicating injection via this method is feasible. In comparison, the installation of a dedicated injection well took 4 hours. It was possible to raise the probe rods over the course of injections with the Geoprobe 8040DT direct push and rotary rig. This can allow for injection over varying depths if required.

Bypass of hydrogen peroxide at ground surface was observed when completing direct injection through the probe rods. This is presumed to occur from the flow of pressurized hydrogen peroxide preferentially along the outside of the probe rod due to poor sealing between the probe rod and subsurface soils. While bypass was observed at some of the direct injection points, it was estimated to be less than 10 L where evident. The volume of hydrogen peroxide that may have seeped into the formation is unknown.

Leaking from the threaded connections on the probe rods may also further add to this issue. Limited leaking was observed from above ground threaded connections in some instances during the injections. Tightening of the threaded connections was observed to stop this. It was also observed that the threaded connections between probe rods loosened slightly as they were advanced. Given these observations, using o-rings to seal the threaded connections on the probe rods could be considered to minimize leaking and the potential for bypass from these points.

With the observation of materials from the subsurface entering the bottom of the probe rod at IP2 as it was raised, future injections should maintain pressure (through the injection of liquids) in the probe rod as it is raised to reduce the potential for material ingress.

Dissolved Oxygen

The injection of hydrogen peroxide increased the dissolved oxygen concentration notably in groundwater at least 3 m away. Continued elevated dissolved oxygen concentrations were recorded at least a week after the completion of injections. An increase in the concentration of dissolved oxygen likely results from the decomposition of hydrogen peroxide; it does not necessarily indicate the presence of hydrogen peroxide or associated radicals which are necessary for oxidation of petroleum hydrocarbons in soil. In addition to the oxidation of petroleum hydrocarbons, the increase in dissolved oxygen in groundwater from the decomposition of hydrogen peroxide will enhance biodegradation of petroleum hydrocarbons.

Temperature

The injection of hydrogen peroxide resulted in increased groundwater temperature at least 2.5 m away. An increase in temperature was sustained for at least 8 days after injections. The increase in temperature indicates that exothermic reactions are occurring or have occurred. Exothermic reactions are likely a

combination of the oxidation of petroleum hydrocarbon, decomposition of hydrogen peroxide, and oxidation of naturally occurring materials. The temperature of groundwater remained well below 70 °C and consequently elevated groundwater temperatures are not expected to prevent the generation of radicals that can further oxidize petroleum hydrocarbons.

Groundwater temperature remained elevated longer at 16-100 than at 16-117. The reason for this is not certain, however it may be the result of the enhancement of hydrogen peroxide upgradient of 16-100 through the application of VTX at IP2. Additionally, injection of 20% hydrogen peroxide at 16-117 may have generated a more vigorous reaction that resulted in the faster decomposition of hydrogen peroxide and associated radicals.

ORP

ORP in groundwater increased at 16-100 and 16-117 following the injection of hydrogen peroxide at IP1 to IP4, indicating the development of oxidizing conditions at these monitoring well locations and further confirming the presence of oxidizing conditions.

pH

Measured pH ranged between 7 and 9 at monitoring wells 16-100 and 16-117 suggesting neutral to alkaline conditions in groundwater at these locations. An acidic pH can sustain oxidation reactions by mobilizing iron ions and increasing the potential for a modified Fenton's system and the generation of oxidizing radicals. With neutral or alkaline conditions this potential is reduced. The addition of a chelated iron compound, such as VTX, has the potential to make available iron ions in a form that can increase the potential of generating a modified Fenton's system.

Soil Quality

F1 and F2 (>C10-C16) concentrations at target zone soils collected at 16-117 (pre-injection) and from the adjacent borehole location 16-120 (post injection) did not identify a reduction in F1 and F2 concentrations post injection 0.8 m away. It is acknowledged that a measurable reduction in F1 or F2 concentrations in soil would most likely require multiple rounds of injections. It was not expected that one injection event would reduce F1 or F2 concentrations in soil.

Summary

Overall, the pilot test indicates that hydrogen peroxide can be readily injected using the direct push technology at a reasonable flow rate. There are also indications of hydrogen peroxide effects in monitoring wells adjacent to the injection locations through increases in DO concentration, temperature, and ORP. Changes in these parameters suggest that oxidation reactions have occurred as a result of the injection of hydrogen peroxide, but do not directly confirm that hydrogen peroxide is present in adjacent monitoring wells. Further testing would be necessary with greater oxidant volumes to evaluate radius of influence of the hydrogen peroxide itself. In order to effectively remediate the soil within a treatment zone,

hydrogen peroxide will need to come into direct contact with PHC impacts throughout the intended treatment zone.

2.3 Monitoring Well Response Evaluation

2.3.1 Methodology

Slug tests to evaluate hydraulic conductivity were completed at monitoring well locations 12-55, 13-56, 13-57, 16-62D, 16-100, 16-102, in accordance with SNC-Lavalin's Preferred Operating Procedure "Monitoring Well Response Testing – Field Procedure." Multiple rising and falling head tests were completed at each well, whereby water level displacement was initiated with a slug and water levels were monitored using dataloggers set to record measurements at 0.5 second intervals. The test locations are shown on Drawing 635031-801.

2.3.2 Results and Discussion

Slug tests were interpreted using AQTESOLV for Windows Version 4.5, by HydroSOLVE Inc. (2007). The Bouwer & Rice[2] (1976) analytical solution for unconfined aquifers was used to analyze the majority of tests. The Springer-Gelhar (1991) solution was used in instances where the response was oscillatory. A summary of the hydraulic conductivity results are presented in Table C below.

Table B: Hydraulic Conductivity of Select Wells – Muncho Lake

Monitoring Well Locations	Hydraulic Conductivity (m/s)	Geomean Hydraulic Conductivity (m/s)
12-55	1.7×10^{-4} to 1.6×10^{-3}	4.3×10^{-4}
13-56	5.1×10^{-4} to 7.5×10^{-4}	6.3×10^{-4}
13-57	2.1×10^{-4} to 3.8×10^{-4}	2.7×10^{-4}
16-62D	8.2×10^{-4} to 1.3×10^{-3}	1.1×10^{-3}
16-100	7.7×10^{-5} to 1.1×10^{-4}	9.4×10^{-5}
16-102	4.4×10^{-4} to 9.9×10^{-4}	6.9×10^{-4}
Overall Geomean (m/s)		4.2×10^{-4}

The hydraulic conductivity results indicate that the sands and gravels are highly permeable with a geomean hydraulic conductivity estimate of 4.2×10^{-4} m/s, which is consistent with the ranges reported by Freeze and Cherry (1979) for gravel (10^{-3} m/s to 1 m/s) and clean sand (10^{-5} m/s to 10^{-2} m/s). These results

[2] Bouwer, H., & R.C. Rice, 1976. *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells.* Water Resources Research, pp. 12:423-28.

indicate that soils at Muncho Lake are highly permeable and conductive for the injection and/or pumping of liquids. The analyses are provided in Appendix IV.

2.4 Pump Test

2.4.1 Methodology

A pump test was completed at monitoring well 16-116 to evaluate hydraulic conductivity and radius of influence. The pump test was completed in accordance with SNC-Lavalin's Preferred Operating Procedure "Water Well Pump Test." Drawing 635031-802 shows the test location.

Using a Grundfos Redi-flo 2 installed near the well bottom a steady state flow rate of 23 L/min was achieved. Pumped liquids were discharged directly to the above ground open top storage tank. Water levels in the pump well and adjacent monitoring wells 16-102 and 16-118 were manually monitored with an electronic water level probe prior to, during, and after the pump test. Dataloggers set to record measurements at 2 second intervals were also deployed in adjacent monitoring wells 16-102 and 16-118.

Pumped liquid was also sampled for analysis of BTEX/volatile petroleum hydrocarbons (VPH)/F1 and F2-F4 parameters during the test. The sample, MW16-116-161006INITIAL, was collected to evaluate pre-surfactant application water quality.

2.4.2 Results and Discussion

Pump testing at monitoring well 16-116 identified that the well was able to yield a continuous 23.5 L/min, which was the maximum rate able to be sustained by the Grundfos pump. The well likely could have sustained a higher yield if a higher capacity pump was used. Steady state drawdown in monitoring well 16-116 was measured to be 0.044 m. Steady state drawdown at monitoring well 16-102 which was 1.7 m away was measured to be 0.015 m. Results from the pump test are presented in Table 3.

The pump test data were analyzed using a modified version of the Thiem (1906) solution for steady state pumping, as described by Kruseman and De Ridder (1990). Using this solution, the transmissivity of an unconfined aquifer can be estimated by

$$T = \frac{Q}{2\pi(S_w - S_1)} \ln\left(\frac{r_1}{r_w}\right)$$

Where Q is the pump rate, S_w is the steady state drawdown in the pump well, S_1 is the steady state drawdown in the observation well (16-102), r_w is the radius of the pump well, and r_1 is the distance to the observation well (16-102).

A transient analysis of the data was also completed using AQTESOLV. The analytical solution used was the Theis curve matching method (1935) adapted for unconfined aquifers.

The transmissivity was estimated to be 9.0 x 10^{-3} m^2/s by the Thiem equation and 1.4 x 10^{-2} m^2/s by the Theis solution, which translates to hydraulic conductivities of 6.0 x 10^{-4} m/s and 9.5 x 10^{-4} m/s (geomean of 7.6 x 10-4 m/s) assuming an aquifer thickness of 15 m (which is not presently known as the bottom of the aquifer has not been encountered during drilling). These results are consistent with the hydraulic conductivity estimate derived from the slug test results from MW 16-102 (6.9 x 10^{-4} m/s) and further confirms that soils associated with the regional aquifer are highly permeable and conducive to the injection and/or pumping of liquids.

Analysis for the pump test at Muncho Lake is provided in Appendix V.

2.5 Surfactant Application (Push/Pull) Test

2.5.1 Methodology and Observations

Tersus was engaged to provide onsite support with optimizing the Task mixture for the surfactant application. SNC-Lavalin provided Tersus with a soil sample collected from the PHC impacted profile at 16-116 for the completion of bench scale testing. Tersus also completed an optimization step using a diesel surrogate to further inform the optimization of the Task surfactant for application. Tersus's procedure for the optimization of Task is presented in Appendix II. Following the identification of an appropriate mix ratio for Task, potassium hydroxide (KOH), Acetic acid, and water by Tersus two batches were mixed for injection. The surfactant was injected as indicated in Table B. A higher injection flowrate for the second batch was observed due to the use of a higher capacity pump. No bypass to surface was observed during the injection.

Table C: Summary of Surfactant Application – Muncho Lake

Injection Location	Flow (L/min)	Pressure (psi)	Surfactant Mixture	Comments
16-116	11-24	0-4	~1,350,700 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic acid	1st Batch injected over ~60 minutes
16-116	11-24	16	~1,350,700 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic acid	2nd Batch injected over ~45 minutes

After approximately 18 hours, monitoring wells 16-102, 16-116, and 16-118 were monitored for the presence of LNAPL. Following monitoring in these wells a Grundfos Redi-flo 2 pump was installed just off the bottom of monitoring well 16-102. Tersus initially recommended pumping from 16-102 to evaluate the potential for circulating the injected surfactant towards this monitoring well location.

While pumping was completed from monitoring well 16-102 pumped liquids were monitored for EC and pH. The sample, MW16-102-161007-1, was also collected for analysis of BTEX/VPH/F1 and F2-F4 parameters during pumping to evaluate post-surfactant application water quality. Following pumping at 16-102 the Grundfos Redi-flo 2 pump was installed just off the bottom of monitoring well 16-116 for further groundwater extraction.

Table D: Summary of Surfactant Extraction – Muncho Lake

Extraction Location	Flow (L/min)	Duration (min)	Volume (L)	Comments
16-102	23	50	432	-
16-116	23	240	5200	Pumped groundwater was foamy with no evidence of free phase PHC

While pumping was completed from monitoring well 16-116 pumped liquids were monitored for TDS and pH. Water quality was also evaluated qualitatively throughout the test. Pumped liquids were also sampled for analysis of BTEX/VPH/F1 and F2-F4 parameters throughout the test. The samples MW16-116-161007-1, MW16-116-161007-2, MW16-116-161007-3, MW16-116-161007-4, and MW16-116-161007-5 were collected during pumping to evaluate post-surfactant application water quality.

Refer to the attached Drawing 635031-802 which shows the test location. Results from the surfactant push/pull test are presented in Table 4.

Groundwater Monitoring

Monitoring of 16-118, approximately 1.2 m away from injection well 16-116, identified that total dissolved solids (TDS) in groundwater was 120 parts per million (ppm) at the start of surfactant injection. During injection at 16-116, TDS at 16-118 increased to 160 ppm and the pH was 9.

During the injection of the Task surfactant at 16-116, TDS in groundwater at monitoring well 16-102, approximately 1.7 m away from 16-116, ranged from 1,150 ppm to 2,250 ppm and pH ranged from 12 to 13. Purged liquid from this well was bubbly and had a strong surfactant odor.

Approximately 18 hours following surfactant injection at 16-116, wells 16-102, 16-116, and 16-118 were monitored for the presence of LNAPL and none was detected.

Measured pH at 16-102 was 8.8 and TDS was 141 ppm prior to commencement of pumping at 16-102. Measured pH at 16-116 was 10 and TDS was 250 ppm prior to commencement of pumping at 16-102 Pumped liquids from 16-102 had a pH of 10 for the duration of extraction from this location. Measured TDS increased slightly from 180 to 220 ppm during pumping from 16-102. Bubbles were present in recovered liquids when pumping from 16-102 suggesting the presence of surfactant in the pumped groundwater.

During subsequent pumping from injection well 16-116, the pumped groundwater pH decreased from 11 to 9 and TDS decreased from 350 ppm to 160 ppm. Bubbles were present in the pumped groundwater from this location during the extraction test. While pumping from 16-116 the pH at 16-102 was noted to drop to 9 and TDS was noted to drop to 140 ppm

Groundwater Analytical

Groundwater samples were collected from well 16-116 prior to surfactant application and while pumping from 16-102 and 16-116. Analytical results indicated the following:`

- Dissolved PHC impacts were not detected at 16-116 prior to surfactant application and therefore did not exceed *Canadian Drinking Water Quality Guidelines*[3] (CDWQG) for BTEX, or the *Federal Interim Groundwater Quality Guidelines*[4] (FIGWQG) for Tier 2 Residential Land Use (RL) for BTEX, F1-BTEX, and F2 ($>C_{10}$-C_{16});
- Following injection of the Task surfactant, the concentration of F2 ($>C_{10}$-C_{16}) in pumped groundwater from 16-116 was 8,700 µg/L, exceeding the FIGWQG RL guideline for this parameter. Trace concentrations of xylenes and F1-BTEX were also present at concentrations less than both of the previously referenced guidelines;
- The F2 ($>C_{10}$-C_{16}) concentration in pumped groundwater from 16-116 decreased to 2,100 µg/L as pumping continued from this location; and
- The concentration of F2 ($>C_{10}$-C_{16}) in pumped groundwater from 16-102 subsequent to surfactant injection at 16-116 was 2,000 µg/L. F2 ($>C_{10}$-C_{16}) was not detected in a previous groundwater sample collected from well 16-102 in July 2016.

Groundwater sampling results for the surfactant application (push/pull) tests are presented in Table 5.

2.5.2 Results and Discussion

Surfactant injections and recovery were completed at Muncho Lake Maintenance Camp with relative ease. Surfactant was injected at a monitoring well at a flow rate of 23 L/min. This suggests the larger scale application of this in-situ remediation option would likely not be affected by physical limitations.

Groundwater Monitoring

Observations from monitoring conducted during injection and recovery suggested that recovered groundwater was dilute (i.e., lower pH and TDS values) relative to what would have been expected. Therefore, limited recovery of the surfactant may have occurred with preferential migration of the surfactant a potential cause.

Groundwater Analytical

Groundwater analytical results indicated a substantial increase in PHC concentrations in the surfactant injection well, from less than 150 µg/L to an initial concentration upon pumping of 8,700 µg/L. The

[3] *Canadian Drinking Water Quality Guidelines (CDWQG),* Health Canada, August 2012.
[4] *Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites* (FIGWQG), prepared for the Federal Contaminated Sites Action Plan (FSCAP) Secretariat of Environment Canada, November 2015.

F2 (>C_{10}-C_{16}) concentration in pumped groundwater from 16-116 decreased as pumping continued from this location to 2,100 µg/L.

Summary

Overall, the pilot test indicates that surfactant can be readily injected and recovered at a reasonable flow rate. Groundwater analytical results also indicate that the Task surfactant was effective in increasing the dissolved PHC mass for recovery. However, based on the maximum recovered F2 (>C_{10}-C_{16}) concentration of 8,700 µg/L, it would likely require in excess of 1,000 pore volumes to reduce soil hydrocarbon concentrations substantially which is likely not practical. Given the magnitude of soil PHC concentrations and the absence of measurable LNAPL in monitoring wells at the Site, the potential for mass removal for surfactant application may be limited. However as indicated previously, measured pH and TDS values in recovered groundwater were lower than would have been expected indicating limited surfactant recovery, with preferential migration of the surfactant a potential cause. Therefore, it is possible that higher recovered dissolved hydrocarbon concentrations may be achieved with more comprehensive pilot testing.

2.6 LIF Evaluation

2.6.1 Methodology and Observations

Vertex Environmental Inc. (Vertex) was engaged to provide onsite observation of the advancing of direct push tooling, and gauge, in their experience, the potential for advancing the LIF device at the Muncho Lake Maintenance Camp. Vertex and SNC-Lavalin observed Ernco advance 1.5 inch (38 mm) diameter probe rods to the potential target depth of 14.6 m at two locations. Vertex and SNC-Lavalin also observed the advancement of a 2.25 inch (57 mm) diameter probe rod to a depth of 9.1 m. The 2.25 inch probe was removed and the depth of the open hole was evaluated. The hole was then filled with 10/20 sand. 1.5 inch probe rods were then advanced in the 2.25 inch bore to the potential target depth of 14.6 m.

Following the advancement of the direct probe rods, the holes were backfilled with sand and bentonite chips. Soil samples collected were also shipped to Vertex for off-site testing with the LIF device to confirm that it would respond to the type of hydrocarbons encountered.

The 1.5” (38 mm) diameter probe rods were advanced to 14.6 m at two locations in approximately 12 minutes. The probe rods were advanced with the hammer on the Geoprobe 8040DT direct push and rotary rig set at approximately 25% of maximum capacity. Limited wobbling of the probe rods was observed during advancement. At the second direct push location, rod advancement was more difficult from a depth of 6.7 m to 9.1 m as noted by more wobbling and more forceful hammering.

Advancement of a 2.25” (57 mm) diameter probe rod to a depth of 9.1 m was completed in 7 minutes. Following removal of the 2.25” diameter probe rod the hole remained open to a depth of 2.7 m. One bag of filter sand was used to fill the hole to ground surface. A 1.5” (38 mm) diameter probe rod was then advanced to a depth of 14.6 m with hammering from a depth of 9.1 m to 14.6 m and required light to

moderate hammering (approximately 25% of maximum hammering capacity). Advancing the bore using the 2.25” and 1.5” tooling took a total of 23 minutes.

Advancement of a second 2.25” diameter probe rod to a depth of 9.1 m was completed in 5 minutes. Following removal of the 2.25” diameter probe rod at the second location the hole remained open to a depth of 5.8 m. 2 bags of filter sand were used to fill the hole to ground surface. A 1.5” (38 mm) diameter probe rod was then advanced to a depth of 14.6 m. Advancing the bore using the 2.25” and 1.5” tooling took a total of 20 minutes at the second location.

Target depths were reached and refusal did not occur. Soil samples shipped to Vertex for off-site testing with the LIF tool exhibited a fluorescence response confirming that it would respond to the type of hydrocarbons encountered. Observations made by Vertex during the LIF evaluation are provided in their memorandum in Appendix VI.

2.6.2 Results and Discussion

Advancement of the 1.5” rods with a solid point without refusal indicates that the LIF tool can be advanced at the Site. It was observed by Vertex that soil conditions were very “tight” for this type of advancement to the target depths required. Based on this, to minimize damage to tooling Vertex recommends a “pre-probing” strategy in which 2.25” tooling is advanced to approximately 9 meters below ground surface (mbgs) prior to deploying the LIF device, and this would be sufficient to achieve full scale characterization. It is noted that as advancement of the LIF requires a downward velocity of less than 2 cm / s for data collection, a “pre-probing” approach through shallower soils will result in faster drilling in the upper 9 m, leading to a similar overall length of time to reach the target depth at each location. Soil samples shipped to Vertex for off-site testing with the LIF tool exhibited a fluorescence response confirming that it would respond to the type of hydrocarbons encountered.

3 Fireside Maintenance Camp

In advance of ground disturbance activities BC One Call was contacted and members were requested to locate and mark utilities subject to encroachment. Additionally a utility survey was completed in the areas where ground disturbance was planned. Utilities or buried lines were marked by the utility survey contractor. Following the completion of the utility survey, SNC-Lavalin's ground disturbance checklist was reviewed and completed.

To allow for the collection and temporary storage of recovered liquids during the pilot test, an open top steel tank was supplied and delivered to the Site.

Work at the Fireside Maintenance Camp included:

- Borehole advancement;
- Hydrogen peroxide injection into injection points;
- Pump testing;
- Surfactant application (push/pull) test; and
- LIF evaluation.

Refer to the attached Drawings 636200-501 and 636200-502 showing the locations of the test areas, boreholes, and monitoring wells.

