Ecology Review Preliminary Draft Work Plan
PMG Phase 1 Downgradient Plume Interim Action
Powder Mill Gulch
Boeing Everett Plant, Washington

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Prepared for

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1.0 INTRODUCTION

This document constitutes the work plan to conduct the first phase (Phase 1) of an interim action (IA) in the downgradient plume area of Powder Mill Gulch (PMG; Site) at the Boeing Commercial Airplanes (BCA) Plant in Everett, Washington (Everett plant; Figure 1). The objectives of the Phase 1 IA are to: (1) establish hydraulic containment and prevent further migration, to the maximum extent practicable,of chlorinated solvent-contaminated groundwater beyond Seaway Boulevard and off Boeing property, and (2) reduce, to the maximum extent practicable, migration of chlorinated solvent-contaminated groundwater to the surface waters of Powder Mill Creek, south of Seaway Boulevard. These objectives will be met through installation and operation of a groundwater extraction and treatment (GET) system that will establish capture zones for hydraulic control, as shown on Figure 2. The GET system will include three groundwater extraction wells, a groundwater treatment system consisting of an air stripper, and an engineered outfall for discharge of treated groundwater to Powder Mill Creek.

The IA will be conducted under Agreed Order No. DE96HS-N274 (Order) and subsequent amendments (specifically Amendment No. 5) between The Boeing Company and the Washington State Department of Ecology (Ecology 1997). Amendment No. 5 outlines the requirements for this work plan and other technical, administrative, and scheduling considerations for the Phase 1 IA.

As indicated in Amendment No. 5, the IA is to be divided into two phases: the first phase (Phase 1) addresses the plume south of Seaway Boulavard and the second phase (Phase 2) addresses the plume north of Seaway Boulevard. This work plan describes activities pertaining to Phase 1 of the IA only; provides details of the Phase 1 IA design; and describes system construction, startup, operation, and monitoring. This work plan also includes the plans and specifications (Appendix A) and an operation and maintenance plan (Appendix B) for GET system construction and operation.

2.0 BACKGROUND

The following sections describe the site conceptual model, objectives of the IA, and administrative background for the Site.

2.1 SITE CONCEPTUAL MODEL

2.2 INTERIM ACTION REMEDIAL OBJECTIVES AND APPROACH

The interim action objectives (IAOs) of the downgradient plume Phase 1 IA are listed below:

- **IAO 1:** Establish hydraulic containment and prevent further migration, to the maximum extent practicable, of chlorinated solvent-contaminated groundwater beyond Seaway Boulevard and off Boeing property.

  IAO 2: Reduce, to the maximum extent practicable, migration of chlorinated solvent-contaminated groundwater to the surface waters of Powder Mill Creek, south of Seaway Boulevard.

It is anticipated that operation of this IA will continue through the feasibility study and cleanup action plan phases of the project and that the IA may be included within the final remedy. The specific criteria for shutting down the IA system are indicated in Section 10, but these may be amended or superseded in the cleanup action plan.

The proposed IA approach to meet the downgradient plume Phase 1 IA remediation objectives and a discussion of how this approach achieves the remediation objectives are described below:

- **Approach to IAO 1**: The groundwater extraction and treatment system will consist of three groundwater extraction wells south of Seaway Boulevard that will intercept and hydraulically control groundwater leaving the Boeing property (see Figure 2), thereby minimizing further migration of trichloroethene (TCE)-impacted groundwater off of Boeing property. Furthermore, the extraction wells will provide a hydraulic barrier to offsite migration of TCE-impacted groundwater, thereby allowing flushing of the offsite aquifer with clean groundwater to accelerate restoration of groundwater beneath offsite properties. Groundwater restoration beneath the Boeing Everett property will be accelerated through direct removal of TCE mass from the groundwater and increased flushing.
- **Approach to IAO 2**: The groundwater extraction wells will be configured to intercept or otherwise divert groundwater flow paths from discharging to Powder Mill Creek on Boeing property, thereby reducing TCE flux into the stretch of creek upstream of the culvert (which is the area of highest flux to the creek based on TCE concentrations measured in the creek).