3.1 Borehole Advancement

3.1.1 Methodology and Observations

To allow for chemical oxidizer application (injection) with a dedicated injection well one borehole was advanced (i.e., 16-39). The borehole was initially advanced with the DT45 soil sampling system using the Geoprobe 8040DT direct push and rotary rig. The DT45 sampling system was advanced until refusal at a depth of 12.2 m. Air rotary drilling was then used to advance a 4.5 inch diameter casing to a depth 26.8 m. It was not possible to reach the target depth of 30 m as there were issues with the supplied air rotary tooling. The air rotary tooling was removed from the borehole and an attempt was made to advance the DT45 tooling again. Refusal was encountered at a depth of 12.5 m which was approximately 0.3 m beyond the depth to slough. As borehole advancement was not possible to the target depth for injection, the hole was abandoned and backfilled with bentonite to ground surface.

The borehole log is provided in Appendix I. Refer to Drawing 636200-502 for a site plan showing the location of the borehole.

3.1.2 Results and Discussion

Borehole advancement and monitoring well installation with DT45 tooling and the Geoprobe 8040DT direct push and rotary rig was not possible to the target depth of 29 m due to refusal at a depth 12.2 m. The cause of refusal was not identified, but was likely the result of encountering a cobble, boulder, or layer of high density. Borehole advancement and monitoring well installation to depths of 13 m to 32 m with DT45 tooling is not considered a suitable approach at the Fireside Maintenance camp.

Where boreholes and monitoring wells (including injection wells) are required at a depth greater than 13 m air rotary or sonic drilling has been effective historically.

3.2 Hydrogen Peroxide Injection

3.2.1 Methodology and Observations

In-situ chemical injections were completed at three locations using hydrogen peroxide. 50% (m/m) hydrogen peroxide was mixed with water to concentrations between 11.5% (m/m) and 20% (m/m). Hydrogen peroxide was directly injected through 2.25" probe rods advanced to a target depth of 29.3 m, coincident with the depth where PHC impacts in soil were found in the adjacent monitoring well 13-03. Probe rods for direct injection were advanced with the Geoprobe 8040DT direct push and rotary rig. The injection probe rods were advanced with a standard expendable 2.45 inch outer diameter drive point. Following advancement of the probe rods to the target depth, compatible tooling was connected to the top of the probe rod to allow for injection through the inner diameter of the probe rod. A flow meter and pressure gauge were connected so that total volume, flow rate, and injection pressure could be monitored during injection. Following advancement the probe rods were raised approximately 0.3 m to cause the expendable drive point to come off of the bottom of the probe rods and to ease the injection of hydrogen peroxide.

Hydrogen peroxide was injected at three direct injection locations (IP1, IP2, and IP3). Refer to Drawing 636200-502 which shows the location of the injection points. VTX Catalyst 4.4 (VTX) was injected into IP2 to enhance the action of hydrogen peroxide. VTX was mixed with water at a ratio 1 L VTX: 4 L H_2O prior to injecting. A total VTX mixed volume of 200 L was injected into IP2.

The injection of hydrogen peroxide was completed as indicated in the following table.

Table E: Summary of Hydrogen Peroxide Injections - Fireside

Injection Locations	Flow (L/min)	Pressure (psi)	Hydrogen Peroxide Injection Concentration (% m/m)	Volume (L)	Duration (Hrs)	Comments
IP1	13-23	18-38	11.5	3,333	4.3	-
IP2	26	8	11.5	3,485	4	200 L of VTX

						mixture added.
IP3	18-19	18-24	20%	1,798	2	-

In conjunction with the hydrogen peroxide injections, groundwater was monitored at monitoring well BH13-03 before, during, and after the hydrogen peroxide injections at the direct injection points. Groundwater was monitored for temperature, pH, DO, ORP, salinity, and EC.

IP1 Injection Observations and Monitoring

- Probe rods advanced to target depth of 29.3 m in under 25 minutes.
- Injection fittings were connected to the probe rods and pressurized hydrogen peroxide was delivered to minimize the potential for granular material entering the end of the probe rod as it was raised.
- Bypass of hydrogen peroxide at ground surface was observed throughout the injection. Attempts to minimize the occurrence of bypass by tightening the probe rods did not reduce the bypass.
- Flowrate decreased and backpressure increased as injection progressed.

Groundwater was monitored at monitoring well 13-03 approximately 3.1 m away from IP1. The following was noted at monitoring well 13-03 during injection at IP1:

- Conductivity, pH, temperature, and salinity remained steady at pre-injection levels;
- Dissolved oxygen concentrations remained at less than 1 mg/L over the course of injections at IP1, however it was later noted that the DO probe was not functioning properly and required reconditioning; and
- ORP increased from -22 mV to 82 mV.

Results from the hydrogen peroxide injection and monitoring at 13-03 are presented in Table 6.

IP2 Injection Observations and Monitoring

IP2 was installed approximately 6.5 m from IP1. Pressure and flow rate during the injection at IP2 remained steady during the injection.

Groundwater was monitored at monitoring well 13-03 approximately 3.4 m away from IP2. The following observations and data measurements were made at monitoring well 13-03 during injection at IP2:

- Conductivity, pH, temperature, and salinity remained at pre-injection levels;
- Dissolved oxygen concentrations was steady at less than 1 mg/L. As the dissolved oxygen concentrations were lower than expected the probe was inspected and an air bubble was identified in the probe tip. The probe was subsequently reconditioned and recalibrated and confirmed to work normally. Following probe reconditioning and after the completion of injection at IP2, dissolved oxygen concentrations were measured at 20 mg/L and 21 mg/L; and
- ORP was between 100 mV and 115 mV and increased to 142 mV to 144 mV afterwards.

IP3 Injection Observations and Monitoring

IP3 was installed approximately 9 m from IP1 and 4.1 m from IP2.

- Pressure and flow rate remained steady during the injection.
- Bypass of hydrogen peroxide to ground surface was observed towards the end of injection.

Groundwater was monitored at monitoring well 13-03 approximately 3.5 m away from IP3. The following was noted at monitoring well 13-03 during injection at IP3:

- Conductivity, pH, temperature, and salinity remained steady;
- Dissolved oxygen concentrations increased from 12 mg/L to 19 mg/L; and
- ORP increased from 104 mV to 118 mV.

Post-Injection Groundwater Monitoring

Continued groundwater monitoring was completed at 13-03 post injections. 3 hours after the completion of injections the groundwater temperature in 13-03 increased from 3.5 °C to 7.9 °C. Groundwater temperature continued to rise to 12.6 °C 3.5 hours after the completion of injections after which the temperature decreased. Temperature remained above pre-injection levels 5 hours after injection. 24 hours after injections, the groundwater temperature at 13-03 was at pre-injection levels.

Groundwater monitoring at 13-03 after the completion of injections identified the following:

- Dissolved oxygen concentrations ranged from 16 mg/L to 25 mg/L;
- Monitoring of ORP for 5 hours after injections showed an increase from 118 mV to 148 mV; and
- 24 hours after the completion of injections dissolved oxygen was measured to be 11 mg/L to 15 mg/L and ORP was measured to be 98 mV to 104 mV.

Figures 3 and 4 present temperature, dissolved oxygen concentrations and ORP response over the course of hydrogen peroxide injections at Fireside.

3.2.2 Results and Discussion

Hydrogen peroxide injections were completed at Fireside Maintenance Camp with relative ease. Hydrogen peroxide was injected at direct injection points (through probe rods) at concentrations of 11.5% (m/m) – 20% (m/m), flow rates up to 26 L/min, and pressures less than 40 psi. This suggests the larger scale application of this in-situ remediation option could be completed with few technical limitations.

Installation

Advancement of the 2.25” diameter direct injection probe rods to the target depth of 29 m was relatively fast (less than 25 minutes) indicating injection via this method is feasible. In comparison, the installation

of the dedicated injection well, BH16-38 by vibrasonic drilling in June 2016 took approximately 14 hours. As was the case at Muncho Lake Maintenance Camp, the probe rods were raised (a maximum of 0.3 m) over the course of injections with the Geoprobe 8040DT direct push and rotary rig. This allowed for injection over varying depths.

Bypass of hydrogen peroxide at ground surface was observed when completing direct injection through the probe rods. This is presumed to occur from the flow of pressurized hydrogen peroxide preferentially along the outside of the probe rod due to poor sealing between the probe rod and subsurface soils. Bypass at IP1 was continuous through the injection and attempts to minimize bypass or leaking through tightening of the probe rods had a limited effect. It is estimated that there was 50 L of hydrogen peroxide bypass to ground surface at IP1. Hydrogen peroxide would also have migrated into the formation along the vertical length of the rod.

Limited leaking was observed from above ground threaded connections in some instances during the injections. The threaded connections between probe rods loosened slightly as they were advanced. Ernco indicated that the upper 15 m of probe rods were loose when removed post injection, while the lower 15 m of probe rods remained tight. The use of o-rings to seal the threaded connections on the probe rods could be considered to minimize leaking from these joints.

Dissolved Oxygen

Similar to Muncho Lake Maintenance Camp the injection of hydrogen peroxide increased the dissolved oxygen concentration in groundwater at least 3 m from the injection point. Continued elevated dissolved oxygen concentrations were measured at least 2 days after the completion of injections. The increase in the concentration of dissolved oxygen likely results from the decomposition of hydrogen peroxide. It does not necessarily indicate the presence of hydrogen peroxide or associated radicals which is what is required for affecting oxidation of petroleum hydrocarbons in soil. In addition to the oxidation of petroleum hydrocarbons, the increase in dissolved oxygen in groundwater from the decomposition of hydrogen peroxide enhances the biodegradation of petroleum hydrocarbons.

Temperature

The injection of hydrogen peroxide increased the temperature of groundwater at least 3 m away. An increase in temperature was sustained for 1 day after injections. The increase in temperature indicates that exothermic reactions are occurring. Exothermic reactions are likely a combination of the oxidation of petroleum hydrocarbon, decomposition of hydrogen peroxide, and oxidation of naturally occurring materials. The temperature of groundwater remained well below 70 °C and consequently elevated groundwater temperatures are not expected to prevent the generation of radicals that can further oxidize petroleum hydrocarbons.

An increase in groundwater temperature was measured at 13-03 after the injection of 20% (m/m) hydrogen peroxide at IP3. It is not clear whether or not the injection of 20% (m/m) hydrogen peroxide at IP3 (3.5 m away from monitoring well 13-03) caused the increase in temperature in groundwater at monitoring well 13-03 or if the increase was caused by the injection of VTX and 11.5% (m/m) hydrogen

peroxide at IP2 3.4 m away. In any case, the increased temperature was short lived and approached background conditions within a day.

ORP

ORP increased at 13-03 following the injection of hydrogen peroxide at IP1, IP2, and IP3, suggesting the development of oxidizing conditions at this monitoring well location and further indicating effects from hydrogen peroxide injection.

pH

Measured pH ranged between 7 and 8 at monitoring well 13-03 throughout the injections suggesting neutral to alkaline conditions in groundwater at this location. Similar to Muncho Lake Maintenance Camp, the neutral pH is expected to limit the potential for the creation of a modified Fenton's system and the associated generation of oxidizing radicals. The addition of a chelated iron compound, such as VTX, has the potential to make available iron ions in a form that can generate a modified Fenton's system.

Summary

Overall, the pilot test indicates that hydrogen peroxide can be readily injected at a reasonable flow rate using direct push technology. There are also indications of hydrogen peroxide effects adjacent the injection locations through increases in DO concentration, temperature, and ORP. Changes in these parameters suggest that oxidation reactions have occurred as a result of the injection of hydrogen peroxide, but do not directly confirm that hydrogen peroxide is present in adjacent monitoring wells. Further testing would be necessary with greater oxidant volumes to evaluate radius of influence of the hydrogen peroxide itself. In order to effectively remediate the soil within a treatment zone, hydrogen peroxide will need to come into direct contact with PHC impacts throughout the intended treatment zone.

3.3 Pump Test

3.3.1 Methodology and Observations

A pump test was initially completed at monitoring well 16-38 to evaluate hydraulic conductivity and radius of influence. The pump test was completed in accordance with SNC-Lavalin's Preferred Operating Procedure "Water Well Pump Test". A Grundfos Redi-flo 2 pump was installed near the bottom of the monitoring well. Following the installation of the pump, SNC-Lavalin was unable to develop a steady state flow rate from the well due to limited saturated thickness.

After it was determined that continuous pumping at monitoring well 16-38 was not possible, a decision was made to move the pump test to monitoring well location BH13-06. A steady state flow rate of 17 L/min was developed from the well. Pumped liquids were discharged directly to the above ground open top storage tank. Water levels in the pump well and adjacent monitoring wells 14-10 and 16-38 were manually monitored with an electronic water level probe prior to, during, and after the pump test.

Dataloggers set to record measurements at 2 second intervals were also deployed in adjacent monitoring wells 14-10 and 16-38.

Pumped liquid was also sampled for analysis of BTEX/VPH/F1 and F2-F4 parameters during the test. The sample, MW13-06-161009, was collected to evaluate pre-surfactant application water quality at 13-06.

3.3.2 Results and Discussion

Pump testing was initially completed at 16-38. It was indentified that the well was unable to sustain a continuous yield with the Grundfos RediFlo 2 submersible pump. The pump test was then completed at 13-06 which identified that this well was able to yield a continuous 16.7 L/min. Steady state drawdown in monitoring well 13-06 was measured to be 1.45 m. Steady state drawdown at monitoring well 16-38 which was 2.9 m away was measured to be 0.12 m. Steady state drawdown at monitoring well 14-10 which was 9 m away was measured to be 0.019 m. Results from the pump test are presented in Table 7.

The pump test data were analyzed using a modified version of the Thiem (1906) solution for steady state pumping, as described by Kruseman and De Ridder (1990). Using this solution, the transmissivity of an unconfined aquifer can be estimated by

$$T = \frac{Q}{2\pi(S_w - S_1)} \ln\left(\frac{r_1}{r_w}\right)$$

Where Q is the pump rate, S_w is the steady state drawdown in the pump well, S_1 is the steady state drawdown in the observation well (16-38), r_w is the radius of the pump well, and r_1 is the distance to the observation well (16-38).

A transient analysis of the data was also completed using AQTESOLV. The analytical solution used was the Moench curve matching method (1997) adapted for unconfined aquifers in which there is a delayed yield response.

The transmissivity was estimated to be 1.6 x 10^{-4} m^2/s by the Thiem equation and 1.5 x 10^{-4} m^2/s by the Moench solution, which translates to hydraulic conductivities of 1.0 x 10^{-5} m/s and 9.8 x 10^{-6} m/s assuming an aquifer thickness of 15 m (which is not presently known as the bottom of the aquifer has not been encountered during drilling). These results are consistent with the hydraulic conductivity estimate derived from a previous slug test at MW 13-06 (1.7 x 10^{-5} m/s) reported by Arcadis (2016[5]).

The hydraulic conductivity estimated of 1.0 x 10^{-5} m/s through analysis of the pump test data is within the range reported by Freeze and Cherry (1979) for clean sand (10^{-5} m/s to 10^{-2} m/s), but below the range reported for gravel (10^{-3} m/s to 1 m/s). The results of the pump test indicate that the soils associated with the regional aquifer are fairly permeable and conducive to the injection and/or pumping of liquids.

[5] Arcadis, 2016. Data Synthesis, Fireside Maintenance Camp, Kilometer 839, Alaska Highway, BC. Dated March 2016.

Analysis for the pump test at Fireside is provided in Appendix VII.

3.4 Surfactant Application (Push/Pull) Test

3.4.1 Methodology and Observations

When it was identified that monitoring well 16-38 did not yield groundwater at a rate sufficient for completing a pump test it was decided to modify the push/pull test such that surfactant injection would be completed into monitoring well 16-38 and the pump (pull) portion of the test would be completed from BH13-06 which was 2.9 m away and considered to be approximately downgradient.

At Fireside, SNC-Lavalin used the surfactant Iveysol 106 which is a proprietary, non-ionic surfactant formulated for solubilising and mobilizing fuel oil based contaminants. The surfactant was mixed and injected as indicated in Table E.

Table F: Summary of Surfactant Application - Fireside

Injection Location	Flow (L/min)	Pressure (psi)	Surfactant Mixture
16-38	6-8	30	1,000 L H_2O: 20 L Iveysol 106

Approximately 15.5 hours following injection a Grundfos Redi-flo 2 pump was installed near the bottom of monitoring well BH13-06 for the extraction portion of the test. While pumping was completed from monitoring well BH13-06 pumped liquids were monitored for EC, pH, and meniscus development. Pumped liquids were also sampled for analysis of BTEX/VPH/F1 and F2-F4 parameters throughout the test. The samples MW13-06-161011-1, MW13-06-161011-2, MW13-06-161011-3, MW13-06-161011-4, and MW13-06-161011-5 were collected during pumping to evaluate post-surfactant application water quality.

Water quality at monitoring well 16-38 was also monitored for EC, pH, and meniscus development. This well was also sampled for analysis of BTEX/VPH/F1 and F2-F4 parameters towards the end of the pull test (Sample MW16-38-161011). Monitoring wells 16-38 (Sample MW16-38-161027/28) and 13-06 (Sample MW13-06-161121) were also sampled after the completion of the pilot test for analysis of BTEX/VPH/F1 and F2-F4 parameters.

Table G: Summary of Surfactant Extraction - Fireside

Extraction Location	Flow (L/min)	Duration (Hrs)	Volume (L)	Comments
13-06	16	5	4,800	Suds observed in pumped groundwater

Results from the surfactant push/pull test are presented in Table 8.

Groundwater Monitoring

As recommended by the surfactant supplier, Ivey International Inc., meniscus development was evaluated throughout extraction at 13-06 to evaluate qualitatively for the presence of surfactant. There was no observable change in the height of the meniscus throughout the test. Meniscus development was also evaluated in groundwater from well 16-38 where the surfactant was injected and the observed height of the meniscus was similar to the meniscus in water pumped from 13-06. During collection of samples from pumped groundwater from 13-06 the meniscus development in the vials was initially limited, but became more pronounced towards the end of pumping.

Suds and a slight surfactant odour were observed in water pumped from 13-06 at the start of pumping. Suds were observed throughout pumping, however they appeared to diminish towards the end of the test after five hours of pumping. Electrical conductivity in pumped groundwater was 1.3 mS/cm, temperature ranged from 3.9 degrees to 4.6 degrees Celsius, and pH ranged from 7.26 to 7.46.

Groundwater Analytical

Groundwater samples were collected from groundwater monitoring well 13-06 prior to surfactant application, and during pumping and after the completion of the pilot test from 13-06 and 16-38. Analytical results identified the following:

- BTEX concentrations did not exceed the CDWQG and BTEX, F1-BTEX and F2 ($>C_{10}$-C_{16}) did not exceed FIGWQG RL guidelines at 13-06 prior to and following surfactant injection at 16-38. Only F2 ($>C_{10}$-C_{16}) and trace xylenes concentrations were detected. F2 ($>C_{10}$-C_{16}) concentrations were marginally higher following surfactant injection (i.e., 630 µg/L vs 670-860 µg/L); and
- Following surfactant application, concentrations of F1-BTEX and F2 ($>C_{10}$-C_{16}) in groundwater at 16-38 exceeded the FIGWQG RL guidelines for F1-BTEX and F2 ($>C_{10}$-C_{16}) and the CDWQG for ethylbenzene and xylenes and ethylbenzene. The concentrations of F2 ($>C_{10}$-C_{16}) were 2,300 µg/L and 3,200 µg/L.

Groundwater sampling results for the surfactant push/pull test is presented in Table 9. Analytical reports are provided in Appendix III.

3.4.2 Results and Discussion

Although aquifer soils were not as permeable at Fireside than Muncho Lake, permeability was sufficient to complete surfactant injections and recovery. Surfactant was injected at a monitoring well at a flow rate of 6-8 L/min and recovered at an adjacent well at 16 L/min. This suggests the larger scale application of this in-situ remediation option would likely not be affected by physical limitations.

Groundwater Monitoring

Observations from monitoring conducted during injection and recovery suggested that limited recovery of the surfactant occurred. Preferential migration of the surfactant may have occurred in a different direction to well 13-06 where extraction occurred. The volume of surfactant injected in well 16-38 may also not have been sufficient to lead to a more concentrated detection in adjacent monitoring well 13-06

(i.e., 2.9 m away), however it was noted that suds and slight surfactant odour were observed in water pumped at the start of pumping at 13-06 and meniscus development became more pronounced towards the end of pumping.

Groundwater Analytical

Groundwater analytical results in extraction well 13-06 indicated only a marginal increase in F2 ($>C_{10}$-C_{16}) concentrations following surfactant injection at 16-38 (i.e., 630 µg/L vs 670-860 µg/L). Similar to interpretations made from groundwater monitoring data, preferential migration of the surfactant may have occurred in a different direction to well 13-06 where extraction occurred. The volume of surfactant injected in well 16-38 may also not have been sufficient to lead to higher PHC solubilisation levels in adjacent monitoring well 13-06 (i.e., 2.9 m away). Therefore, it is not known how effective the Iveysol 106 surfactant is in mobilizing and solubilising PHC.

Summary

Overall, the pilot test indicates that surfactant can be readily injected and recovered at a reasonable flow rate. However, groundwater analytical results indicated only a marginal increase in surfactant concentrations in the adjacent recovery well (i.e., 630 µg/L vs 670-860 µg/L) which would not be practical for full scale implementation. Given the magnitude of soil PHC concentrations and the absence of measurable LNAPL in monitoring wells at the Site, the potential for mass removal for surfactant application may be limited. However as indicated previously, observations from monitoring conducted during injection and recovery suggested that limited recovery of the surfactant occurred, with preferential migration of the surfactant and/or insufficient injection volume being potential causes. Therefore, it is likely that higher recovered dissolved hydrocarbon concentrations could be achieved with surfactants with more comprehensive testing.