2.3 CONCEPTUAL DESIGN WORK PLAN

A summary focused feasibility study (Landau Associates 2009a) presenting the various technologies considered for downgradient plume IAs, the analysis of these alternatives, and justification for the preferred alternative was submitted to Ecology in April 2009. A conceptual IA design (Landau Associates 2009b), which includes the rationale for performing the proposed IA, was submitted to

Ecology in October 2009 and received conditional approval (Ecology 2009) in December 2009. Elements of the metrics for determining whether the IA objectives are adequately being met were not resolved and were deferred to this final work plan. Monitoring and evaluation approaches are discussed in detail in Section 7.

3.0 INTERIM ACTION DESIGN

The IA conceptual design includes extraction of groundwater from three strategically located extraction wells, treatment of extracted groundwater with a low profile (tray-style) air stripper, and discharge of treated groundwater at an engineered outfall into Powder Mill Creek. A more detailed description of the proposed extraction system, treatment system, and outfall are described in the sections below.

3.1 EXTRACTION WELL LOCATION AND DESIGN

Three groundwater extraction wells will be used to achieve the IAOs presented in Section 2.2. The configuration of the extraction wells was established using groundwater modeling as detailed in Landau Associates' *Numerical Groundwater Flow Modeling of Powder Mill Gulch* technical memorandum, dated October 28, 2009, included as Appendix C. The three wells will be installed on Boeing property south of Seaway Boulevard as follows (and as shown on Figure 2):

- Two wells will be installed south of Seaway Boulevard near the bottom of the embankment, one of which has already been installed (EGW175), to create a hydraulic barrier to prevent further migration of TCE-impacted groundwater from the Boeing property to offsite/downgradient property(ies) and to reduce TCE flux to Powder Mill Creek.
- One well will be installed to the south-southwest of the two wells discussed above to reduce TCE flux to Powder Mill Creek.

Each extraction well will be (or has been) installed into the Esperance Sand aquifer above the underlying silt layer.

These wells have been, or will be, constructed of stainless-steel casings and screen sections, and in accordance with the *Water Well Construction Act of 1971* [Revised Code of Washington (RCW) Chapter 18.104] and the Ecology *Minimum Standards for Construction and Maintenance of Wells* [Washington Administrative Code (WAC) Chapter 173-160].

Each well will be equipped with a downhole centrifugal extraction pump [i.e., electric submersible pump with variable frequency drive (VFD)] appropriately sized to transfer groundwater at the design flow rate from the well, through the conveyance piping system (see Section 3.2), to the groundwater treatment system (see Section 3.3). Based on groundwater modeling results (see Appendix C) and aquifer testing results (Landau Associates 2009c), the two wells immediately south of Seaway Boulevard will pump at an estimated rate approximately 40 gallons per minutes (gpm) each. The southerly well next to Powder Mill Creek will pump at an estimated rate approximately 30 gpm, for a total design extraction rate from the three wells of approximately 110 gpm. The actual flow rate will likely vary from the design extraction rate and will be determined during system startup and testing.

Pump selection was determined based on an evaluation of head loss due to gravity and frictional losses throughout the piping system. Head loss evaluation worksheets are provided in Appendix D. Flow rates for head loss calculations are based on the design flow rates as described above with an additional 220 gpm added downstream of extraction wells EGW175 and EGW182 to accommodate potential future expansion of the system north of Seaway Boulevard as part of Phase 2 of the downgradient plume IA (for a total flow of up to 300 gpm through the northern leg of the conveyance system). *This is a conservative total flow rate for pump and pipe sizing for the northern leg only to allow for efficient, potential future expansion of the conveyance system if higher than expected flow rates are realized; the maximum total design flow rate for all other aspects of the treatment system is 225 gpm (which is the maximum flow rate that the treatment system can be expected to adequately treat to the regulatory discharge limits – see Section 3.3 below*). Details and specifications for the pumps are included in the plans and specifications (Appendix A) and the Operation and Maintenance Manual (Appendix B).

Pumping rates and operation will be controlled and monitored via various instrumentation and controls as described in Section 3.6. Controls and valves at the wellhead will be located within a subgrade well vault. Other instrumentation and controls will be located at a nearby local control panel or at the treatment building. Local control panels will be housed inside a weatherproof enclosure with a National Electrical Manufacturers Association (NEMA) 3R rating.

Well vaults will also be equipped with sump pumps with a mechanical float switch to evacuate water that may accumulate in the vault from precipitation.

3.2 CONVEYANCE SYSTEM

Extraction pumps will be attached to 2-inch stainless-steel riser pipes that transition, in the well vault, to plastic conveyance piping. Conveyance piping will consist of 2-inch and 4-inch high density polyethylene (HDPE) piping (SDR 11). Pipe selection and design are based on an internal pressure evaluation (Appendix D) and external pressure/loading evaluation (Appendix E).

Straight pipe sections will be connected via butt-welded (fusion welded) joints, as needed. Other connections will be made with factory molded HDPE fittings.

Conveyance piping from each of the extraction well vaults will be run underground to the treatment system through engineered trenches. Piping will be placed on top of at least 6 inches of bedding material and covered with at least 3.5 ft of select fill. Trenches will be routed around critical wetland areas as indicated on Figure 3. Work within the wetland buffer will be coordinated with the City of Everett in accordance with the City's critical areas ordinance.

3.3 GROUNDWATER TREATMENT SYSTEM

Extracted groundwater will be conveyed through a treatment system to reduce volatile organic compound (VOC) concentrations in groundwater to below applicable discharge limits as specified in a National Pollutant Discharge Elimination System (NPDES) permit to be obtained for this project (see Section 3.3.1.2 below). The treatment system will be housed within a concrete masonry unit (CMU) building located south of Seaway Boulevard (see Figure 3). Architectural and structural design of the building was performed by BergerABAM, and electrical design for the building and treatment system was performed by Automation & Control Engineering, LLC (Appendix A). The treatment system will consist of:

- A ShallowTray® Model 31200 low profile air stripper (tray stripper) groundwater treatment unit equipped with a Roots URAI Model 718 URAI 1,800 cubic feet per minute (cfm) (2,438 cfm at 14" W.C.) positive displacement blower and VFD
- Discharge/transfer pump – Positive displacement centrifugal pump to convey treated groundwater to a temporary holding tank or back to the air stripper, as needed; primary discharge to the system outfall will be by gravity flow
- Discharge temporary holding tank (1,000-gallon cross-linked polyethylene tank) and return conveyance piping.

A process flow diagram of the treatment system is included in Appendix F. More detailed plans and specifications for the treatment system are provided in Appendix A: Plans and Specifications.

3.3.1 BASIC DESIGN CRITERIA AND CALCULATIONS FOR THE GROUNDWATER TREATMENT SYSTEM

Air stripping is a proven and standard technology for removing VOCs from wastewater streams. As a general rule of thumb, volatile contaminants [contaminants with a dimensionless Henry's Constant (H') $\geq$ 0.01] can be effectively removed from wastewater streams using air stripping (Watts 1998). At 50 °F, TCE has a H' value of approximately 0.36. Based on the air stripper manufacturer's modeling output (Appendix G), and assuming appropriate operation and maintenance of the treatment system, the proposed treatment facility should adequately treat the contaminated influent groundwater to below anticipated effluent limitations prior to discharge to Powder Mill Creek.

The two primary design and sizing elements for the air stripper treatment system are: 1) volumetric flow rate of extracted groundwater to achieve hydraulic control of the TCE plume; and 2) level of treatment required to achieve NPDES permit discharge limits. These two elements, along with other design considerations are described in the following subsections.