3.5 LIF Evaluation

3.5.1 Methodology and Observations

Vertex Environmental Inc. (Vertex) was engaged to provide onsite observation of the advancing of direct push tooling, and gauge, in their experience, the potential for advancing the LIF device at the Fireside Maintenance Camp. Vertex and SNC-Lavalin observed Ernco advance 1.5 inch diameter probe rods to a depth of 25.5 to 26 m at two locations. Vertex and SNC-Lavalin also observed the advancement of a 2.25 inch diameter probe rod to a depth of 21 m. The 2.25 inch probe was removed and the depth of the open whole was evaluated. 1.5 inch probe rods were then advanced in the 2.25 inch bore to a depth of 26 m. The 1.5 inch probe rods were then removed, and the 2.25 inch probe rod was then advanced to 33 m, the potential target depth, to observe the advancement of probe rods through soils from 26 m to 33 m. Following the advancement of the direct probe rods, the holes were backfilled with sand and bentonite chips.

The 1.5” diameter probe rods were advanced to between 25.5 m and 26 m at two locations in approximately 35 minutes to 40 minutes. The advancement at the first location was more difficult between a depth of 17.7 m to 19.2 m. An inspection of the drive cap at the end of the probe rods after removal from the first location identified that there was noticeable wear on the cap. Following advancement of the 1.5” probe rods it was noted that 3 rods had a slight bend, however it is uncertain whether this occurred during advancement.

A 2.25” diameter probe rod was advanced at a third location to a depth of 21.3 m. Following removal of the 2.25” probe rod the hole remained open to a depth of 1.8 m. A 1.5” diameter probe rod was then advanced through the same bore and the sluff was fairly continuous to a depth of 21.3. From 21.3 m to 26 m (beyond the depth to which the 2.25” bore was advanced) more significant wobble was observed in the probe rods than at the previous 2 locations. It took approximately 55 minutes to advance a pilot bore with the 2.25” probe rods to 21.3 m and then follow with the 1.5” probe rods to 26 m.

Following advancement of the 1.5” probe rod to 26 m, 2.25” probe rods were advanced in the same bore to a depth of 32.9 m. Advancement of the 2.25” probe rod from 26 m to 32.9 m was challenging except at a depth of 31.4 m to 32 m.

Target depths were reached and refusal did not occur. Observations made by Vertex during the LIF evaluation are provided in Vertex’s memorandum in Appendix VI.

3.5.2 Results and Discussion

Advancement of the 1.5” rods with a solid point without refusal indicates that the LIF tool can be advanced at the Site. It was observed by Vertex that soil conditions were very “tight” for this type of advancement to the target depths required. Based on this, to minimize damage to tooling Vertex recommends a “pre-probing” strategy in which 2.25” tooling is advanced to approximately 20 mbgs prior to deploying the LIF device. As advancement of the LIF tool requires a downward velocity of less than 2 cm/s for data collection, a “pre-probing” approach through shallower soils will result in faster drilling in the upper 20 m, leading to a similar length of time to reach the target depth at each location.

4 Closure

This pilot test was largely an effort to establish proof of concept for in-situ remediation and characterization methods (i.e., chemical oxidation, surfactant injection, and LIF) with the intent of establishing which technologies were feasible options to apply toward meeting the remedial goals for the Sites. Interpretation of the testing, observations, and data collected suggests that the larger scale application of all three of these technologies at the Sites have potential to be applied in the effort to reduce hydrocarbon impacts. Similar conditions exist on the two Sites which include relatively permeable soils, contaminant type, ability to install probe rods to the desired depth, ground surface access in a maintenance yard, weather conditions and available electrical power. The primary difference is the depth of contamination as Muncho Lake contamination is present between approximately 8 m to 14 m below grade, and Fireside impacts are present within three discrete zones at approximately 10 m to 13 m, 20 m to 24 m and 26 m to greater than 30 m below grade.

Further assessment of the two in-situ technologies could be carried out to better understand the probability of successful remediation and the associated costs. There are notable differences in the application of the two technologies and associated requirements to achieve the desired remediation goal. These differences should be considered along with the costs when planning and decisions are made related to the next steps of site remediation. The table below summarizes some of the benefits and uncertainties/challenges as currently understood based on the site investigations and pilot testing.

Table H: Summary of InSitu Technology Benefits and Uncertainties

In-Situ Technology	Benefits	Uncertainties/Challenges
Chemical Oxidation	› Can be targeted/injected directly into areas with PHC impacts; › Application can be completed easily/quickly with direct push technology; › Does not generate a waste stream; › Treatment is rapid (hours to days); and › No permanent infrastructure is required to complete the injections.	› Wide range in estimated mass of oxidant and number of applications to achieve potential target remedial levels; › Remediation of impacts more difficult at lower PHC concentrations or if remediation endpoint concentrations are low; and › Health and safety risks associated with the handling and injection of hydrogen peroxide require attention to safety protocols.
Surfactants	› Can be delivered through targeted well installations screened across specific determined zones of PHC impacts; and › Remediation progress can be monitored through analysis of recovered water samples rather than repeated drilling events.	› Will require significant volumes of groundwater to be pumped, treated, and reinjected on-site; › Potential of treatment equipment and piping freezing during winter months; › Requires separate dedicated power supply generator; › Frequent manpower necessary during treatment equipment operation to ensure uptime; › Requires piping to well heads from treatment system to be buried and frost protected; and › Is challenging to apply where groundwater

		cannot be recovered at a reasonable rate, or where the water table is discontinuous.

Chemical Oxidation

The objectives of the pilot test were met in establishing the proof of concept for peroxide injection using direct push technology. The test results indicate that the effects of hydrogen peroxide oxidation were measurable in adjacent monitoring wells following the injection of the mixture batch. These field measured parameters (DO, ORP, temperature) indicate an oxidation reaction occurred between the hydrogen peroxide and the aquifer soils in the vicinity of the target injection zone.

Estimating the costs for remediation requires understanding the mass of oxidant necessary to remediate the PHC and the well spacing for effective delivery of the oxidant material to the subsurface. The interpretation of the test results provided a better understanding of a suitable injection spacing necessary to deliver the required mass of oxidant to the subsurface. Injection spacing has a significant impact on the potential costs as tightly spaced points increase the remediation costs. Conversely, fewer injection points increases the duration of injection at each location as a greater volume is necessary to affect the target reaction zone. Based on the observations and measurements from the testing at both sites, theoretical calculations of injection volumes, and discussion with remediation contractors interpretation of the testing results suggests that a radius of influence of 2.5 m to 3.5 m may be suitable spacing for injection points at both maintenance camps. Soil hydrocarbon concentrations and vertical thickness would also influence the well spacing.

Determination of the mass of hydrogen peroxide necessary to reduce the PHC impacts by a specified amount requires the test to reach the target end point. This type of test consists of injecting several batches of hydrogen peroxide until no further reaction is measured. There are many variables that determine the mass of hydrogen peroxide required to affect remediation of a target mass of petroleum hydrocarbons (for example: contaminant type, naturally occurring oxygen demand in soil, iron and manganese in soil and groundwater, pH of groundwater, plume geometry, and soil permeability). Moreover, reduction in soil PHC impacts are not necessarily linearly proportional with the mass of hydrogen peroxide injected, with a decrease in oxidant efficiency expected as remediation progresses.

A high level estimate of the hydrogen peroxide mass required to achieve the target remediation can be made. For in situ hydrogen peroxide injection/treatment, vendors and injection contractors generally use an estimated mass ratio of 5 to 50 hydrogen peroxide (100% w/w):1 petroleum hydrocarbons. A greater ratio is used when conditions for oxidation are less favourable. An earlier bench scale test of soil samples from each maintenance camp indicated that the natural oxygen demand was neither exceptionally high nor low in any of the samples at either of the camp sites. Given that petroleum hydrocarbons at Muncho Lake and Fireside are longer chain hydrocarbons, sorbed to soil, have a high concentration, and are at a neutral pH it is roughly estimated that the required mass ratio for hydrogen peroxide to petroleum hydrocarbon is on the order of 50:1. The actual ratio may be higher or lower than this.

Assuming that average F2 ($>C_{10}$-C_{16}) concentrations of 3,800 µg/g are present in soil it is estimated (given a 50 hydrogen peroxide: 1 petroleum hydrocarbon ratio) that 380 kg of hydrogen peroxide is required for each cubic metre of petroleum hydrocarbon impacted soil to reduce the F2 ($>C_{10}$-C_{16}) concentration in soil

to levels in accordance with CCME PHC CWS. Calculations and additional discussion with respect to these considerations are presented in Appendix VIII along with assumptions and sensitivities.

Assuming a 5,000 m^3 remediation volume and the above considerations, the estimated cost for remediation would be on the order of $4-5 M for each site. This estimate assumes a cost of hydrogen peroxide of $0.87/kg 50% m/m hydrogen peroxide and that application would be completed by a 3 person crew using direct push. Actual costs to complete remediation with hydrogen peroxide will depend on: the volume of impacts targeted for remediation; the ratio of hydrogen peroxide required to oxidize PHC impacts; the starting concentration of PHC impacts in soil; the endpoint concentration of PHCs required to achieve remediation; and the supply and delivery cost of hydrogen peroxide to the sites.

Surfactants

The objectives of the pilot test were largely met in establishing the proof of concept for surfactant application through injection wells. The analytical results from recovered groundwater at Muncho Lake indicate that the Task surfactant was effective in increasing the dissolved PHC mass for recovery. At Fireside however, only marginal increases in PHC concentrations were noted in recovered groundwater using the Iveysol 106 surfactant. Given the magnitude of soil PHC concentrations and the absence of measurable LNAPL in monitoring wells at the Site, the potential for mass removal with surfactant application may be limited. Field measurements and observations made suggested that limited recovery of the surfactant may have occurred which would bias dissolved PHC concentrations low in recovered groundwater, with preferential migration of the surfactant a potential cause leading to it not being readily recoverable during the extraction portion of the test. Therefore, it is possible that higher recovered dissolved PHC may be achieved through further evaluation.

Estimating the costs for remediation through surfactants is dependent on the recovered hydrocarbon mass per pore volumes of injected surfactant, which is calculated from the dissolved PHC concentration in recovered groundwater. Assuming that average F2 ($>C_{10}$-C_{16}) concentrations of 3,500 µg/g are present in soil and that dissolved phase concentrations from surfactant application at Muncho Lake are maintained at 8,700 µg/L for the duration, it would require in excess of 1,000 pore volumes to reduce soil hydrocarbon concentrations substantially, which is not considered to be practical. For Muncho Lake a surfactant enhanced pump and treat system would need to recover, treat, and re-inject recovered liquids at flowrates on the order of 1,000 to 2,000 L/min to achieve this. Installing, operating, and maintaining a surfactant enhanced pump and treat system capable of this is estimated to cost more than $4 M for 3 years. Assuming that surfactant will need to be applied for every 2 pore volumes recovered it is estimated that surfactants will cost on the order of $30 M. Calculations and additional discussion related to the surfactant flushing are presented in Appendix IX.

5 Notice to Reader

This report has been prepared by SNC-Lavalin Inc. (SNC-Lavalin) for Canada, who has been party to the development of the scope of work for this project and understands its limitations. Copyright of this report vests with Her Majesty the Queen in Right of Canada. This report was prepared in accordance with a services contract between SNC-Lavalin and Canada, including General Conditions 2035 of the Standard Acquisition Clauses and Conditions (SACC) Manual.

This report is intended to provide information to Canada to assist it in making business decisions. SNC-Lavalin is not a party to the various considerations underlying the business decisions, and does not make recommendations regarding such business decisions.

The findings, conclusions and recommendations in this report have been developed in a manner consistent with the level of skill normally exercised by environmental professionals currently practising under similar conditions in the area. The findings contained in this report are based, in part, upon information provided by others. If any of the information is inaccurate, modifications to the findings, conclusions and recommendations may be necessary.

The findings, conclusions and recommendations presented by SNC-Lavalin in this report reflect SNC-Lavalin's best judgement based on the site conditions at the time of the site inspection on the date(s) set out in this report and on information available at the time of preparation of this report. They have been prepared for specific application to these sites and are based, in part, upon visual observation of the site, subsurface investigation at discrete locations and depths, and specific analysis of specific materials as described in this report during a specific time interval. Substances other than those described may exist within the site, reported substance parameters may exist in areas of the site not investigated, and concentrations of substances greater or less than those reported may exist between sample locations.

The findings and conclusions of this report are valid only as of the date of this report. If site conditions change, new information is discovered, or unexpected site conditions are encountered in future work, including excavations, borings, or other studies, the findings, conclusions and/or recommendations of this report should be re-evaluated. It is recommended that users of this report should engage a suitably qualified professional to assist in interpreting the significance, if any, of the findings.

Figures

Figure 1: Groundwater Temperature During Hydrogen Peroxide Injections - Muncho Lake Maintenance Camp

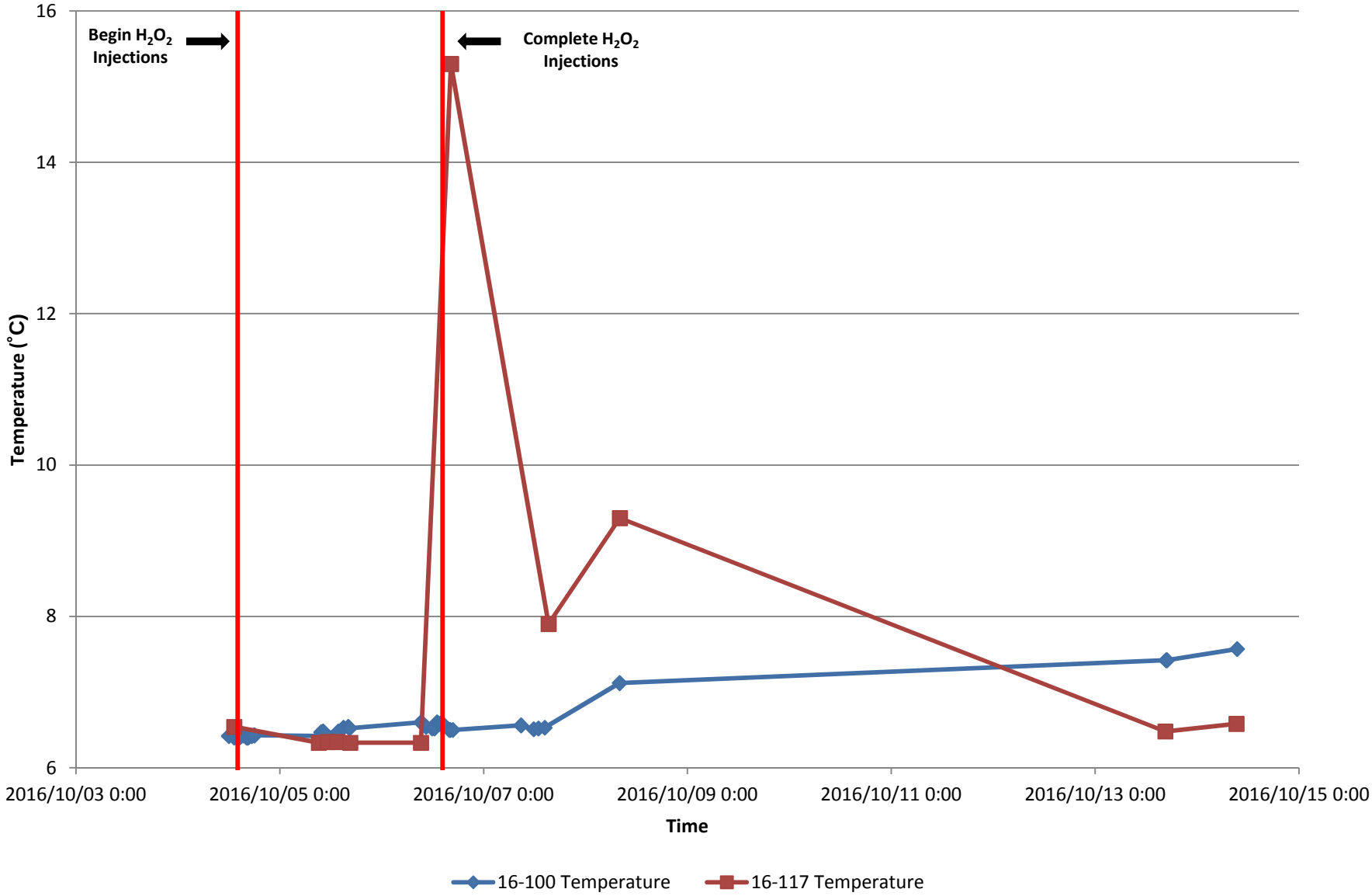


Figure 2: Dissolved Oxygen Concentration and Oxidation Reduction Potential During Hydrogen Peroxide Injections - Muncho Lake Maintenance Camp

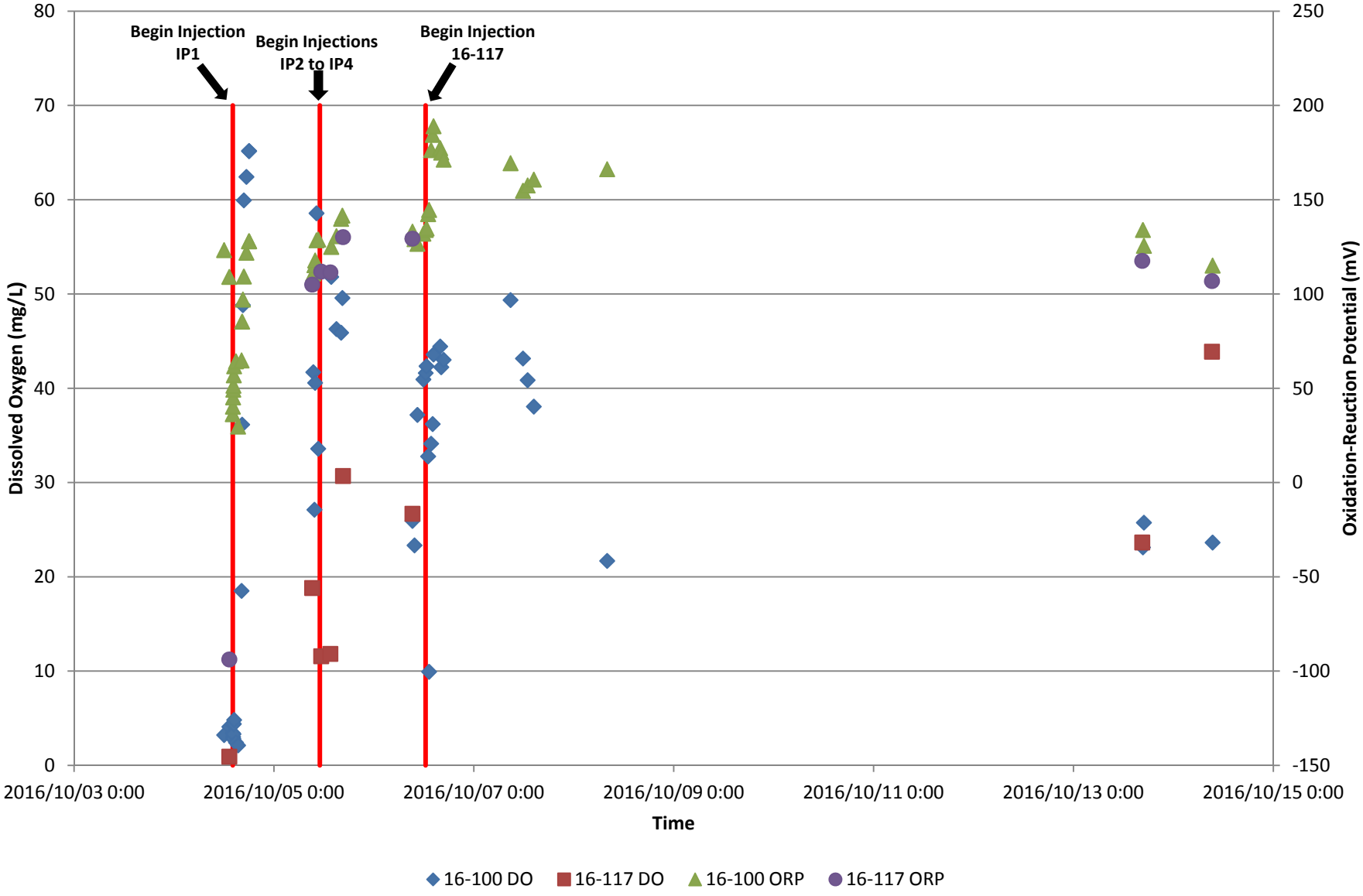


Figure 3: Groundwater Temperature During Hydrogen Peroxide Injections - Fireside Maintenance Camp