3.3.1.1 Volumetric Flow Rate

The volumetric flow rate through the treatment system will be determined based on achieving adequate hydraulic control of the TCE plume on Boeing property to prevent further offsite migration of TCE and discharge of TCE to Powder Mill Creek on Boeing property. The groundwater extraction flow rate was estimated using groundwater modeling as detailed in Landau Associates' *Numerical Groundwater Flow Modeling of Powder Mill Gulch* technical memorandum, dated October 28, 2009 (Appendix C.) This modeling evaluation approximated a combined flow rate from the three extraction wells on Boeing property of 110 gpm; 40 gpm from each of the wells adjacent to Seaway Boulevard and 30 gpm from the southerly well proximate to Powder Mill Creek. Actual flow rates may be different from the estimated flow rates based on site-specific conditions. Potential expansion of the groundwater extraction system in the future to address offsite contamination may increase the flow to approximately 225 gpm (the maximum flow rate that the treatment system can be expected to adequately treat to the regulatory discharge limits – see Section 3.3.1.2 below). Therefore, 110 gpm is used as the operating flow rate and 225 gpm as the maximum design flow rate through the treatment system.

3.3.1.2 Anticipated Discharge Limits

The effluent water discharge limit will be determined by the applicable water quality standards for surface waters of the state of Washington as defined by WAC 173-201A-240, which indicates that human health-based water quality criteria shall be based on the U.S. Environmental Protection Agency's (EPA) National Toxics Rule (40 CFR 131.36). Based on this rule, the anticipated discharge limits for TCE and TCE breakdown products 1,1-dichloroethene (1,1-DCE) and vinyl chloride (VC) (not anticipated to be present above negligible concentrations in the extracted groundwater) for the treatment system effluent are:

Constituent	Discharge Limit
TCE	2.7 μg/L
1,1-DCE*	0.057 μg/L
VC	2.0 μg/L

*40 CFR 131.36 does not include values for cis-1,2-DCE or trans-1,2-DCE.

3.3.1.3 Sizing of Treatment Unit

The treatment system was sized accordingly based on the estimated volumetric flow rate of the groundwater extraction system and the anticipated regulatory effluent discharge limit. The air stripper system has been designed based on the following parameters:

- Average operating flow rate of 110 gpm, based on modeled groundwater extraction rates to achieve hydraulic control
- Maximum design flow rate of up to 225 gpm (to accommodate increased flow rates based on site-specific conditions and potential future expansion of the system up to the maximum flow rate that the treatment system can be expected to adequately treat to the regulatory discharge limits)
- Influent TCE concentration of 1,000 micrograms per liter (μg/L) - this is a conservative estimate based on the highest TCE concentration observed from two extraction wells (EGW175 and EGW176) during an aquifer pumping test; actual steady-state TCE concentrations in extracted groundwater (i.e., after hydraulic equilibrium has been established) are anticipated to be less than 400 μg/L based on pumping test results and the anticipated extraction of groundwater from less impacted areas of the plume and clean groundwater from outside of the plume.
- Effluent TCE concentration of less than (<)2.7 μg/L, VC concentration of <2.0 μg/L , and 1,1-DCE concentration of <0.057 μg/L (based on the discharge limit described in Section 3.3.1.2 above)
- Average water temperature of 50 degrees Fahrenheit (°F)
- Average ambient air temperature of 55 °F.

Utilizing modeling software developed by the manufacturer of the air stripping unit (BISCO Environmental 2009) with inputs of the parameters indicated above, the proposed ShallowTray five-tray low-profile air stripper with a 1,800 actual cubic foot per minute (ACFM) blower will achieve an air-to-water ratio of 60:1 and will achieve the necessary level of treatment for the design system. The model output is included in Appendix G. For the initial anticipated flow rate of 110 gpm, the model indicates that only three trays will be needed to achieve the effluent discharge limit TCE concentration (including a safety factor of 25 percent applied to the model parameters).

3.3.1.4 Stripper Fouling Evaluation

To determine whether air stripper fouling would be a significant concern for the operation and maintenance of the proposed treatment system, a stripper fouling evaluation was performed. Fouling of air strippers generally occurs from one of four sources (Suthersan 1999):

- Solids sedimentation
- Iron and manganese precipitation
- Carbonate scaling
- Biological film growth.

Solids Sedimentation – Solids sedimentation will be addressed as part of normal maintenance of the system; however, it is not anticipated to be a significant concern as extraction wells will be properly constructed and developed to limit the intake of aquifer fines and significant groundwater turbidity has not been observed in the proposed treatment area.

Suthersan (1999) provides the following guidance for the other three fouling factors:

- For iron and manganese concentrations less than 5 milligrams per liter (mg/L), routine maintenance is sufficient; for concentrations greater than 10 mg/L, pre-aeration and filtration of precipitations should be provided.
- For hardness (carbonate scaling) concentrations less than 150 mg/L [as calcium carbonate ($CaCO_3$)], routine maintenance would be sufficient; for concentrations greater than 300 mg/L, more frequent cleanup, pH control, or filtration may be required.
- For total biodegradable organics concentrations of more than 10 mg/L, biological microbial film growth may cause operational problems.

Existing groundwater data from the PMG TCE plume area were compared against this guidance. The results are summarized below:

Iron and Manganese – The highest concentrations of iron and manganese recorded for the Site are 0.5 mg/L and 0.0834 mg/L, respectively. These concentrations are sufficiently low that pre-aeration and filtrations should not be necessary.

Hardness – The average hardness concentration in groundwater from wells where hardness sampling has been performed was approximately 80 mg/L hardness (as CaCO3) with 119 mg/L as the highest recorded concentration. Additionally, groundwater at the Site was determined to have a tendency to dissolve calcium carbonate (as opposed to precipitate calcium carbonate), as determined using both the Langelier and Ryznar indices. Therefore, pH control and filtration are not likely to be necessary.

Biodegradable Organics – TCE is the primary biodegradable organic that will be in groundwater running through the stripper system. The average TCE concentration running through the system is not anticipated to exceed 1 mg/L; therefore, significant biofilm growth is not anticipated.

Based on these factors, air stripper fouling is not anticipated to be a significant problem and does not warrant any supplemental preventive measures (such as pH adjustment, pre-aeration, or filtration), other than standard maintenance practices. A summary of the stripper fouling evaluation calculations is included in Appendix H.

3.3.2 RESULTS TO BE EXPECTED FROM THE TREATMENT PROCESS

At the design influent liquid flow rate of 110 gpm and a conservative influent TCE concentration of 1,000 μg/L, based on the manufacturers modeling software, air stripping is expected to achieve a calculated treatment efficiency of 99.99 percent with only three of the possible five trays in place, resulting in a calculated TCE discharge concentration of <1 μg/L, and meeting the regulatory discharge criteria TCE concentration of 2.7 μg/L. At the maximum flow rate of 225 gpm, the air stripper is expected to achieve a treatment efficiency of 99.92 percent with all five trays in place, resulting in a calculated discharge TCE concentration of <1 μg/L.

3.3.3 PHYSICAL PROVISION FOR HAZARDOUS MATERIAL SPILL CONTROL AND/OR ACCIDENTAL DISCHARGE PREVENTION

The treatment system equipment and influent manifold and valves will be located inside the treatment system building. The floor of the building will be constructed of a seamless concrete slab and will be sloped (0.5 percent slope) toward the center of the building toward a concrete sump capable of holding approximately 475 gallons of liquid in the event of a release from the treatment system. Any release into the sump can be manually transferred, via a sump pump, into a holding tank for additional storage capacity, temporary storage for collection and offsite disposal, or transfer back to the stripper for treatment.

Additionally, the air stripper system will be equipped with level alarms and automatic shutoff devices to the well pumps to ensure that the stripper sump is not overfilled or is not receiving liquids (which could be due to an upstream leak or release). Any releases at the wellheads will run back into the well at which they occur. Check valves immediately downstream of the wellheads will ensure that the contents of conveyance piping will not all flow back to the well vaults.

3.4 AIR DISCHARGE

To determine whether air emissions controls or treatment would be required for the vapor-phase effluent of the proposed air stripper treatment system, a regulatory and technical evaluation of the potential air emissions from the system was performed. Using a conservative estimated TCE concentration of 1,000 µg/L observed during an aquifer pumping test from extraction wells EGW175 (located south of Seaway Boulevard, which will be incorporated into the final extraction system) and EGW176 (located north of Seaway Boulevard, may be used in possible future expansion of the system), and the average operating flow rate of 110 gpm, the maximum mass of TCE that would be discharged in the vapor-phase from the treatment system would be approximately 482 pounds of TCE per year. Accounting for potential expansion of the system to a maximum design flow rate of 225 gpm, the maximum mass of TCE that would be discharged in the vapor-phase from the treatment system would be approximately 986 pounds of TCE per year.