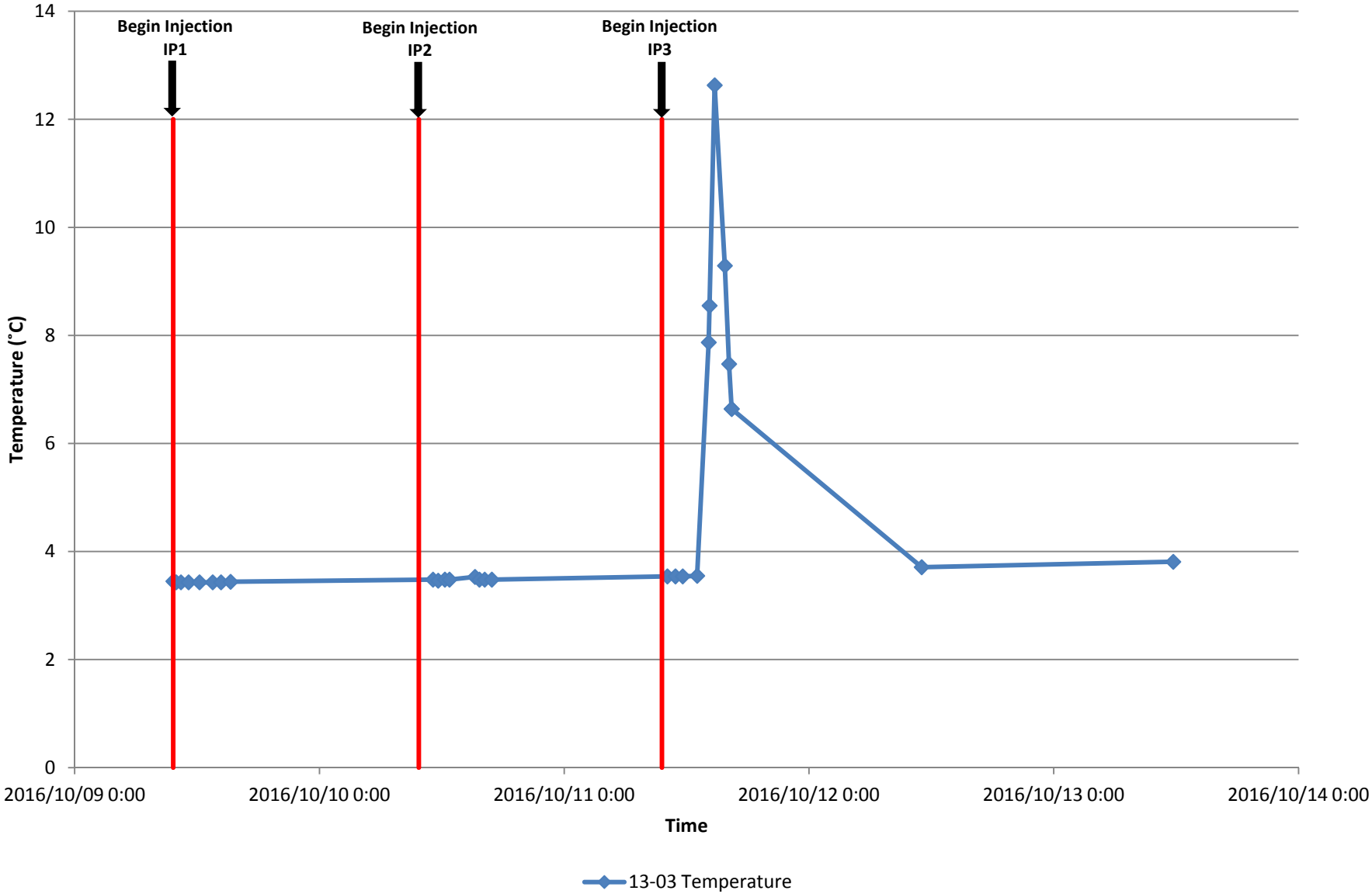
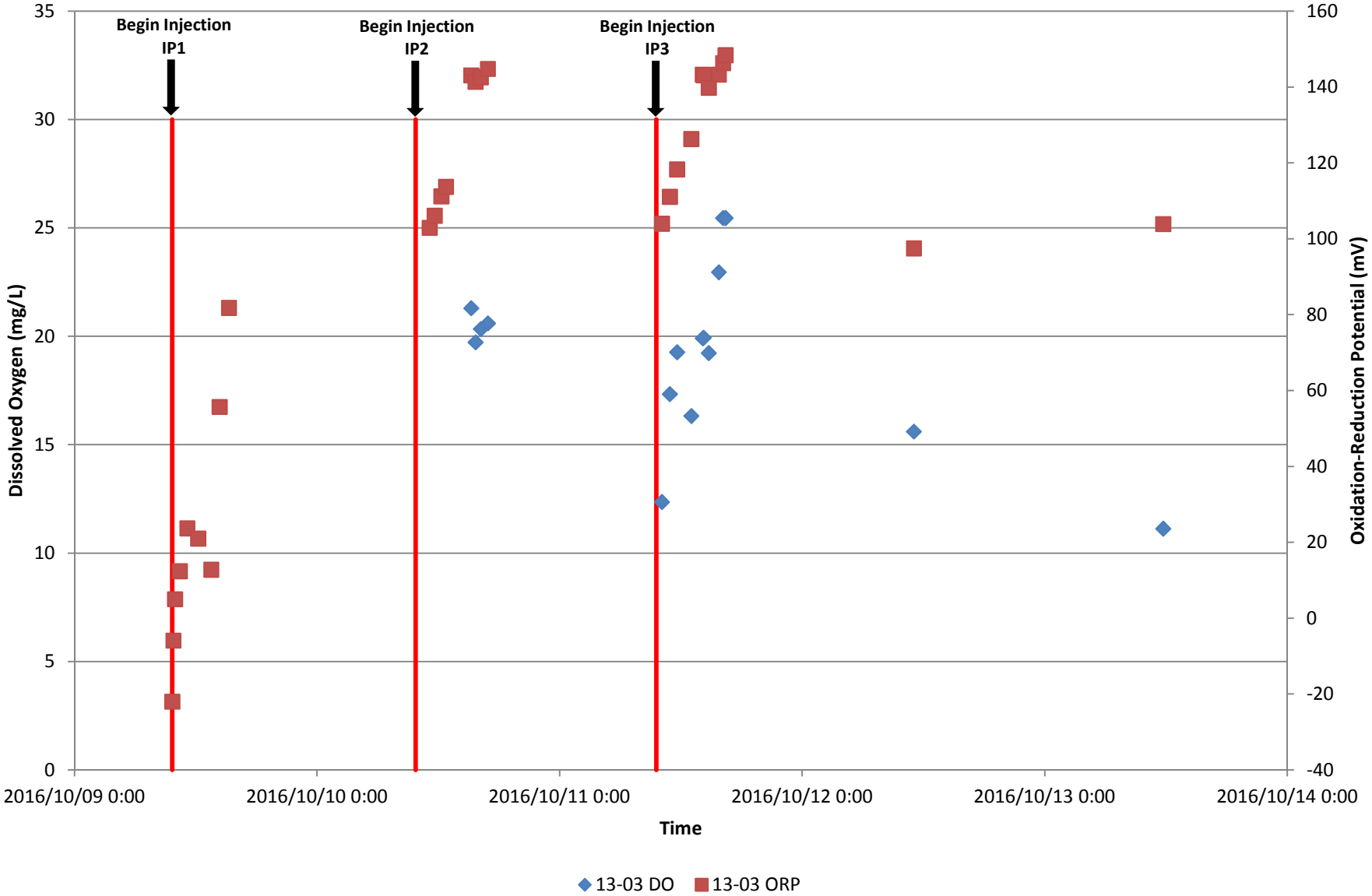


Figure 4: Dissolved Oxygen Concentration and Oxidation-Reduction Potential During Hydrogen Peroxide Injections - Fireside Maintenance Camp



Tables

Table 1: Muncho Lake Maintenance Camp – Summary of Analytical Results for Soil

Sample Location	Sample ID	Sample Date (yyyy mm dd)	Depth Interval (m)	Field Screen[a] (ppm)	Monocyclic Aromatic Hydrocarbons					Gross	Petroleum Hydrocarbon Fractions				MTBE
					Benzene µg/g	Ethylbenzen µg/g	Toluene µg/g	Xylenes µg/g	Styrene µg/g	VPH (C6-C10) µg/g	F1- µg/g	F2 (>C10-C16) µg/g	F3 (>C16-C34) µg/g	F4 (>C34-C50) µg/g	MTBE µg/g
BH16-116	BH16-116-01	2016 10 03	8.1 - 8.2	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	< 10	< 10	< 0.10
	BH16-116-02	2016 10 03	9.0 - 9.1	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	< 10	< 10	< 0.10
	BH16-116-03	2016 10 03	9.8 - 9.9	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	< 10	< 10	< 0.10
	BH16-116-04	2016 10 03	11.4 - 11.6	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	55	***57***	***3,300***	860	< 10	< 0.10
	BH16-116-05	2016 10 03	12.6 - 12.8	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	< 10	< 10	< 0.10
BH16-117	BH16-117-01	2016 10 04	9.4 - 9.6	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	16	< 10	< 0.10
	BH16-117-02	2016 10 04	10.2 - 10.4	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	46	***48***	***2,000***	860	< 10	< 0.10
	BH16-117-03	2016 10 04	11.0 - 11.1	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	19	22	***270***	120	< 10	< 0.10
	BH16-117-04	2016 10 04	12.2 - 12.3	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	22	25	***220***	110	< 10	< 0.10
BH16-119	BH16-119-01	2016 10 07	10.8 - 11.0	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	21	22	***890***	410	< 10	< 0.10
	BH16-119-02	2016 10 07	11.6 - 11.7	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	120	***130***	***2,300***	860	< 10	< 0.10
	BH16-119-03	Duplicate	11.6 - 11.7	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	100	***110***	***1,800***	710	< 10	< 0.10
	QA/QC RPD%				*	*	*	*	*	18	17	24	19	*	*
BH16-120	BH16-120-1	2016 10 13	9.4 - 9.6	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	< 10	< 10	< 10	< 10	< 10	< 0.10
	BH16-120-2	2016 10 13	10.2 - 10.4	-	< 0.0050	< 0.010	< 0.020	< 0.040	< 0.030	30	***31***	***2,700***	1,500	< 10	< 0.10
	BH16-120-3	2016 10 13	11.3 - 11.4	-	0.0080	< 0.010	< 0.020	< 0.040	< 0.030	22	23	***4,300***	1,700	< 20	< 0.10
Federal Guideline/Standard															
CCME CEQG/CWS Residential Coarse-Grained Surface (sample depth < 1.5m)[b]					0.03	0.082	0.1	11	5	n/a	30	150	300	2,800	n/a
CCME CEQG/CWS Residential Coarse-Grained Subsoil (sample depth > 1.5m)[b]					0.03	0.082	0.1	11	5	n/a	30	150	2,500	10,000	n/a
BC Standard															
CSR Residential Land Use (RL) (sample depth < 3.0m)[c]					0.04	1	1.5	5	5	200	n/a	n/a	n/a	n/a	320
CSR Commercial Land Use (CL) (sample depth > 3.0m)[c]					0.04	7	2.5	20	50	200	n/a	n/a	n/a	n/a	700

Associated Maxxam file(s): B690914, B692253.

All terms defined within the body of SNC-Lavalin's report.

< Denotes concentration less than indicated detection limit or RPD less than indicated value.

- Denotes analysis not conducted.

n/a Denotes no applicable standard/guideline.

RPD Denotes relative percent difference.

* RPDs are not calculated where one or more concentrations are less than five times RDL.

RDL Denotes reported detection limit.

BOLD Concentration greater than CCME CEQG/CWS Residential Land Use (RL) standard.

SHADOW Concentration greater than CSR Residential Land Use (RL) Standard (Commercial Land Use [CL] below 3.0 m).

[a] Field screening results are measured based on a 'dry headspace' method using a combustible gas meter calibrated to a hexane standard.

[b] Pathways: Contact (Direct/Eco), Management Limit, Protection of Groundwater for Aquatic Life, Vapour Inhalation, Protection of Potable Groundwater.

[c] The site-specific factors used for determining the matrix standards for this site include: intake of contaminated soil, groundwater used for drinking water, toxicity to soil invertebrates and plants, and groundwater flow to surface water used by freshwater aquatic life (whichever is most stringent).

Table 2: Muncho Lake Maintenance Camp - Hydrogen Peroxide Injection Results

Activity	Date	Time	Injection Location	Injection Concentration (% m/m)	Injection Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Temperature (Deg C)	Specific Conductance (mS/cm^{c})	Conductivity (mS/cm)	TDS (g/L)	Salinity	Dissolved Oxygen (% Saturation)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Observations/Notes
IP 1 start of advancement	2016/10/04	13:06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.25" injection rod used (MC5 system)
IP 1 completion	2016/10/04	13:14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Injection rod driven to 12.2 m- raised approximately 0.05 m
Pre-injection monitoring (baseline)	2016/10/04	12:00	-	-	-	-	-	16-100	6.42	-	0.203	-	-	-	3.22	7.48	123.3	-
Pre-injection monitoring (baseline)	2016/10/04	13:15	-	-	-	-	-	16-100	6.4	-	0.198	-	-	-	4.09	7.72	109.1	-
Pre-injection monitoring (baseline)	2016/10/04	13:15	-	-	-	-	-	16-117	6.54	-	0.608	-	-	-	0.93	11.72	-93.8	Post well construction and development
Pre-injection monitoring (baseline)	2016/10/04	14:05	-	-	-	-	-	16-100	6.39	-	0.203	-	-	-	4.35	8.81	36.3	-
Injection of 10% H2O2 at IP1 commenced	2016/10/04	14:06	IP1	~11.5%	0	-	-	-	-	-	-	-	-	-	-	-	-	Start of injection at IP1
Injection of 11.5% H2O2 at IP1	2016/10/04	14:07	IP1	~11.5%	-	-	-	16-100	6.39	-	0.202	-	-	-	3.43	8.62	40.3	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:10	IP1	~11.5%	0	6.7	10	16-100	6.39	-	0.202	-	-	-	3.02	8.51	45.2	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:13	IP1	~11.5%	40.5	10	24	16-100	6.39	-	0.202	-	-	-	2.82	8.42	49.3	2 RV pumps used for injection
Injection of 11.5% H2O2 at IP1	2016/10/04	14:15	IP1	~11.5%	-	-	-	16-100	6.39	-	0.202	-	-	-	3.32	8.41	51.4	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:16	IP1	~11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	Bubbling/bypass around IP1 at surface
Injection of 11.5% H2O2 at IP1	2016/10/04	14:19	IP1	~11.5%	87.5	7.73	24	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:20	IP1	~11.5%	-	-	-	16-100	6.4	-	0.202	-	-	-	4.39	8.33	56.9	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:25	IP1	~11.5%	-	-	-	16-100	6.42	-	0.201	-	-	-	4.82	8.27	61.7	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:28	IP1	~11.5%	162.9	7.77	24	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:42	IP1	~11.5%	267.6	8.04	30	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	14:52	IP1	~11.5%	-	-	-	16-100	6.42	-	0.2	-	-	-	2.42	8.1	64.3	-
Injection of 11.5% H2O2 at IP1	2016/10/04	15:08	IP1	~11.5%	485.7	8	30	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	15:22	IP1	~11.5%	-	-	-	16-100	6.43	-	0.2	-	-	-	2.12	8	29.7	-
Injection of 11.5% H2O2 at IP1	2016/10/04	15:32	IP1	~11.5%	663.7	7.32	22	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	15:43	IP1	~11.5%	742.6	13.2	4	-	-	-	-	-	-	-	-	-	-	Raised injection rod to 12.0 m (i.e. by 0.15 m)
Injection of 11.5% H2O2 at IP1	2016/10/04	16:11	IP1	~11.5%	1106.7	13.6	4	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at IP1	2016/10/04	16:12	IP1	~11.5%	-	-	-	16-100	6.4	0.296	0.191	0.192	0.14	152.7	18.51	7.92	64.8	-
Injection of 11.5% H2O2 at IP1	2016/10/04	16:20	IP1	~11.5%	-	-	-	16-100	6.4	0.293	-	-	0.14	293.3	36.15	7.87	85.4	-
Injection of 11.5% H2O2 at IP1	2016/10/04	16:31	IP1	~11.5%	-	-	-	16-100	6.4	0.291	-	-	0.14	396.8	48.82	7.83	97.1	-
Injection of 11.5% H2O2 at IP1	2016/10/04	16:45	IP1	~11.5%	1452.8	12.1	4	16-100	6.41	0.285	0.184	-	0.14	486.2	59.94	7.76	109.3	-
Injection of 11.5% H2O2 at IP1	2016/10/04	16:56	IP1	~11.5%	1582	12.3	2	16-100	-	-	-	-	-	-	-	-	-	Raised injection rod to 11.85 m (i.e. by 0.15 m)
Injection of 11.5% H2O2 at IP1	2016/10/04	17:22	IP1	~11.5%	1923	13	0	16-100	6.42	0.285	0.184	0.186	0.14	507.1	62.43	7.68	121.9	-
Injection of 11.5% H2O2 at IP1	2016/10/04	17:31	IP1	~11.5%	1999	21.2	10	16-100	-	-	-	-	-	-	-	-	-	Swapped 3/4" injection hose for 1" injection hose
Injection of 11.5% H2O2 at IP1	2016/10/04	18:00	IP1	~11.5%	2590	22.4	8	16-100	6.43	0.293	0.189	0.191	0.14	529.7	65.17	7.64	128	-
Injection of 11.5% H2O2 at IP1	2016/10/04	18:00	IP1	~11.5%	2590	22.4	8	16-100	6.43	0.293	0.189	0.191	0.14	529.7	65.17	7.64	128	-
Injection of 11.5% H2O2 at IP1	2016/10/04	18:00	IP1	~11.5%	2618	22.4	8	16-100	-	-	-	-	-	-	-	-	-	Injection stopped
IP2 advancement	2016/10/05	9:00	IP2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Injection rod (2.25") driven to 12.3 m at IP2.
Monitoring at MW 16-117	2016/10/05	9:10	-	-	-	-	-	16-117	6.33	-	0.183	-	-	-	18.82	8.02	105	-
Injection of 11.5% H2O2 at IP1	2016/10/05	9:26	IP1	~11.5%	2618	20	16	16-100	6.42	0.315	0.203	0.205	0.15	339.4	41.71	7.88	110.9	Injection restarted
Injection of 11.5% H2O2 at IP1	2016/10/05	9:42	IP1	~11.5%	2951.9	20.5	16	16-100	6.47	0.322	0.208	0.209	0.15	220.8	27.12	7.76	115.3	-
Injection of 11.5% H2O2 at IP1	2016/10/05	9:52	IP1	~11.5%	3129.9	13.2	10	16-100	6.47	0.327	0.211	0.212	0.16	329.9	40.58	7.71	117.8	2 RV pumps used for injection
Injection of 11.5% H2O2 at IP1	2016/10/05	10:12	IP1	~11.5%	3399.5	13.5	8	16-100	6.48	0.329	0.212	0.214	0.16	479	58.57	7.57	128.5	-
Injection of 10% H2O2 at IP1	2016/10/05	10:36	IP1	~11.5%	3440.3	13.5	-	16-100	6.45	0.314	0.203	0.204	0.15	274.2	33.59	7.73	128.9	Injection at IP1 ended
Injection of VTX at IP2	2016/10/05	11:00	IP2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Injection/application of 40L VTX mixed with 120L H2O at IP2 after raising IP2 to 12.15 m. Unable to inject VTX via submersible or drum pump. Proceeded to pour VTX solution down injection tubing.

Table 2 (Cont'd): Muncho Lake Maintenance Camp - Hydrogen Peroxide Injection Results

Activity	Date	Time	Injection Location	Injection Concentration (% m/m)	Injection Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Temperature (Deg C)	Specific Conductance (mS/cm[c])	Conductivity (mS/cm)	TDS (g/L)	Salinity	Dissolved Oxygen (% Saturation)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Observations/Notes
Post development monitoring at 16-117	2016/10/05	11:19	-	-	-	-	-	16-117	6.34	0.288	0.185	0.187	0.14	93.8	11.58	8.13	111.9	-
Injection of 11.5% H2O2 at IP2	2016/10/05	12:57	IP2	~11.5%	0	6.3	48	-	-	-	-	-	-	-	-	-	-	Injection into IP2 post VTX application noted to be at slow rate and high pressure.
Injection of 11.5% H2O2 at IP2	2016/10/05	13:31	IP2	~11.5%	103	2.5	35-50	16-117	6.34	0.288	0.185	0.187	0.14	96	11.83	8.11	111.5	-
Injection of 11.5% H2O2 at IP2 ended	2016/10/05	13:40	IP2	~11.5%	177	4.3	-	-	-	-	-	-	-	-	-	-	-	Raised injection rod to 12.0 m (i.e. by 0.15 m) - did not notice significant increase in flow or decrease in pressure. Stopped injections at IP2.
Monitoring post injection at IP2	2016/10/05	13:44	IP2	-	-	-	-	16-100	6.48	0.34	0.22	0.221	0.16	417.9	51.82	7.84	125	-
Installation of IP3 approximately 1.0 m SSE of IP2 and injection of 11.5% H2O2	2016/10/05	13:50	IP3	~11.5%	0	21	10	-	-	-	-	-	-	-	-	-	-	Injection at IP3 noted to be completed at similar flow rate and pressure as IP1.
Injection of 11.5% H2O2 at IP3 ended	2016/10/05	14:30	IP3	~11.5%	900	21	10	-	-	-	-	-	-	-	-	-	-	Injection ended
Installation of IP4 approximately 0.15 m W of IP2 and injection of 11.5% H2O2	2016/10/05	14:39	IP4	~11.5%	0	22.1	10	-	-	-	-	-	-	-	-	-	-	IP4 injection rod advanced to 12.2 m and raised to 12.05 m before commencing with H2O2 injection.
Injection of 11.5% H2O2 at IP4	2016/10/05	14:59	IP4	~11.5%	440	22	10	16-100	6.53	0.329	0.213	0.14	0.16	376.8	46.29	7.83	130.7	No residual pressure observed in IP2 and IP3 which remained in place during injection at IP4
Injection of 11.5% H2O2 at IP4	2016/10/05	16:06	IP4	~11.5%	1596	22	10	16-100	6.54	0.32	0.211	0.212	0.16	374	45.9	7.68	139.9	Bubbling/gurgling heard at 16-117
Injection of 11.5% H2O2 at IP4 ended	2016/10/05	16:25	IP4	~11.5%	2071	-	-	16-100	6.52	0.338	0.218	0.219	0.16	403.3	49.58	7.66	141.6	Completed injection at 1P4
Monitoring post injection at IP4	2016/10/05	16:34	-	-	-	-	-	16-117	6.33	0.279	0.18	0.183	0.13	248.9	30.7	7.98	130.2	-
Post injection monitoring at MW16-117 (following day)	2016/10/06	9:14	-	-	-	-	-	16-117	6.33	0.284	0.183	0.184	0.14	216.6	26.69	8.17	129.4	-
Post injection monitoring at MW16-100 (following day)	2016/10/06	9:14	-	-	-	-	-	16-100	6.6	0.328	0.213	0.213	0.16	212.1	25.94	7.9	133.1	-
Injection of 11.5% H2O2 at MW16-117	2016/10/06	9:20	MW16-117	~11.5%	0	18.8	16	-	-	-	-	-	-	-	-	-	-	During removal of IP2 liquids (11.5% peroxide) were noted to come out when breaking the rods suggesting IP2 was plugged. Following the removal of the last rod it was noted the bottom rod was plugged with sand/fines. This was considered the cause of difficulty with injecting VTX and H2O2 at this location.
Injection of 11.5% H2O2 at MW16-117	2016/10/06	9:34	MW16-117	~11.5%	255	14.7	8	-	-	-	-	-	-	-	-	-	-	-
Injection of 11.5% H2O2 at MW16-117 ended	2016/10/06	9:44	MW16-117	~11.5%	304	-	-	16-100	6.58	0.328	0.213	0.214	0.16	190.8	23.34	7.77	129.1	Injection of 11.5% H2O2 at MW16-117 ended.
Continued monitoring at MW16-100	2016/10/06	10:26	-	-	-	-	-	16-100	6.54	0.312	0.202	0.203	0.15	302.8	37.18	7.88	126.6	-
Continued monitoring at MW16-100	2016/10/06	11:52	-	-	-	-	-	16-100	6.52	0.295	0.191	0.192	0.14	339.4	40.94	7.92	132	-
Injection of 20% H2O2 at MW16-117	2016/10/06	12:25	MW16-117	~20%	0	8.4	4	16-100	6.52	0.291	0.188	0.189	0.14	339.1	41.62	7.93	134	Started injection of 20% H2O2 at MW16-117. Low flow noted likely associated with pump issue as injection pressure noted to remain low.
Injection of 20% H2O2 at MW16-117	2016/10/06	12:37	MW16-117	~20%	120.2	14.3	10	16-100	6.54	0.29	0.188	0.189	0.14	345.2	42.35	7.93	134.8	Continued to troubleshoot low flow associated with pump issues.
Injection of 20% H2O2 at MW16-117	2016/10/06	13:00	MW16-117	~20%	470	14.8	10	16-100	6.6	0.302	0.196	0.197	0.14	268.1	32.78	7.84	142.4	Continued to troubleshoot low flow associated with pump issues. Was able to increase flow to 21 L/min.
Injection of 20% H2O2 at MW16-117	2016/10/06	13:14	MW16-117	~20%	661.7	20.9	20	16-100	6.59	0.313	0.203	0.203	0.15	81.4	9.93	7.76	144.6	-
Injection of 20% H2O2 at MW16-117	2016/10/06	13:43	MW16-117	~20%	1205.3	20.5	18	16-100	6.58	0.329	0.213	0.213	-	274.8	34.13	7.79	176.3	-
Injection of 20% H2O2 at MW16-117	2016/10/06	14:06	MW16-117	~20%	1701.8	20.7	18	16-100	6.59	0.327	0.212	0.212	0.16	294.8	36.21	7.76	184.4	-

Table 2 (Cont'd): Muncho Lake Maintenance Camp - Hydrogen Peroxide Injection Results

Activity	Date	Time	Injection Location	Injection Concentration (% m/m)	Injection Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Temperature (Deg C)	Specific Conductance (mS/cm[C])	Conductivity (mS/cm)	TDS (g/L)	Salinity	Dissolved Oxygen (% Saturation)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Observations/Notes
Injection of 20% H2O2 at MW16-117 ended	2016/10/06	14:18	MW16-117	~20%	1833.2	-	-	16-100	6.58	0.327	0.212	0.212	0.16	355.6	43.58	7.83	189	Injection of 20% H2O2 at MW16-117 ended.
Continued monitoring at MW16-100	2016/10/06	15:54	-	-	-	-	-	16-100	6.5	0.294	0.19	0.191	0.14	362	44.44	7.92	177.4	-
Continued monitoring at MW16-100	2016/10/06	16:09	-	-	-	-	-	16-100	6.5	0.292	0.189	0.19	0.14	343.9	42.24	7.93	175	-
Post injection monitoring at MW16-117	2016/10/06	16:19	-	-	-	-	-	16-117	15.3	-	-	-	-	-	-	6.52	-	Temperature collected from purge water
Continued monitoring at MW16-100	2016/10/06	16:44	-	-	-	-	-	16-100	6.5	0.289	0.187	0.188	0.14	350.2	43.02	7.93	171.3	-
Continued monitoring at MW16-100	2016/10/07	8:48	-	-	-	-	-	16-100	6.56	0.29	0.188	0.189	0.14	401.5	49.36	8.19	169.4	-
Continued monitoring at MW16-100	2016/10/07	11:47	-	-	-	-	-	16-100	6.51	0.285	0.186	0.186	0.14	351.6	43.16	7.97	154.8	-
Continued monitoring at MW16-100	2016/10/07	12:54	-	-	-	-	-	16-100	6.52	0.286	0.185	0.186	0.14	332.8	40.86	7.97	157.6	-
Continued monitoring at MW16-100	2016/10/07	14:23	-	-	-	-	-	16-100	6.53	0.286	0.185	0.186	0.14	310.2	38.06	7.97	160.7	-
Post injection monitoring at MW16-117	2016/10/07	15:18	-	-	-	-	-	16-117	7.9	-	-	-	-	-	-	-	-	Temperature collected from purge water
Continued monitoring at MW16-100	2016/10/08	8:00	-	-	-	-	-	16-100	7.12	-	0.195	-	-		21.69	8.09	166.2	Temperature appeared to be stratified. 7.12 Deg C ~ middle of screen. 6.8-6.9 Deg C at base of screen.
Continued monitoring at MW16-117	2016/10/08	8:05	-	-	-	-	-	16-117	9.3	-	-	-	-	-	-	7.71	-	Temperature collected from purge water
Continued monitoring at MW16-117	2016/10/13	16:30	-	-	-	-	-	16-117	6.48	-	0.184	-	-	-	23.65	8.05	117.6	-
Continued monitoring at MW16-100	2016/10/13	16:40	-	-	-	-	-	16-100	7.42	-	0.208	-	-		23.12	7.7	134	-
Continued monitoring at MW16-100	2016/10/13	16:54	-	-	-	-	-	16-100	7.42	-	0.201	-	-		25.75	7.42	125.6	-
Continued monitoring at MW16-117	2016/10/14	9:15	-	-	-	-	-	16-117	6.58	-	0.182	-	-	-	43.89	7.93	106.9	-
Continued monitoring at MW16-100	2016/10/14	9:24	-	-	-	-	-	16-100	7.57	0.336	0.224	0.218	0.16	197.6	23.64	7.67	115.1	-
Monitoring at MW16-116	2016/10/14	9:40	-	-	-	-	-	16-116	6.57	0.287	0.186	0.187	0.14	83.4	10.21	8.19	99	-

Table 3: Muncho Lake Maintenance Camp – Pump Test Results

Activity	Date	Time	Test Time (s)	Test Time (min)	Pumping Location	Pump Rate (GPM)	Pump Rate (L/min)	Pumped Volume (G)	Pumped Volume (L)	Monitoring Location	Depth to Water (m)	Drawdown (m)	Observations/Notes
Monitoring Static Conditions	2016/10/06	10:35	-	-	-	-	-	-	-	MW 16-116	8.324	-	Pump well MW 16-116
Monitoring Static Conditions	2016/10/06	9:08	-	-	-	-	-	-	-	MW 16-102	8.15	-	Deep observation well MW 16-102. Logger G1875 deployed at 9:24 at approximately 10.6 m depth.
Monitoring Static Conditions	2016/10/06	9:12	-	-	-	-	-	-	-	MW 16-118	8.356	-	Shallow observation well MW 16-118. Logger C8737 deployed at 9:36 at approximately 9.8 m depth.
Pump Test	2016/10/06	10:35	19	0.32	MW 16-116	3.5	13.25	1.11	4.20	-	-	-	Start of pump test - first attempt
Pump Test	2016/10/06	10:35	40	0.67	MW 16-116	4.9	18.55	2.82	10.69	MW 16-116	8.35	0.026	-
Pump Test	2016/10/06	10:37	120	2	MW 16-116	4.9	18.55	9.36	35.41	MW 16-116	8.36	0.036	-
Pump Test	2016/10/06	10:42	420	7	MW 16-116	0	0	33.86	128.15	MW 16-116	8.324	0	Pump off - recovery to static in PW. Re-start test at 10:44
Pump Test	2016/10/06	10:44	30	0.5	MW 16-116	5.33	20.17	2.67	10.09	MW 16-116	8.363	0.039	Start of pump test - second attempt
Pump Test	2016/10/06	10:45	60	1	MW 16-116	5.33	20.17	5.33	20.17	MW 16-116	8.366	0.042	-
Pump Test	2016/10/06	10:45	90	1.5	MW 16-116	6	22.71	8.33	31.53	MW 16-116	8.368	0.044	-
Pump Test	2016/10/06	10:46	120	2	MW 16-116	6.21	23.50	11.44	43.28	MW 16-116	8.368	0.044	-
Pump Test	2016/10/06	10:48	240	4	MW 16-116	6.21	23.50	23.86	90.29	MW 16-116	8.37	0.046	-
Pump Test	2016/10/06	10:55	660	11	MW 16-116	0	0	67.33	254.83	MW 16-116	8.324	0	Pump off - recovery to static in PW. Re-start test at 10:55
Pump Test	2016/10/06	10:55	20	0.33	MW 16-116	5.33	20.17	1.78	6.72	MW 16-116	8.356	0.032	Start of pump test - third attempt
Pump Test	2016/10/06	10:58	180	3	MW 16-116	0	0	15.99	60.52	MW 16-116	8.324	0	Pump off - recovery to static in PW. Re-start test at 10:58
Pump Test	2016/10/06	10:58	20	0.33	MW 16-116	5.43	20.55	1.81	6.85	MW 16-116	8.358	0.034	Start of pump test - final attempt
Pump Test	2016/10/06	10:59	40	0.67	MW 16-116	5.43	20.55	3.62	13.70	MW 16-116	8.365	0.041	-
Pump Test	2016/10/06	11:00	90	1.5	MW 16-116	6.14	23.24	8.74	33.07	MW 16-116	8.368	0.044	-
Pump Test	2016/10/06	11:00	105	1.75	MW 16-116	6.2	23.47	10.29	38.94	MW 16-116	8.368	0.044	-
Pump Test	2016/10/06	11:03	300	5	MW 16-116	6.2	23.47	30.44	115.20	MW 16-116	8.368	0.044	-
Pump Test	2016/10/06	11:07	495	8.25	MW 16-116	6.2	23.47	50.59	191.47	MW 16-118	8.361	0.005	-
Pump Test	2016/10/06	11:09	630	10.5	MW 16-116	6.2	23.47	64.54	244.27	MW 16-102	8.162	0.012	-
Pump Test	2016/10/06	11:23	1500	25	MW 16-116	6.2	23.47	154.44	584.54	MW 16-102	8.165	0.015	-
Pump Test	2016/10/06	11:28	1770	29.5	MW 16-116	6.2	23.47	182.34	690.14	MW 16-118	8.362	0.006	-
Pump Test	2016/10/06	11:41	2526	42.1	MW 16-116	6.2	23.47	260.46	985.83	MW 16-116	-	-	End of pump test/start of recovery test
Recovery Test	2016/10/06	11:43	2670	44.5	MW 16-116	0	0	260.46	985.83	MW 16-118	8.36	0.004	-
Recovery Test	2016/10/06	11:46	2820	47	MW 16-116	0	0	260.46	985.83	MW 16-102	8.152	0.002	-
Recovery Test	2016/10/06	11:54	3345	55.75	MW16-116	0	0	260.46	985.83	MW 16-116	8.326	0.002	-
Recovery Test	2016/10/06	12:11	4320	72	MW16-116	0	0	260.46	985.83	MW 16-116	8.326	0.002	-
Recovery Test	2016/10/06	12:13	4500	75	MW16-116	0	0	260.46	985.83	MW 16-118	8.36	0.004	-
Recovery Test	2016/10/06	12:15	4620	77	MW16-116	0	0	260.46	985.83	MW 16-102	8.152	0.002	-

Table 4: Muncho Lake Maintenance Camp - Surfactant Application Results

Activity	Date	Time	Injection/ Pumping Location	Injection Concentration	Injection/ Pumped Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Depth to Water (m)	TDS (ppm)	pH	Observations/Notes
Pre-injection monitoring (baseline)	2016/10/06	9:08	-	-	-	-	-	16-102	8.15	-	-	-
Pre-injection monitoring (baseline)	2016/10/06	9:10	-	-	-	-	-	16-116	8.324	250	9.1	-
Pre-injection monitoring (baseline)	2016/10/06	9:12	-	-	-	-	-	16-118	8.356	-	-	-
Mixing and injection of Task and KOH (postassium hydroxide) - Batch 1 Start	2016/10/06	13:24	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	0	11.1	4	-	-	-	-	Batch prepared for injection in 16-116. Mixture based on Mark Hasegawa's recommendations following bench scale testing. Surfactant solution had TDS of 20,000 ppm and pH of 13.2
Injection of Task and KOH (postassium hydroxide) - Batch 1	2016/10/06	13:43	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	304	17	0	-	-	-	-	-
Monitoring of 16-118	2016/10/06	13:51	16-116	-	-	-	-	16-118	8.355	-	-	Clear - no odour
Injection of Task and KOH (postassium hydroxide) - Batch 1	2016/10/06	14:19	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	891	16.9	0	16-118	-	120	-	16-118 was noted to be turbid/brown due to disturbance
End of injection Batch 1 of Task and KOH (postassium hydroxide)	2016/10/06	14:35	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	1329	-	-	-	-	-	-	-
Monitoring of 16-102	2016/10/06	14:35	16-116	-	-	-	-	16-102	-	~1150	12.75	16-102 was purged and noted to be bubbly with strong surfactant odour. TDS was diluted 3x as out of range.
Monitoring of 16-102	2016/10/06	15:06	16-116	-	-	-	-	16-102	-	~1950	12	Based on monitoring at 16-102 Mark Hasegawa estimated 16-102 had 1/6th initial TDS injection concentration at 16-116. TDS was diluted 3x as out of range.
Mixing and injection of Task and KOH (postassium hydroxide) - Batch 2 Start	2016/10/06	15:55	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	1329	23.8	16	-	-	-	-	Different pump used for injection into 16-102 (hence higher injection rate)
Monitoring of 16-118	2016/10/06	15:58	16-116	-	-	-	-	16-118	-	160	9	-
Monitoring of 16-102	2016/10/06	15:58	16-116	-	-	-	-	16-102	-	-	13	-
Monitoring of 16-102	2016/10/06	16:30	16-116	-	-	-	-	16-102	-	~2250	-	Based on monitoring at 16-102 Mark Hasegawa estimated 16-102 had 25% of initial injection concentration at 16-116. TDS was diluted 3x as out of range.
End of injection Batch 2 of Task and KOH (postassium hydroxide)	2016/10/06	16:40	16-116	~1350 L H_2O: 40 L Task: 10 kg KOH: 30 L 7% Acetic Acid	2702	-	-	-	-	-	-	End of surfactant injection at 16-116
Monitoring of 16-118	2016/10/06	17:00	-	-	-	-	-	16-118	-	180	9	-
Monitoring of 16-102	2016/10/06	17:00	-	-	-	-	-	16-102	-	2200	12.8	-
Pre-pump (pull) test monitoring (baseline)	2016/10/07	8:45	-	-	-	-	-	16-118	8.391	-	-	No product detected
Pre-pump (pull) test monitoring (baseline)	2016/10/07	8:47	-	-	-	-	-	16-116	8.354	-	-	No product detected
Pre-pump (pull) test monitoring (baseline)	2016/10/07	8:49	-	-	-	-	-	16-102	8.182	141	8.8	No product detected
Start of pump (pull) test. Pump from 16-102	2016/10/07	8:50	16-102	-	0	22.74	-	16-102	-	180	9.8	Pumping started at 16-102 based on recommendation from Mark Hasegawa
Monitoring of 16-116	2016/10/07	8:50	16-102	-	-	-	-	16-116	-	250	10.2	-
Monitoring of 16-102	2016/10/07	9:15	16-102	-	-	-	-	16-102	-	220	10.2	-
End of pump (pull) test from 16-102	2016/10/07	9:38	16-102	-	432	-	-	-	-	-	-	Sample collected
Start of pump (pull) test. Pump from 16-116	2016/10/07	9:46	16-116	-	0	22.5	-	-	-	-	-	Discharge from 16-116 quite foamy, no free oil observed
Monitoring of 16-102	2016/10/07	9:56	16-116	-	-	-	-	16-116	-	350	11.2	-
Continued pumping (pull) test from 16-116	2016/10/07	9:59	16-116	-	311	-	-	-	-	-	-	Sample collected
Monitoring of 16-116	2016/10/07	10:05	16-116	-	-	-	-	16-116	-	260	10.6	-
Monitoring of 16-118	2016/10/07	10:05	16-116	-	-	-	-	16-118	-	151	8.9	-
Continued pumping (pull) test from 16-116	2016/10/07	10:21	16-116	-	731	-	-	-	-	-	-	Sample collected
Continued pumping (pull) test from 16-116	2016/10/07	10:36	16-116	-	1056	23.1	-	-	-	-	-	Sample collected
Monitoring of 16-116	2016/10/07	10:38	16-116	-	-	-	-	16-116	-	204	10.3	-
Continued pumping (pull) test from 16-116	2016/10/07	11:07	16-116	-	1698	-	-	-	-	-	-	Sample collected
Monitoring of 16-116	2016/10/07	11:23	16-116	-	-	-	-	16-116	-	195	10.3	-
Monitoring of 16-116	2016/10/07	11:36	16-116	-	-	-	-	16-116	-	199	8.98	pH on other meter was 10.39
Monitoring of 16-118	2016/10/07	11:45	16-116	-	-	-	-	16-118	-	137	8.9	-
Continued pumping (pull) test from 16-116	2016/10/07	11:47	16-116	-	2611	23.3	-	-	-	-	-	Foam evident in pumped water - no free oil evident
Monitoring of 16-102	2016/10/07	11:52	16-116	-	-	-	-	16-102	-	148	8.75	pH on other meter was 10.36. Bubbles in water
Continued pumping (pull) test from 16-116	2016/10/07	12:15	16-116	-	3123	-	-	-	-	-	-	Sample collected
Continued pumping (pull) test from 16-116	2016/10/07	12:54	16-116	-	4036	23.1	-	-	-	-	-	Suds still evident in pumped water
Monitoring of 16-116	2016/10/07	12:57	16-116	-	-	-	-	16-116	-	166	9	-
Monitoring of 16-116	2016/10/07	13:32	16-116	-	-	-	-	16-116	-	162	9.1	-
Monitoring of 16-118	2016/10/07	13:35	16-116	-	-	-	-	16-118	-	137	8.78	-
Monitoring of 16-102	2016/10/07	13:37	16-116	-	-	-	-	16-102	-	144	8.78	-
Continued pumping (pull) test from 16-116	2016/10/07	13:46	16-116	-	4961	-	-	-	-	-	-	Suds still evident in pumped water, sample collected
Ended pumping (pull) test from 16-116	2016/10/07	13:49	16-116	-	5253	-	-	-	-	-	-	Push test ended
Energetics pumped out open top tank	2016/10/08	7:55	-	-	-	-	-	-	-	-	-	Approximately 6.5 m^3 removed from tank.

Table 5: Muncho Lake Maintenance Camp – Summary of Analytical Results for Groundwater – Surfactant Application

Sample Location	Sample ID	Sample Date (yyyy mm dd)	Monocyclic Aromatic Hydrocarbons					Gross Parameters		Petroleum Hydrocarbon Fractions				MTBE
			Benzene µg/L	Ethylbenzene µg/L	Toluene µg/L	Xylenes µg/L	Styrene µg/L	VH (C6-C10) µg/L	VPH (C6-C10) µg/L	F1- µg/L	F2 (>C10-C16) µg/L	F3 (>C16-C34) µg/L	F4 (>C34-C50) µg/L	MTBE µg/L
MW16-102	MW16-102-161007-1	2016 10 07	< 0.40	< 0.40	< 0.40	1.4	< 0.40	< 300	< 300	< 300	***2,000***	< 200	< 200	< 4.0
MW16-116	MW16-116-161006INITIAL	2016 10 06	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 300	< 300	< 300	< 150	< 200	< 200	< 4.0
	MW16-116-161007-1	2016 10 07	< 0.40	< 0.40	0.44	6.2	< 0.40	340	330	330	***8,700***	550	< 200	< 4.0
	MW16-116-161007-2	2016 10 07	< 0.40	< 0.40	< 0.40	5.1	< 0.40	< 300	< 300	< 300	***7,900***	1,000	< 200	< 4.0
	MW16-116-161007-3	2016 10 07	< 0.40	< 0.40	< 0.40	3.6	< 0.40	< 300	< 300	< 300	***5,000***	610	< 200	< 4.0
	MW16-116-161007-4	2016 10 07	< 0.40	< 0.40	< 0.40	2.8	< 0.40	< 300	< 300	< 300	***3,300***	210	< 200	< 4.0
	MW16-116-161007-5	2016 10 07	< 0.40	< 0.40	< 0.40	1.4	< 0.40	< 300	< 300	< 300	***2,100***	< 200	< 200	< 4.0
Federal Guideline														
Canadian Drinking Water Quality Guidelines (CDWQG)			5	1.6	24	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	15
FGQG Tier 2 Residential Land Use (RL)[a]			140	16,000	83	3,900	72	n/a	n/a	810	1,300	n/a	n/a	340
BC Standard														
CSR Drinking Water (DW)			5	2.4	24	300	n/a	15,000[c]	n/a	n/a	n/a	n/a	n/a	15
CSR Aquatic Life (AW)[b]			4,000	2,000	390	n/a	720	15,000[c]	1,500	n/a	n/a	n/a	n/a	34,000

Associated Maxxam file(s): B690914.

All terms defined within the body of SNC-Lavalin's report.

< Denotes concentration less than indicated detection limit or RPD less than indicated value.

- Denotes analysis not conducted.

n/a Denotes no applicable standard/guideline.

RPD Denotes relative percent difference.

* RPDs are not calculated where one or more concentrations are less than five times RDL.

RDL Denotes reported detection limit.

SHADED Concentration greater than Canadian Drinking Water Quality Guidelines (CDWQG) Guideline

BOLD Concentration greater than FGQG Tier 2 Residential Land Use (RL) Guideline

OUTLINE Concentration greater than CSR Drinking Water (DW) standard

SHADOW Concentration greater than CSR Aquatic Life (AW) standard

[a] Pathways Included: Freshwater Aquatic Life - Coarse, Inhalation - Coarse, Soil Organisms Direct Contact - Coarse (whichever is most stringent).

[b] Standard to protect freshwater aquatic life.

[c] Applicable at all sites irrespective of water use.

Table 6: Fireside Maintenance Camp - Hydrogen Peroxide Injection Results

Activity	Date	Time	Injection Location	Injection Concentration (%m/m)	Injection Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Depth to Water (m)	Temperature (Deg C)	Specific Conductance (mS/cm^{C})	Conductivity (mS/cm)	TDS (g/L)	Salinity	Dissolved Oxygen (% Saturation)	Dissolved Oxygen (mg/L)	pH	ORP	Observations/Notes
IP 1 start of advancement	2016/10/09	8:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.25" injection rod used (MC5 system). Injection rod driven to 29.3 m - raised to 29 m.
Pre-injection monitoring (baseline)	2016/10/09	9:40	-	-	-	-	-	13-03	29.02	3.45	1.262	0.742	0.821	0.63	4.4	0.57	7.42	-22	Probe set at depth of ~30 m.
Injection of 11.5% H2O2 at IP1 commenced	2016/10/09	9:40	IP1	~11.5%	0	22.6	18	-		-	-	-	-	-	-	-	-	-	-
Monitoring at 13-03	2016/10/09	9:47	IP1	~11.5%	-	-	-	13-03	-	3.43	1.261	0.741	0.819	0.63	1.4	0.18	7.43	-5.9	-
Monitoring at 13-03	2016/10/09	9:57	IP1	~11.5%	-	-	-	13-03	-	3.43	1.26	0.741	0.819	0.63	1	0.14	7.42	5	-
Injection of 11.5% H2O2 at IP1	2016/10/09	10:00	IP1	~11.5%	340	18	24	-	-	-	-	-	-	-	-	-	-	-	Some bypass noted at ground surface. Tightened rods but limited flow still noted.
IP2 advancement start	2016/10/09	10:04	IP1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monitoring at 13-03, Injection of 11.5% H2O2 at IP1	2016/10/09	10:25	IP1	~11.5%	782	15.5	38	13-03	-	3.43	1.258	0.74	0.818	0.62	0.6	0.08	7.4	12.4	-
IP2 advancement end	2016/10/09	10:28	IP1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.25" injection rod used (MC5 system). Injection rod driven to 29 m
Monitoring at 13-03, Injection of 11.5% H2O2 at IP1	2016/10/09	11:10	IP1	~11.5%	1451	15.1	-	13-03	-	3.43	-	0.738	-	-	-	0.05	7.39	23.7	Bypass continued to be noted
Monitoring at 13-03, Injection of 11.5% H2O2 at IP1	2016/10/09	12:14	IP1	~11.5%	2266	14.2	38	13-03	-	3.43	1.253	0.737	0.814	0.62	0.4	0.05	7.39	21	Bypass continued to be noted
Monitoring at 13-03, Injection of 11.5% H2O2 at IP1	2016/10/09	13:32	IP1	~11.5%	2824	13.4	23	13-03	-	3.43	1.251	0.736	0.813	0.62	0.3	0.04	7.39	12.8	Bypass continued to be noted
Injection of 11.5% H2O2 at IP1 ended	2016/10/09	14:00	IP1	~11.5%	3333	-	-	-	-	-	-	-	-	-	-	-	-	-	End of peroxide injection at IP1
Monitoring at 13-03	2016/10/09	14:21	-	-	-	-	-	13-03	-	3.43	1.241	0.73	0.807	0.62	2.8	0.37	7.42	55.7	-
Monitoring at 13-03	2016/10/09	15:17	-	-	-	-	-	13-03	-	3.44	0.661	0.389	0.436	0.32	3.6	0.47	7.42	81.8	-
IP2 depth adjustment	2016/10/10	9:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.25" injection rod used (MC5 system). Injection rod driven to 29.3 and - raised to 29 m.
Injection of 200 L VTX at IP2 commenced	2016/10/10	9:45	IP2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200 L of VTX solution (160 L water mixed with 40 L VTX) injected using submersible pump pumping from bucket
Injection of 11.5% H2O2 at IP2 commenced	2016/10/10	10:50	IP2	~11.5%	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monitoring at 13-03	2016/10/10	11:08	IP2	-	-	-	-	13-03	-	3.48	-	0.723	-	-	-	0.14	7.46	102.9	-
Injection of 11.5% H2O2 at IP2	2016/10/10	11:28	IP2	~11.5%	608	26.2	8	-	-	-	-	-	-	-	-	-	-	-	No bypass noted
Monitoring at 13-03	2016/10/10	11:38	IP2	-	-	-	-	13-03	-	3.46	-	0.726	-	-	-	0.11	7.46	106.1	-
Monitoring at 13-03	2016/10/10	12:18	IP2	-	-	-	-	13-03	-	3.48	-	0.717	-	-	-	0.13	7.45	111.2	-
Monitoring at 13-03	2016/10/10	12:45	IP2	-	-	-	-	13-03	-	3.48	-	0.71	-	-	-	0.15	7.46	113.7	-
Injection of 11.5% H2O2 at IP2 ended	2016/10/10	15:00	IP2	~11.5%	3485	26.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Monitoring at 13-03	2016/10/10	15:15	-	-	-	-	-	13-03	-	3.53	-	0.703	-	-	-	21.3	7.14	143.1	DO probe reconditioned and recalibrated after readings were noted to out of the expected range and after the sensor when calibrated was noted to be out of range.
Monitoring at 13-03	2016/10/10	15:41	-	-	-	-	-	13-03	-	3.48	-	0.696	-	-	-	19.73	7.21	141.4	-
Monitoring at 13-03	2016/10/10	16:12	-	-	-	-	-	13-03	-	3.48	-	0.694	-	-	-	20.34	7.21	142.6	-
Monitoring at 13-03	2016/10/10	16:54	-	-	-	-	-	13-03	-	3.48	-	0.695	-	-	-	20.6	7.21	144.8	-
IP3 advancement	2016/10/11	9:15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.25" injection rod used (MC5 system). Injection rod driven to 29.3 and - raised to 29 m.
Injection of 20% H2O2 at IP3 commenced	2016/10/11	9:35	IP3	~20%	0	18.4	24	-	-	-	-	-	-	-	-	-	-	-	-
Injection of 20% H2O2 at IP3	2016/10/11	9:52	IP3	~20%	408	18.6	18	-	-	-	-	-	-	-	-	-	-	-	-
Monitoring at 13-03	2016/10/11	10:07	IP3	-	-	-	-	13-03	-	3.54	-	0.72	-	-	-	12.36	7.26	104	-
Monitoring at 13-03	2016/10/11	10:54	IP3	-	-	-	-	13-03	-	3.54	-	0.717	-	-	-	17.34	7.22	111.1	-
Injection of 20% H2O2 at IP3 ended	2016/10/11	11:16	IP3	~20%	1798	-	-	-	-	-	-	-	-	-	-	-	-	-	Injection ended - limited bypass noted towards end of injection
Monitoring at 13-03	2016/10/11	11:37	-	-	-	-	-	13-03	-	3.54	-	0.707	-	-	-	19.27	7.21	118.3	-
Monitoring at 13-03	2016/10/11	13:02	-	-	-	-	-	13-03	-	3.55	-	0.689	-	-	-	16.33	7.22	126.3	-
Monitoring at 13-03	2016/10/11	14:10	-	-	-	-	-	13-03	-	7.87	-	0.768	-	-	-	19.91	7.24	143.3	-
Monitoring at 13-03	2016/10/11	14:15	-	-	-	-	-	13-03	-	8.55	-	0.78	-	-	-	19.94	7.24	143.1	-
Monitoring at 13-03	2016/10/11	14:45	-	-	-	-	-	13-03	-	12.63	-	0.895	-	-	-	19.23	7.22	139.8	-
Monitoring at 13-03	2016/10/11	15:45	-	-	-	-	-	13-03	-	9.29	-	0.818	-	-	-	22.96	7.25	143.3	-
Monitoring at 13-03	2016/10/11	16:10	-	-	-	-	-	13-03	-	7.47	-	0.768	-	-	-	25.46	7.25	146.3	-
Monitoring at 13-03	2016/10/11	16:25	-	-	-	-	-	13-03	-	6.64	-	0.745	-	-	-	25.46	7.25	148.4	-
Monitoring at 13-03	2016/10/12	11:03	-	-	-	-	-	13-03	-	3.71	-	0.715	-	-	-	15.61	7.28	97.5	-
Monitoring at 13-03	2016/10/13	11:43	-	-	-	-	-	13-03	-	3.81	-	0.713	-	-	-	11.13	7.28	103.9	-

Table 7: Fireside Maintenance Camp – Pump Test Results

Activity	Date	Time	Test Time (s)	Test Time (min)	Pumping Location	Pump Rate (GPM)	Pump Rate (L/min)	Pumped Volume (G)	Pumped Volume (L)	Monitoring Location	Depth to Water (m)	Drawdown (m)	Observations/Notes
Monitoring Static Conditions	2016/10/09	11:40	-	-	-	-	-	-	-	MW 13-06	31.855	-	Pump well MW 13-06
Monitoring Static Conditions	2016/10/09	11:33	-	-	-	-	-	-	-	MW 14-10	32.41	-	Deep observation well MW 14-10. Logger G1875 deployed at 11:31 at approximately 33.5 m depth.
Monitoring Static Conditions	2016/10/09	11:20	-	-	-	-	-	-	-	MW 16-38	31.646	-	Shallow observation well MW 16-38. Logger C8737 deployed at 10:57 at approximately 32.5 m depth.
Pump Test	2016/10/09	11:43	0	0	MW 13-06	4.5	17.03	-	-	-	-	-	Beginning of pump test
Pump Test	2016/10/09	11:54	670	11.17	MW 13-06	4.5	17.03	50.25	190.20	MW 13-06	33.259	1.404	-
Pump Test	2016/10/09	11:55	735	12.25	MW 13-06	4.73	17.90	55.37	209.59	MW 13-06	33.265	1.41	-
Pump Test	2016/10/09	11:57	810	13.5	MW 13-06	4.73	17.90	61.29	231.97	MW 13-06	33.282	1.427	-
Pump Test	2016/10/09	12:04	1260	21	MW 13-06	4.75	17.98	96.91	366.81	MW 13-06	33.315	1.46	-
Pump Test	2016/10/09	12:07	1425	23.75	MW 13-06	4.75	17.98	109.97	416.25	MW 16-38	31.725	0.079	-
Pump Test	2016/10/09	12:11	1620	27	MW 13-06	4.75	17.98	125.41	474.68	MW 14-10	32.419	0.009	-
Pump Test	2016/10/09	12:13	1800	30	MW 13-06	0	0	139.66	528.62	-	-	-	Pump sputtered and shut off
Pump Test	2016/10/09	12:15	1920	32	MW 13-06	4.39	16.62	148.44	561.85	-	-	-	Pump re-started
Pump Test	2016/10/09	12:22	2340	39	MW 13-06	4.39	16.62	179.17	678.16	MW 13-06	33.155	1.3	-
Pump Test	2016/10/09	12:33	3000	50	MW 13-06	4.39	16.62	227.46	860.94	MW 13-06	33.2	1.345	-
Pump Test	2016/10/09	12:43	3540	59	MW 13-06	4.42	16.73	267.24	1011.51	MW 13-06	33.217	1.362	-
Pump Test	2016/10/09	13:16	5580	93	MW 13-06	4.42	16.73	417.52	1580.32	MW 13-06	33.273	1.418	-
Pump Test	2016/10/09	13:32	5940	99	MW 13-06	4.42	16.73	444.04	1680.70	MW 13-06	33.31	1.455	-
Pump Test	2016/10/09	13:42	7140	119	MW 13-06	4.39	16.62	531.84	2013.02	MW 13-06	33.3	1.445	-
Pump Test	2016/10/09	13:45	7320	122	MW 13-06	4.39	16.62	545.01	2062.87	MW 13-06	33.3	1.445	-
Pump Test	2016/10/09	13:49	7560	126	MW 13-06	4.39	16.62	562.57	2129.33	MW 16-38	31.765	0.119	Steady state in PW
Pump Test	2016/10/09	13:52	7740	129	MW 13-06	4.39	16.62	575.74	2179.18	MW 14-10	32.419	0.009	Steady state in PW
Pump Test	2016/10/09	13:54	7800	130	MW 13-06	4.39	16.62	580.13	2195.80	MW 13-06	33.3	1.445	Steady state in PW
Pump Test	2016/10/09	13:54	7800	130	MW 13-06	0	0	580.13	2195.80	-	-	-	End of pump test/start of recovery test
Recovery Test	2016/10/09	14:02	8265	137.75	MW 13-06	0	0	580.13	2195.80	MW 13-06	31.999	0.144	-
Recovery Test	2016/10/09	14:03	8301	138.35	MW 13-06	0	0	580.13	2195.80	MW 13-06	31.997	0.142	-
Recovery Test	2016/10/09	14:05	8520	142	MW 13-06	0	0	580.13	2195.80	MW 16-38	31.71	0.064	-
Recovery Test	2016/10/09	15:42	14340	239	MW 13-06	0	0	580.13	2195.80	MW 16-38	31.666	0.02	-
Recovery Test	2016/10/09	15:47	14640	244	MW 13-06	0	0	580.13	2195.80	MW 14-10	32.413	0.003	-

Table 8: Fireside Maintenance Camp - Surfactant Application Results

Activity	Date	Time	Injection/ Pumping Location	Injection Concentration	Injection/ Pumped Volume (L)	Injection Flowrate (L/min)	Injection Pressure (PSI)	Monitoring Location	Depth to Water (m)	Conductivity (mS/cm)	Temperature (Deg C)	pH	Observations/Notes
Mixing and injection of Iveysol 106 and water - Batch 1 Start	2016/10/10	15:45	16-38	~1000 L H_2O: 20 L Iveysol 106	0	6	~30	-	-	-	-	-	Surfactant batch mixed in accordance with Iveysol's recommendation (1 x 20 L pail with 1,000 L H_2O).
Mixing and injection of Iveysol 106 and water - Batch 1 Ended	2016/10/10	18:20	16-38	~1000 L H_2O: 20 L Iveysol 106	1081	8	~30	-	-	-	-	-	Injection into 16-38 noted to require relatively high pressure to achieve flow (30 psi for 6-8 L/min)
Pump (pull) test from 13-06 commenced	2016/10/11	9:44	13-06	-	0	16.2	-	-	-	-	-	-	Pumping reduced to 14.1 then increased to 15.9 within 5 minutes after start. Initial water appeared clear and had bubbles and slight surfactant odor when pumped
Pump (pull) test from 13-06	2016/10/11	9:49	13-06	-	-	-	-	13-06	-	-	-	-	High miniscus observed on waterproof paper as per Iveysol recommendation for monitoring for the presence of Iveysol. High miniscus suggests low surfactant concentration
Pump (pull) test from 13-06	2016/10/11	9:53	13-06	-	254	15.9	-	13-06	-	-	-	-	1st sample collected. High miniscus observed.
Pump (pull) test from 13-06	2016/10/11	10:05	13-06	-	462	15.9	-	13-06	-	1.3	3.9	7.42	High miniscus observed.
Pump (pull) test from 13-06	2016/10/11	10:30	13-06	-	-	-	-	13-06	-	1.3	4.6	7.26	High miniscus observed.
Pump (pull) test from 13-06	2016/10/11	10:38	13-06	-	-	-	-	13-06	-	-	-	-	2nd sample collected.
Pump (pull) test from 13-06	2016/10/11	10:47	13-06	-	-	-	-	13-06	-	-	-	-	High miniscus observed. Suds observed in pumped groundwater
Pump (pull) test from 13-06	2016/10/11	11:30	13-06	-	1838	15.9	-	13-06	-	-	-	-	High miniscus observed. Suds observed in pumped groundwater
Pump (pull) test from 13-06	2016/10/11	11:44	13-06	-	-	-	-	13-06	-	-	-	-	3rd sample collected. Sample included 1 L plastic bottle for surfactant analysis
Pump (pull) test from 13-06	2016/10/11	12:03	13-06	-	-	-	-	13-06	-	-	-	-	High miniscus observed.
Pump (pull) test from 13-06	2016/10/11	12:40	13-06	-	-	-	-	16-38	-	-	-	-	Sample collected form 16-38. Sample had suds and high miniscus observed.
Pump (pull) test from 13-06	2016/10/11	12:50	13-06	-	-	-	-	13-06	-	-	-	-	4th sample collected.
Pump (pull) test from 13-06 ended	2016/10/11	14:38	13-06	-	4798	-	-	13-06	-	-	-	-	5th sample collected. Less suds observed in pumped water. High miniscus observed.
Energetics pumped out open top tank	2016/10/11	16:00	-	-	-	-	-	-	-	-	-	-	Approximately 7 m^3 removed from tank.

Table 9: Fireside Maintenance Camp - Summary of Analytical Results for Groundwater - Surfactant Application

Sample Location	Sample ID	Sample Date (yyyy mm dd)	Monocyclic Aromatic Hydrocarbons					Gross Parameters		Petroleum Hydrocarbon Fractions				MTBE	MBAS
			Benzene µg/L	Ethylbenzen µg/L	Toluene µg/L	Xylenes µg/L	Styrene µg/L	VH (C6-C10) µg/L	VPH (C6-C10) µg/L	F1- µg/L	F2 (>C10-C16) µg/L	F3 (>C16-C34) µg/L	F4 (>C34-C50) µg/L	MTBE µg/L	MBAS[d] µg/L
BH13-06	MW13-06-161009	2016 10 09	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 300	< 300	< 300	630	< 200	< 200	< 4.0	-
	MW13-06-161011-1	2016 10 11	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 300	< 300	< 300	830	< 200	< 200	< 4.0	-
	MW13-06-161011-2	2016 10 11	< 0.40	< 0.40	< 0.40	0.47	< 0.40	< 300	< 300	< 300	710	< 200	< 200	< 4.0	-
	MW13-06-161011-3	2016 10 11	< 0.40	< 0.40	< 0.40	2.2	< 0.40	< 300	< 300	< 300	670	< 200	< 200	< 4.0	< 50
	MW13-06-161011-4	2016 10 11	< 0.40	< 0.40	< 0.40	2.1	< 0.40	< 300	< 300	< 300	700	< 200	< 200	< 4.0	-
	MW13-06-161011-5	2016 10 11	< 0.40	< 0.40	< 0.40	0.53	< 0.40	< 300	< 300	< 300	860	< 200	< 200	< 4.0	-
	MW13-06-161121	2016 11 21	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 300	< 300	< 300	730	250	< 200	< 4.0	-
IW16-38	MW16-38-161011	2016 10 11	0.40	**2.1**	1.9	**50**	< 0.40	1,500	1,400	***1,500***	***2,300***	600	< 200	< 4.0	-
	MW16-38-161027/28	2016 10 27/28	< 0.40	0.96	1.1	**27**	< 0.40	670	640	670	***3,200***	1,500	< 200	< 4.0	
Federal Guideline															
Canadian Drinking Water Quality Guidelines (CDWQG)			5	1.6	24	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	15	n/a
FGQG Tier 2 Residential Land Use (RL)[a]			140	16,000	83	3,900	72	n/a	n/a	810	1,300	n/a	n/a	340	n/a
BC Standard															
CSR Drinking Water (DW)			5	2.4	24	300	n/a	15,000[c]	n/a	n/a	n/a	n/a	n/a	15	n/a
CSR Aquatic Life (AW)[b]			4,000	2,000	390	n/a	720	15,000[c]	1,500	n/a	n/a	n/a	n/a	34,000	n/a

Associated Maxxam file(s): B690897, B696711, B6A5716.

All terms defined within the body of SNC-Lavalin's report.

< Denotes concentration less than indicated detection limit or RPD less than indicated value.

- Denotes analysis not conducted.

n/a Denotes no applicable standard/guideline.

RPD Denotes relative percent difference.

* RPDs are not calculated where one or more concentrations are less than five times RDL.

RDL Denotes reported detection limit.

SHADED Concentration greater than Canadian Drinking Water Quality Guidelines (CDWQG) Guideline

BOLD Concentration greater than FGQG Tier 2 Residential Land Use (RL) Guideline

OUTLINE Concentration greater than CSR Drinking Water (DW) standard

SHADOW Concentration greater than CSR Aquatic Life (AW) standard

[a] Pathways Included: Freshwater Aquatic Life - Coarse, Inhalation - Coarse, Soil Organisms Direct Contact - Coarse (whichever is most stringent).

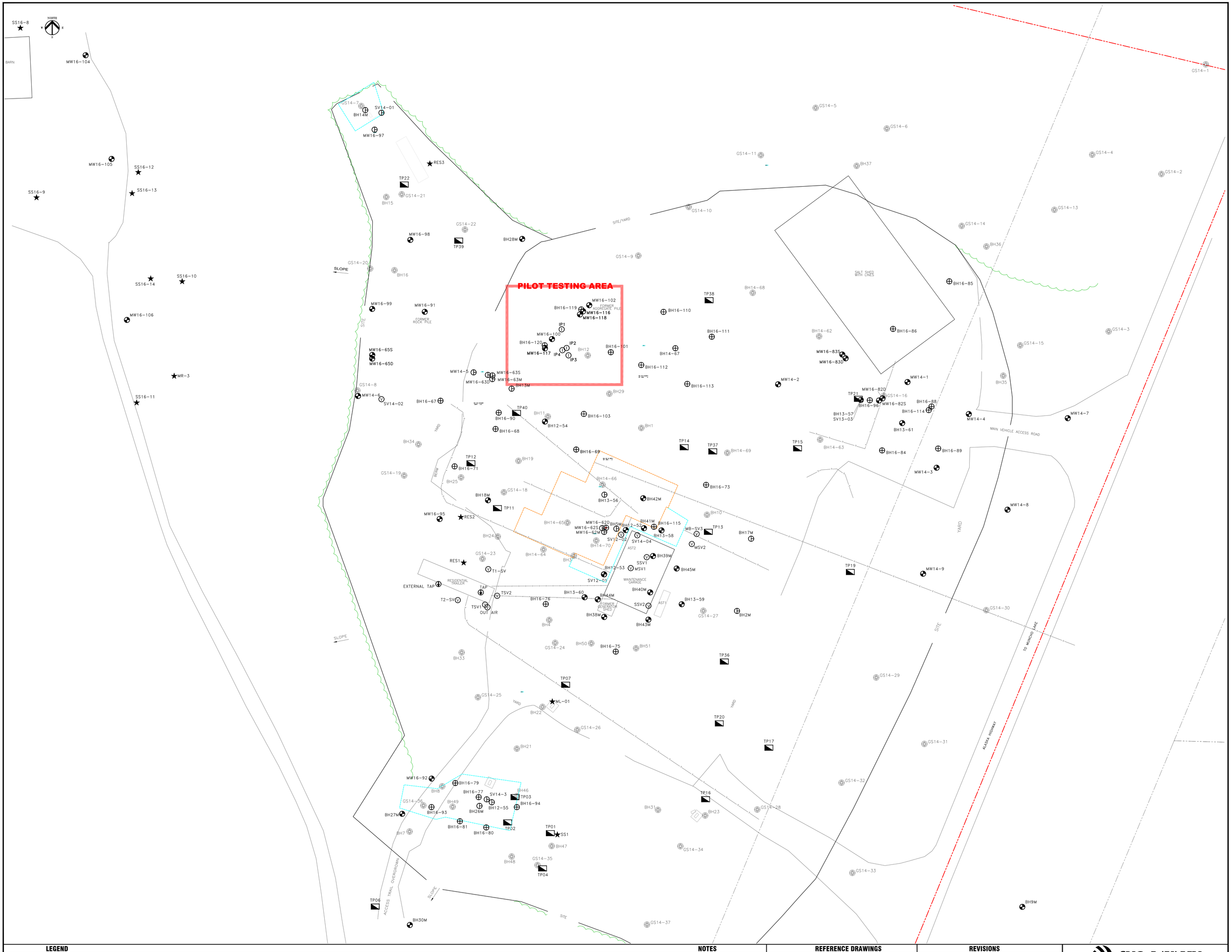
[b] Standard to protect freshwater aquatic life.

[c] Applicable at all sites irrespective of water use.

[d] Methylene Blue Active Surfactants.

Drawings

- 635031-801 – Site Plan – Muncho Lake
- 635031-802 – Site Plan – Muncho Lake Pilot Testing
- 636200-501 – Site Plan – Fireside
- 636200-502 – Site Plan – Fireside Pilot Testing



LEGEND

- SUBJECT PROPERTY LIMITS
- LOT LINE
- COMMUNICATIONS LINE
- ELECTRICAL LINE
- UNKNOWN UTILITY
- APPROXIMATE LIMITS OF 2003 EXCAVATION
- APPROXIMATE LIMITS OF 2004 EXCAVATION
- TREE LINE
- MONITORING WELL
- BOREHOLE
- BOREHOLE BY OTHERS
- DESTROYED MONITORING WELL
- SURFACE SAMPLE
- DRINKING WATER WELL OUTLET
- TEST PIT
- VAPOUR WELL
- INJECTION WELL
- FORMER AST

NOTES

1. ORIGINAL DRAWING IN COLOUR.
2. LOCATION OF EXISTING UTILITIES SHOWN ARE APPROXIMATE ONLY AND SHOULD BE CONFIRMED PRIOR TO INTRUSIVE WORK. NOT ALL UTILITIES MAY BE SHOWN.
3. TO BE PRINTED ON A 43"x36" SHEET SIZE. IF PRINTED ON A DIFFERENT SIZE SHEET, SCALE NUMBER WILL BE WRONG BUT SCALE BAR WILL REMAIN ACCURATE.

REFERENCE DRAWINGS

No.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
2	2017–05–19	ISSUED TO CLIENT	DM	FG
1	2017–02–08	ISSUED TO CLIENT AS DRAFT	BB	FG
0	2016–07–25	ISSUED TO CLIENT	AJK	BH

SNC·LAVALIN

CLIENT NAME: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

PROJECT LOCATION: MUNCHO LAKE ALASKA HIGHWAY, BC

TITLE: **SITE PLAN**

DWN BY: BB | SCALE: 1:300 | DATE: 2017–02–08 | DWG No: 63503 | REV.: 2

CHK'D: FG | PLOT: 20170519.1116 | 635031R1B_800_SERIES

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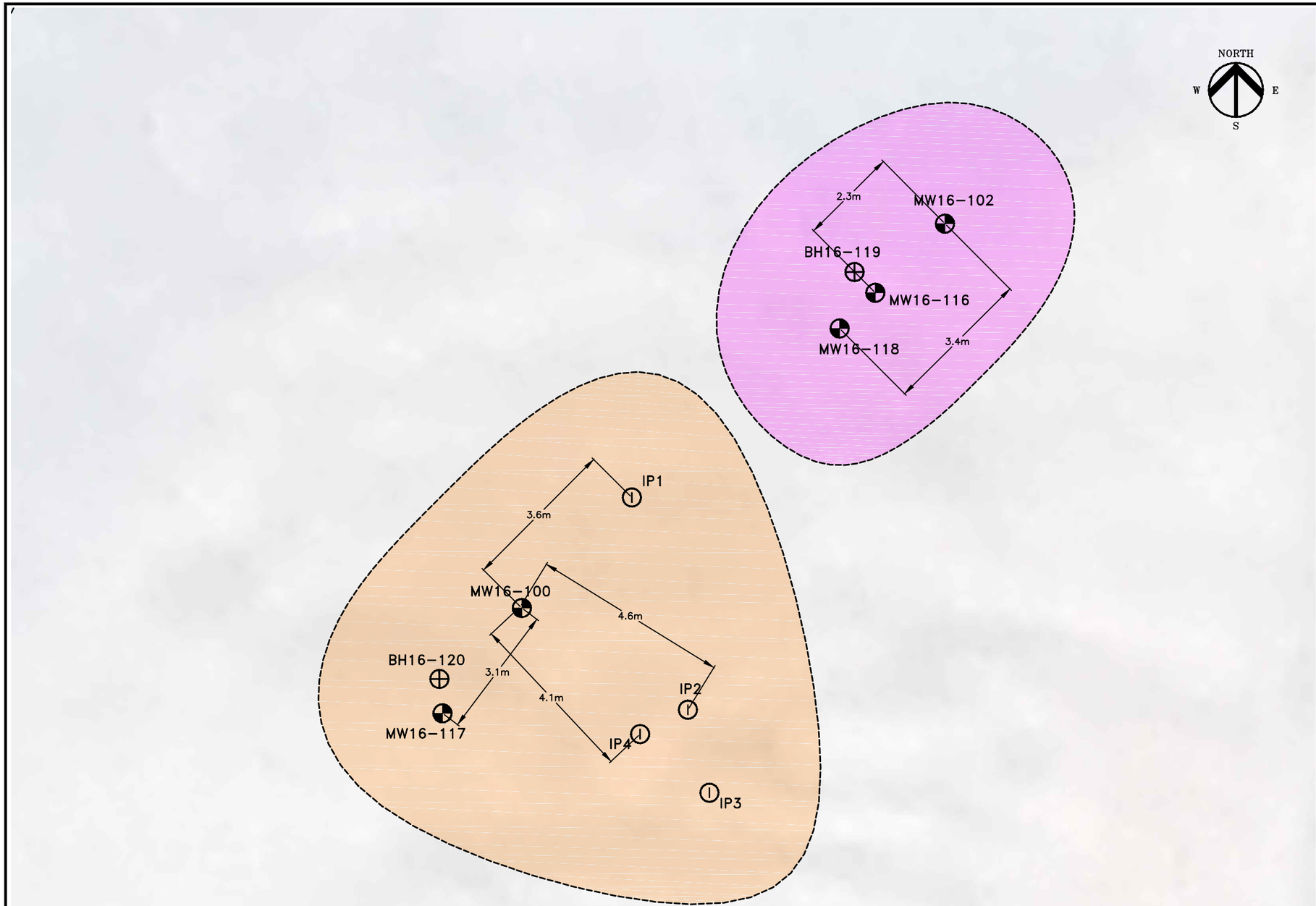


LEGEND

- MONITORING WELL
- BOREHOLE
- INJECTION POINT
- HYDROGEN PEROXIDE TEST AREA
- SURFACTANT TEST AREA

NOTES

1. ORIGINAL DRAWING IN COLOUR.
2. LOCATION OF EXISTING UTILITIES SHOWN ARE APPROXIMATE ONLY AND SHOULD BE CONFIRMED PRIOR TO INTRUSIVE WORK. NOT ALL UTILITIES MAY BE SHOWN.

REFERENCE DRAWINGS

DWG. NO.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
2	2017–05–19	ISSUED TO CLIENT	DM	FG
1	2017–02–08	ISSUED TO CLIENT AS DRAFT	BB	FG
0	2016 12 01	ISSUED TO CLIENT AS DRAFT	BB	FG

0 1 2 3 4 5 METRES

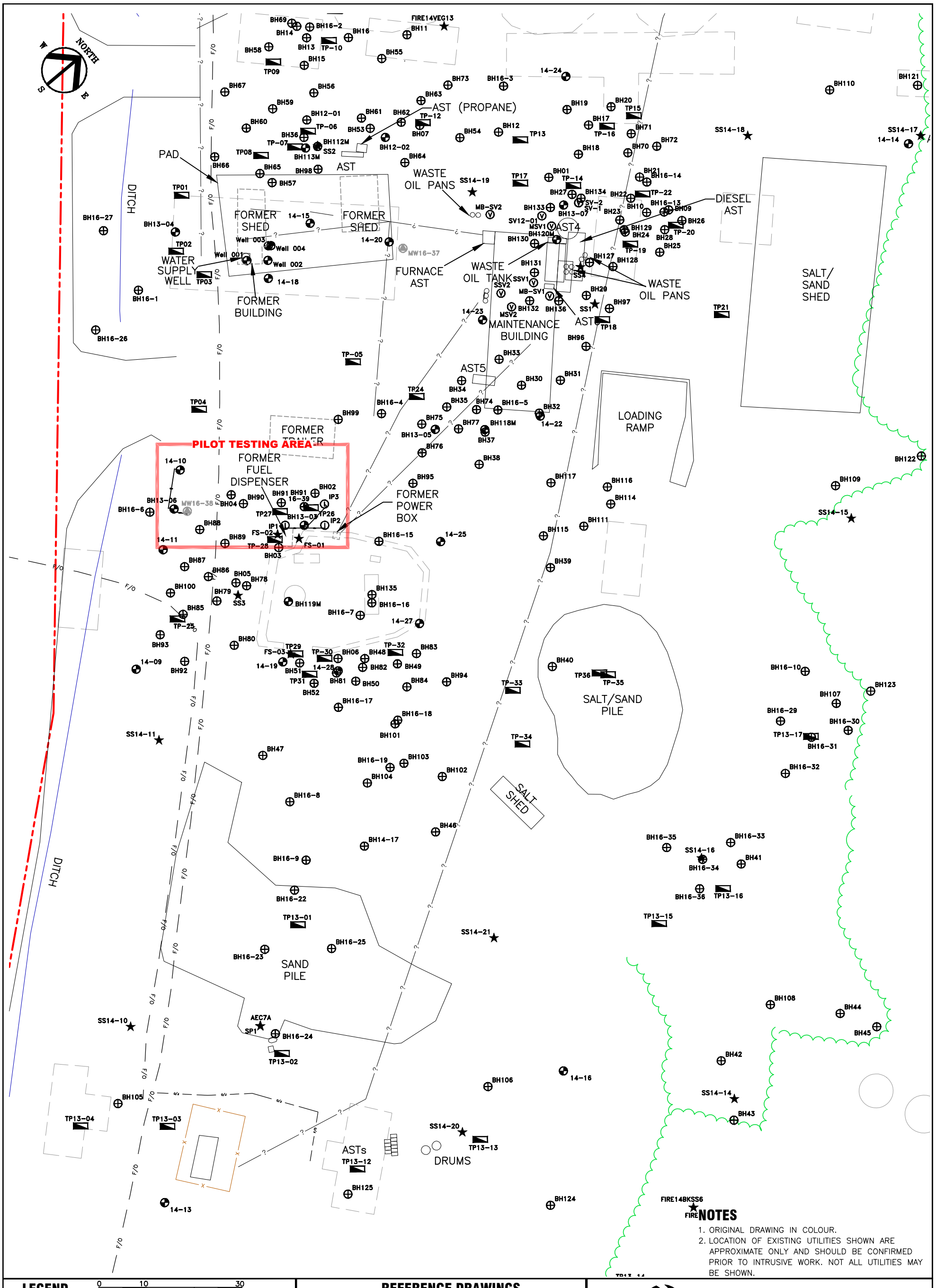
SNC·LAVALIN

CLIENT NAME: PUBLIC WORKS AND GOVERMENT SERVICES CANADA

PROJECT LOCATION: MUNCHO LAKE ALASKA HIGHWAY, BC

TITLE: **SITE PLAN - M□ NC□ O LA□ E PILOT TESTING**

DWN BY: BB	SCALE: 1:100	DATE: 2017–02–08	SERIES No:	REV.: 2
CHK'D: FG	PLOT: 20170519.1106	635031R18_800_SERIES	63503□-□02	



NOTES

1. ORIGINAL DRAWING IN COLOUR.
2. LOCATION OF EXISTING UTILITIES SHOWN ARE APPROXIMATE ONLY AND SHOULD BE CONFIRMED PRIOR TO INTRUSIVE WORK. NOT ALL UTILITIES MAY BE SHOWN.

LEGEND

0 10 30 METRES

- SUBJECT PROPERTY LIMITS
- UNKNOWN UTILITY
- TREE LINE
- FENCE
- FIBRE OPTIC LINE
- FORMER SITE CONFIGURATION
- SITE FEATURE
- REMOVED FACILITIES
- MONITORING WELL
- SOIL VAPOUR WELL
- BOREHOLE
- TESTPIT
- SURFACE SAMPLE
- MONITORING WELL WITH INJECTION WELL CONSTRUCTION
- INJECTION POINT

REFERENCE DRAWINGS

DWG. NO.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
3	2017-05-19	ISSUED TO CLIENT	DM	FG
2	2017-02-08	ISSUED TO CLIENT AS DRAFT	BB	FG
1	2016-12-01	ISSUED TO CLIENT AS DRAFT	BB	FG
0	2016-07-15	INTERNAL REVIEW	DRB	MG

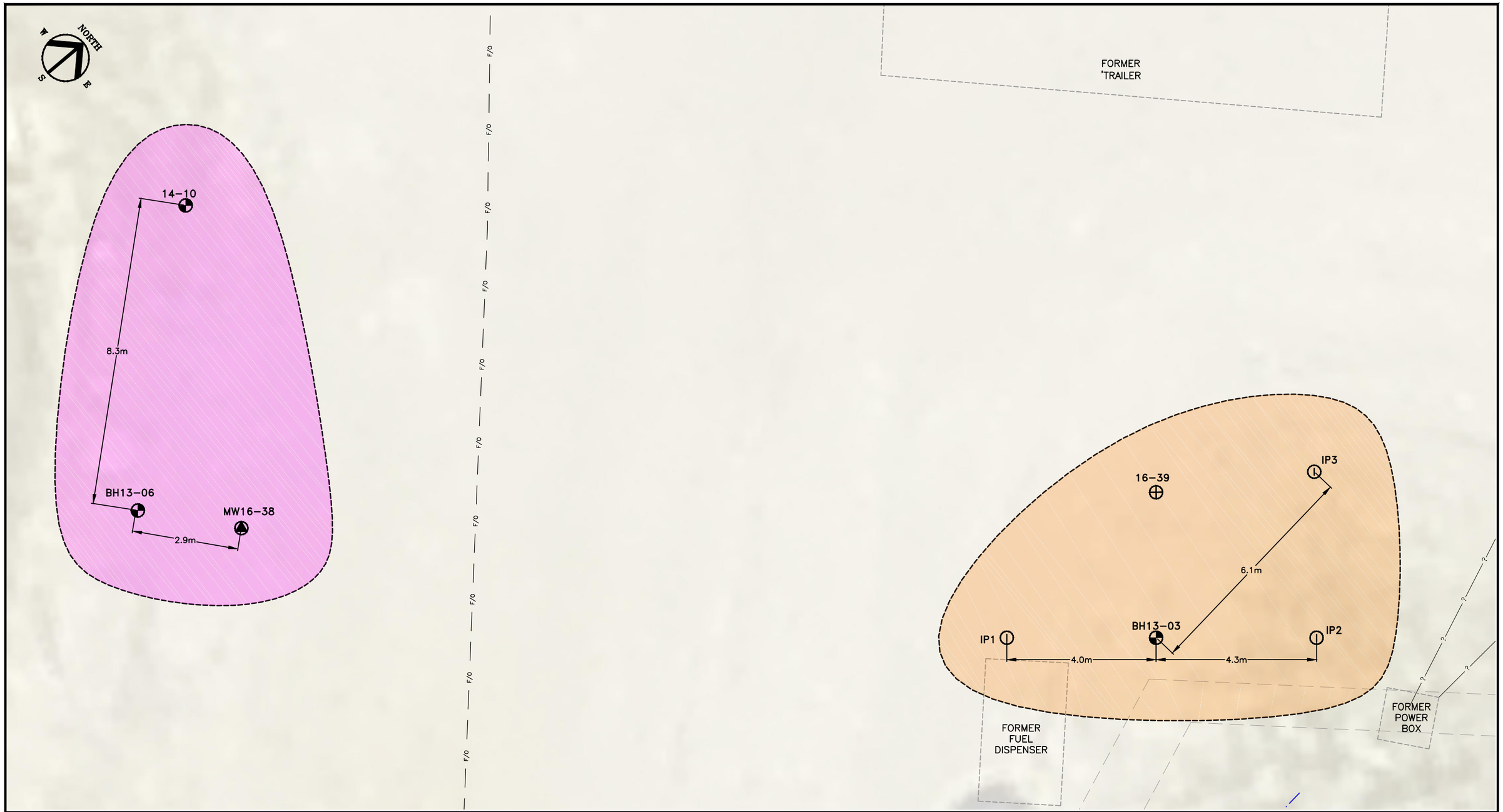
SNC·LAVALIN

CLIENT NAME: PUBLIC WORKS AND GOVERMENT SERVICES CANADA

PROJECT LOCATION: FIRESIDE MAINTENANCE CAMP ALASKA HIGHWAY, BC

TITLE: **SITE PLAN**

DWN BY: BB	SCALE: 1:750	DATE: 2017-02-08	DWG No:	REV.: 3
CHK'D: FG	PLOT: 20170519.1136	CADFILE: 636200R10	636200-50	



LEGEND

0 1 2 3 4 5 METRES

- FIBER OPTIC LINE
- UNKNOWN UTILITY
- FORMER SITE CONFIGURATION
- REMOVED FACILITIES
- MONITORING WELL
- MONITORING WELL WITH INJECTION WELL CONSTRUCTION
- INJECTION POINT
- BOREHOLE LOCATION
- HYDROGEN PEROXIDE TEST AREA
- SURFACTANT TEST AREA

NOTES

1. ORIGINAL DRAWING IN COLOUR.
2. LOCATION OF EXISTING UTILITIES SHOWN ARE APPROXIMATE ONLY AND SHOULD BE CONFIRMED PRIOR TO INTRUSIVE WORK. NOT ALL UTILITIES MAY BE SHOWN.

REFERENCE DRAWINGS

DWG. NO.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
3	2017–05–19	ISSUED TO CLIENT	DM	FG
2	2017–02–08	ISSUED TO CLIENT AS DRAFT	BB	FG
1	2016–12–01	ISSUED TO CLIENT AS DRAFT	BB	FG
0	2016–07–07	INTERNAL REVIEW	DRB	TM

SNC·LAVALIN

CLIENT NAME: PUBLIC WORKS AND GOVERMENT SERVICES CANADA

PROJECT LOCATION: FIRESIDE MAINTENANCE CAMP ALASKA HIGHWAY, BC

TITLE:

SITE PLAN - FIRESIDE MAINTENANCE CAMP PILOT TESTING

DWN BY: BB	SCALE: 1:100	DATE: 2017–02–08	DWG No: 636200-502 REV.: 3
CHK'D: FG	PLOT: 20170519.1143	CADFILE: 636200R10	

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Appendix I

Borehole Logs (Muncho Lake and Fireside Maintenance Camps)

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-116

PAGE 1 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	2016 10 04	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	FG/CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 03
Pipe/Slotted Pipe Dia. (m)	0.05/0.05	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend: Sample Interval; Direct Push

Water/NAPL Levels: Water Level 1; Water Level 2; NAPL; NAPL

Reading within indicated scale; Reading outside indicated scale

Soil Vapour (ppm)

Solid PVC; Slotted PVC

Well Name 1: MW16-116

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery
0	GRAVEL, some sand, trace silt, grey, damp.					80
	SAND, some gravel, trace silt, grey, damp.					
	SAND, fine grained, some gravel, trace silt, grey, dry.					
1	Below 0.8 m - brown.					
	SAND and GRAVEL, fine grained sand, fine and coarse gravel, subangular, grey/brown, dry.					80
2	SAND, fine grained, some gravel to gravelly, subangular, grey/brown, compact, dry. Between 2.1 m and 2.4 m - some pink gravel, some pink sand, fine grained.					
3	Below 3.0 m - trace cobbles.					80
4						
						80
5	Between 4.9 m and 5.2 m - medium to coarse grained sand, some gravel, brown, damp. Between 5.2 m and 5.3 m - grey/white. Between 5.3 m and 5.6 m - fine to coarse grained sand, some silt, brown, moist to wet. Below 5.6 m - trace silt, dry.					
6	Between 6.1 m and 6.7 m - fine to coarse grained sand, some silt, brown, red/orange staining, moist to wet.					70
	Below 6.7 m - gravelly.					
7	At 7.3 m - some pink colouration.					
	At 7.6 m - rock.					60
8	Below 7.9 m - grey/white.			**116-01**		0
	Below 8.5 m - fine to coarse grained sand, subangular to subrounded gravel, brown, moist.					
9	Below 9.1 m - well graded, wet.			**116-02**		0
						80
10	Between 9.7 m and 10.4 m - medium to coarse grained sand.			**116-03**		0

ROAD BOX; CONCRETE; SAND; BENTONITE; GROUT; BENTONITE

NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-116

PAGE 2 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	2016 10 04	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	FG/CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 03
Pipe/Slotted Pipe Dia. (m)	0.05/0.05	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push

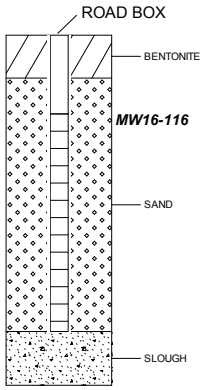
Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

Reading within indicated scale
Reading outside indicated scale

Solid PVC
Slotted PVC

Well Name 1: MW16-116

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm) 10^1 10^2 10^3 10^4
10	SAND, fine grained, some gravel to gravelly, subangular, grey/brown, compact, dry. *(continued)*						
11	Below 11.3 m - hydrocarbon-like odour, grey staining.			116-04		60	
12	Below 12.2 m - fine and coarse gravel, very loose, no odour.			116-05		90	
13	Bottom of hole at 13.0 m.						
14							
15							
16							
17							
18							
19							
20							



NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-117

PAGE 1 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 04
Pipe/Slotted Pipe Dia. (m)	0.05/0.05	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push

Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

Soil Description

Depth in Metres | Stratigraphy Plot | Sample Interval Core Run | Sample Number | Blow Count | % Recovery

Soil Vapour (ppm)
- ○ Reading within indicated scale
- ● Reading outside indicated scale

10^1 10^2 10^3 10^4

Solid PVC
Slotted PVC

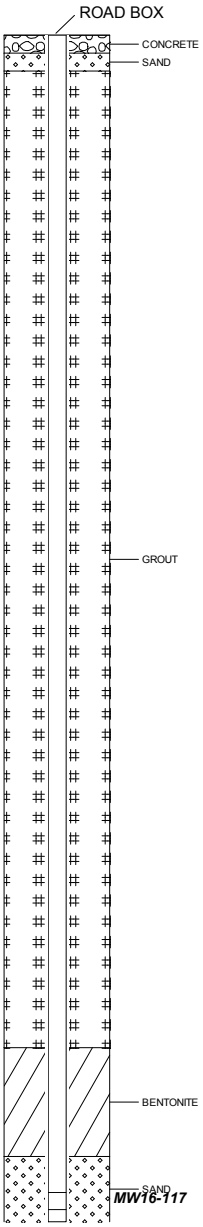
Well Name 1: MW16-117

Depth (m)	Soil Description
0	SAND, fine to coarse grained, gravelly, fine and coarse, subangular, grey/brown, compact, dry.
1	SILT, some gravel, fine and coarse, subangular, dark brown, hard, damp, organics (wood debris). Below 1.5 m - light brown, wet.
2	SAND, fine to coarse grained, some gravel, fine and coarse, subangular, trace cobbles, grey/brown, compact, dry.
3	Between 3.0 m and 3.4 m - fine grained sand, some silt, grey, loose.
4	SILT, trace sand, fine grained, brown, medium plasticity, wet.
	SAND, fine to coarse grained, gravelly, fine and coarse, subangular to subrounded, grey/brown, compact, dry.
5	Below 4.9 m - medium to coarse grained sand.
	SILT, some sand, fine grained, brown, no plasticity, moist.
	SAND, fine to coarse grained, some gravel to gravelly, fine and coarse, subangular to subrounded, grey/brown, compact, dry.
6	Between 6.1 m and 6.3 m - fine grained sand, some silt. At 6.2 m - rock, red. Below 6.2 m - medium to coarse grained sand.
7	SILT, some sand, fine grained, trace gravel, coarse, subangular, brown, low plasticity, wet.
	SAND, medium to coarse grained, some gravel, fine and coarse, subangular to subrounded, trace to some silt, brown, moist. Below 7.3 m - dry.
8	ROCK.
	SAND, fine to coarse grained, some gravel, subangular to subrounded, trace to some silt, trace cobbles, brown, compact, dry. Below 7.9 m - orange staining, damp to moist.
9	Below 8.4 m - wet.
	SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subangular to subrounded, brown, wet, hydrocarbon-like odour.
10	

Sample Number: 117-01

Blow Count: 80

% Recovery: 0



NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-117

PAGE 2 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 04
Pipe/Slotted Pipe Dia. (m)	0.05/0.05	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
Sample Interval
Direct Push

Water/NAPL Levels
Water Level 1
Water Level 2
NAPL
NAPL

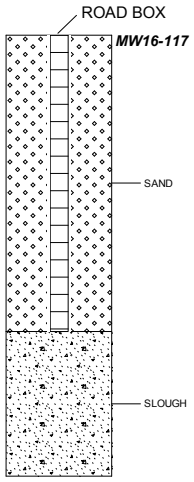
Reading within indicated scale
Reading outside indicated scale

Solid PVC
Slotted PVC

Well Name 1: MW16-117

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm)
10	SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subangular to subrounded, brown, wet, hydrocarbon-like odour. *(continued)*			117-02			0
	Below 10.1 m - grey hydrocarbon-like staining.					20	
11	SAND, fine to medium grained, dark grey, very loose, hydrocarbon-like odour.			117-03			0
	GRAVEL, fine and coarse, subangular to subrounded, some sand, fine to coarse grained, grey, very loose, hydrocarbon-like odour.						
12	SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subangular to subrounded, grey, hydrocarbon-like odour.			117-04		40	0
	Below 12.3 m - brown, no odour.						
13	Between 12.5 m and 12.8 m - silty.						
	Bottom of hole at 13.7 m.						
14							
15							
16							
17							
18							
19							
20							

10^1 10^2 10^3 10^4



NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-118

PAGE 1 OF 1

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 04
Pipe/Slotted Pipe Dia. (m)	0.05/0.05	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push

Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

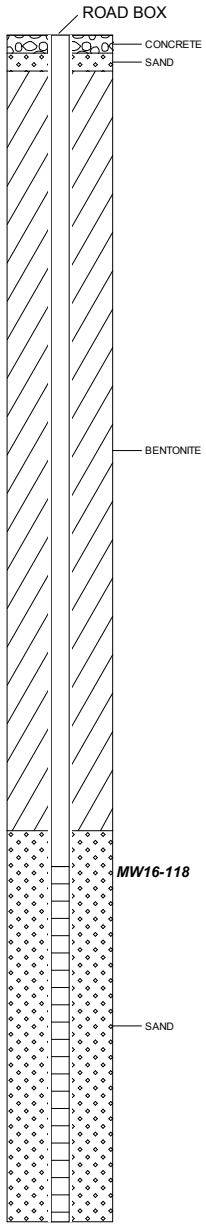
- ○ Reading within indicated scale
- ● Reading outside indicated scale

Soil Vapour (ppm)

- Solid PVC
- Slotted PVC

Well Name 1: MW16-118

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm) 10^1 10^2 10^3 10^4
0	GRAVEL, some sand, trace silt, grey, damp.						
	SAND, some gravel, trace silt, grey, damp.						
	SAND, fine grained, some gravel, trace silt, grey, dry.						
1	Below 0.8 m - brown.						
	SAND and GRAVEL, fine grained sand, fine and coarse gravel, subangular, grey/brown, dry.						
2	SAND, fine grained, some gravel to gravelly, subangular, grey/brown, compact, dry. Between 2.1 m and 2.4 m - some pink gravel, some pink sand, fine grained.						
3	Below 3.0 m - trace cobbles.						
4							
5	Between 4.9 m and 5.2 m - medium to coarse grained sand, some gravel, brown, damp. Between 5.2 m and 5.3 m - grey/white. Between 5.3 m and 5.6 m - fine to coarse grained sand, some silt, brown, moist to wet. Below 5.6 m - trace silt, dry.						
6	Between 6.1 m and 6.7 m - fine to coarse grained sand, some silt, brown, red/orange staining, moist to wet.						
	Below 6.7 m - gravelly.						
7	At 7.3 m - some pink colouration.						
	At 7.6 m - rock.						
8	Below 7.9 m - grey/white.						
	Below 8.5 m - fine to coarse grained sand, subangular to subrounded gravel, brown, moist.						
9	Below 9.1 m - well graded, wet.						
	Between 9.7 m and 10.4 m - medium to coarse grained sand.						
10	Bottom of hole at 10.0 m.						



NOTES

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-119

PAGE 1 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 07
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
Sample Interval
Direct Push

Water/NAPL Levels
Water Level 1
Water Level 2
NAPL
NAPL

Reading within indicated scale
Reading outside indicated scale

Soil Vapour (ppm)
10^1 10^2 10^3 10^4

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery
0	GRAVEL, some sand, trace silt, grey, damp.					
	SAND, some gravel, trace silt, grey, damp.					
	SAND, fine grained, some gravel, trace silt, grey, dry.					
1	Below 0.8 m - brown.					
	SAND and GRAVEL, fine grained sand, fine and coarse gravel, subangular, grey/brown, dry.					
2	SAND, fine grained, some gravel to gravelly, subangular, grey/brown, compact, dry.					
	Between 2.1 m and 2.4 m - some pink gravel, some pink sand, fine grained.					
	Between 2.7 m and 3.0 m - some grey/white.					
3	Below 3.0 m - trace cobbles.					
4						
5	Between 4.9 m and 5.2 m - medium to coarse grained sand, some gravel, brown, damp.					
	Between 5.2 m and 5.3 m - grey/white.					
	Between 5.3 m and 5.6 m - fine to coarse grained sand, some silt, brown, moist to wet.					
6	Below 5.6 m - trace silt, dry.					
	Between 6.1 m and 6.7 m - fine to coarse grained sand, some silt, brown, red/orange staining, moist to wet.					
	Below 6.7 m - gravelly.					
7	At 7.3 m - some pink colouration.					
	At 7.6 m - rock.					
8	Below 7.9 m - grey/white.					
	Below 8.5 m - fine to coarse grained sand, subangular to subrounded gravel, brown, moist.					
9	SAND, fine to coarse grained, gravelly, fine and coarse, subangular to subrounded, brown, loose, wet.					
10						

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NOTES
Bolded sample denotes sample analyzed.
*denotes blind field duplicate.
119-03 is a blind field duplicate of 119-02.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-119

PAGE 2 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 07
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
Sample Interval
Direct Push

Water/NAPL Levels
Water Level 1
Water Level 2
NAPL
NAPL

Reading within indicated scale
Reading outside indicated scale

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm) 10^1 10^2 10^3 10^4
10	SAND, fine to coarse grained, gravelly, fine and coarse, subangular to subrounded, brown, loose, wet. *(continued)* Between 10.1 m and 10.6 m - medium to coarse grained sand. Below 10.7 m - surfactant-like odour. Below 10.8 m - surfactant-like odour, hydrocarbon-like odour, grey hydrocarbon-like staining			**119-01**			
11				**119-02** *119-03			
12	GRAVEL, fine and coarse, subangular to subrounded, some sand to sandy, medium to coarse grained, trace cobbles, very loose, surfactant-like odour, wet.						
13	SILT, sandy, fine grained, trace gravel, fine and coarse, subangular to subrounded, brown, no plasticity, no surfactant-like odour. SAND, medium to coarse grained, gravelly, fine and coarse, subangular to subrounded, brown, loose. Bottom of hole at 13.7 m.						
14							
15							
16							
17							
18							
19							
20							

BENTONITE

NOTES
Bolded sample denotes sample analyzed.
*denotes blind field duplicate.
119-03 is a blind field duplicate of 119-02.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-120

PAGE 1 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 13
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
Sample Interval
Direct Push

Water/NAPL Levels
Water Level 1
Water Level 2
NAPL
NAPL

Reading within indicated scale
Reading outside indicated scale

Soil Vapour (ppm)
10^1 10^2 10^3 10^4

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery
0	SAND, fine to coarse grained, gravelly, fine and coarse, subangular, grey/brown, compact, dry.					
1	SILT, some gravel, fine and coarse, subangular, dark brown, hard, damp, organics (wood debris). Below 1.5 m - light brown, wet.					
2	SAND, fine to coarse grained, some gravel, fine and coarse, subangular, trace cobbles, grey/brown, compact, dry.					
3	Between 3.0 m and 3.4 m - fine grained sand, some silt, grey, loose.					
4	SILT, trace sand, fine grained, brown, medium plasticity, wet.					
	SAND, fine to coarse grained, gravelly, fine and coarse, subangular to subrounded, grey/brown, compact, dry.					
5	Below 4.9 m - medium to coarse grained sand.					
	SILT, some sand, fine grained, brown, no plasticity, moist.					
	SAND, fine to coarse grained, some gravel to gravelly, fine and coarse, subangular to subrounded, grey/brown, compact, dry.					
6	Between 6.1 m and 6.3 m - fine grained sand, some silt. At 6.2 m - rock, red. Below 6.2 m - medium to coarse grained sand.					
7	SILT, some sand, fine grained, trace gravel, coarse, subangular, brown, low plasticity, wet.					
	SAND, medium to coarse grained, some gravel, fine and coarse, subangular to subrounded, trace to some silt, brown, moist. Below 7.3 m - dry.					
8	ROCK.					
	SAND, fine to coarse grained, some gravel, subangular to subrounded, trace to some silt, trace cobbles, brown, compact, dry. Below 7.9 m - orange staining, damp to moist. Below 8.4 m - wet.					
9	SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subangular to subrounded, brown, loose, wet. Below 9.3 m - hydrocarbon-like odour. Between 9.3 m and 9.5 m - grey hydrocarbon-like staining.			120-01		60
10						

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NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

SNC·LAVALIN

Client
Public Works and Gov't Services Canada

Location
Muncho Lake Maintenance Camp, BC

Borehole No. : BH16-120

PAGE 2 OF 2

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	635031
Drilling Method	DT45 Dual Tube	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 13
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
Sample Interval
Direct Push

Water/NAPL Levels
Water Level 1
Water Level 2
NAPL
NAPL

Reading within indicated scale
Reading outside indicated scale

Depth in Metres	Soil Description	Stratigraphy Plot	Sample Interval Core Run	Sample Number	Blow Count	% Recovery	Soil Vapour (ppm) 10^1 10^2 10^3 10^4
10	SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subangular to subrounded, brown, loose, wet. *(continued)* Between 10.1 m and 10.7 m - grey hydrocarbon-like staining. Below 10.7 m - grey, very loose, hydrocarbon-like odour.			**120-02**		20	
11				**120-03**			
12	Below 12.2 m - no recovery.					0	
13							
	Bottom of hole at 13.7 m.						
14							
15							
16							
17							
18							
19							
20							

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NOTES
Bolded sample denotes sample analyzed.

QA FG 2016 12 13 Print Date:2016-12-14

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Client
Public Works and Gov't Services Canada

Location
Fireside Maintenance Camp, BC

Borehole No. : BH16-39

PAGE 1 OF 3

Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	636200
Drilling Method	DT45 Dual Tube/ODEX	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 10
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push
- Odex

Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

Soil Description

Depth in Metres | Stratigraphy Plot | Sample Interval Core Run | Sample Number | Blow Count | % Recovery | Soil Vapour (ppm)

- ○ Reading within indicated scale
- ● Reading outside indicated scale

Soil Vapour (ppm): 10^1 10^2 10^3 10^4

0 — SAND and GRAVEL, fine to coarse grained sand, fine and coarse gravel, subrounded to subangular, brown, loose, dry. — 70

SILT, some sand, fine grained, light brown, compact, low plasticity, damp.

1 — Below 0.9 m - sandy.

SAND, fine to coarse grained, gravelly, fine and coarse, subrounded, grey/brown, loose, dry.
Below 1.5 m - fine to medium grained sand, trace silt. — 80

2

3 — 80

Below 3.7 m - fine to coarse grained sand, trace cobbles.

4

5 — 80 — BENTONITE

At 5.2 m - rock.

6 — 80

7

Below 7.3 m - medium to coarse grained sand.

Below 7.6 m - some gravel, rounded. — 80

8

At 8.8 m - rock.

9

Between 9.1 m and 10.1 m - medium grained sand, trace gravel, no silt, damp. — 80

10

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Client
Public Works and Gov't Services Canada

Location
Fireside Maintenance Camp, BC

Borehole No. : BH16-39

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Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	636200
Drilling Method	DT45 Dual Tube/ODEX	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 10
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push
- Odex

Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

Soil Description

Stratigraphy Plot | Sample Interval Core Run | Sample Number | Blow Count | % Recovery

- Reading within indicated scale
- Reading outside indicated scale

Soil Vapour (ppm)

10^1 10^2 10^3 10^4

Depth in Metres	Soil Description
10	SAND, fine to coarse grained, gravelly, fine and coarse, subrounded, grey/brown, loose, dry. *(continued)* Below 10.1 m - some gravel to gravelly, subangular to subrounded.
11	At 11.0 m - some orange staining.
12	At 12.2 m - refusal of DT45. SAND, gravelly, brown, dry.
13	
14	
15	
16	
17	
18	
19	
20	

80

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Client
Public Works and Gov't Services Canada

Location
Fireside Maintenance Camp, BC

Borehole No. : BH16-39

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Drilling Contractor	ERNCO Environmental Drilling	Date Monitored	n/a	Project Number:	636200
Drilling Method	DT45 Dual Tube/ODEX	Ground Surface Elev. (m)	n/a	Borehole Logged By:	CMH
Borehole Dia. (m)	0.11	Top of Casing Elev. (m)	n/a	Date Drilled:	2016 10 10
Pipe/Slotted Pipe Dia. (m)	none/none	Northing: n/a	Easting: n/a	Log Typed By:	NDS

Drilling Legend
- Sample Interval
- Direct Push
- Odex

Water/NAPL Levels
- Water Level 1
- Water Level 2
- NAPL
- NAPL

Soil Description

Stratigraphy Plot | Sample Interval Core Run | Sample Number | Blow Count | % Recovery

Soil Vapour (ppm)
- ○ Reading within indicated scale
- ● Reading outside indicated scale

10^1 10^2 10^3 10^4

Depth in Metres	Soil Description
20	SAND, gravelly, brown, dry. *(continued)*
21	
22	
23	
24	Below 24.4 m - medium grained sand, trace to some gravel, dark grey, hydrocarbon-like odour.
25	Below 25.3 m - some gravel to gravelly.
26	
27	Bottom of hole at 26.8 m.
28	
29	
30	

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QA FG 2016 12 14 Print Date:2016-12-14

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