Puget Sound Clean Air Agency (PSCAA) Regulation I, Article 6 indicates that that a new source review must be conducted, unless exempted. Per Regulation I (6.04)(c):

> "A Notice of Construction application and Order of Approval are not required for the following new sources, provided that sufficient records are kept to document the exemption:. . .
>
> **"Water Treatment**
> **(94)** Soil and groundwater remediation projects involving <15 pounds per year of benzene or vinyl chloride, <500 pounds per year of perchloroethylene, and <1,000 pounds per year of toxic air contaminants." (Note: toxic air contaminants would include TCE.)

Based on this evaluation, discharge from the system is considered an exempt source, so long as adequate monitoring is performed to document the exemption. Therefore, vapor-phase effluent from the air stripper will be discharged directly to the atmosphere via a 6-inch PVC stack extending above the roof of the treatment system building.

As indicated above, air discharge monitoring will be conducted to document that the air discharge is exempt from treatment prior to discharge. However, if the system is expanded to where treatment of the airstream is required, the discharge line will be designed such that it can be rerouted through vapor-phase granular activated carbon (GAC) vessels prior to stack discharge.

3.5 TREATED WATER DISCHARGE AND OUTFALL

Extracted groundwater will be treated to applicable surface water standards and discharged to Powder Mill Creek through an engineered outfall located approximately 400 ft south of Seaway Boulevard on Boeing property. Operation of this type of outfall requires a NPDES permit and a hydraulics project approval (HPA) permit, which are discussed further in Section 9.1. The discharge outfall will be located approximately 50 ft upstream of the confluence of the constructed wetland discharge outlet and Powder Mill Creek (see Figure 3). The two primary reasons for selecting this location for the outfall are that 1) this is the approximate observed location of where Powder Mill Creek becomes a perennial flowing stream, and 2) groundwater modeling indicates that the extraction system will reduce base flows of the creek by approximately 10 to 20 percent; therefore, the treatment system discharge will be used to replenish this depletion. More detailed plans and specifications for the outfall are provided in the Appendix A (Plans and Specifications).

The treated groundwater discharge line and outfall will consist of a 6-inch buried HDPE pipe (SDR 11) from the treatment system building to a point approximately 20 to 30 ft east and uphill of the east bank of Powder Mill Creek, where the pipe will daylight. The pipe will terminate in a "splash box" vault, that will dissipate the water flow energy and spread the water across an open channel outfall leading to the creek. The open channel will consist of a flat bottom swale (approximately 5 ft wide) with sloped sides (2H:1V maximum slope), approximately 2 ft deep. The channel will be over-excavated and lined with a 6-inch thick bentonite clay liner (or similar) overlain with 4 inches of compacted 1-inch minus gravel. Rock check dams, constructed of quarry spalls and designed per Washington State Department of Transportation (WSDOT) specifications (WSDOT 2008), will be placed periodically along the length of the channel to reduce flow velocities and erosion.

The channel will terminate at the "shoulder" of the creek bank (above the creek's ordinary high water mark), at which point the water will free flow into the creek. To prevent erosion of the creek bank, the shoulder of the bank will be protected with a geotextile fabric and the bank, from the terminus of the channel to the ordinary high water mark of the creek, will be planted with native erosion resistant plants, per the planting schedule found in the Plans and Specifications (Appendix A).

Additional details and drawings of the outfall are included in Appendix A (Plans and Specifications).

3.6 INSTRUMENTATION AND CONTROLS

Various elements of the GET system will be monitored and/or controlled with a programmable logic computer (PLC) system, such as a Supervisory Control and Data Acquisition (SCADA) system, or equivalent, designed by Automation & Control Engineering, LLC (see Appendix A) and compatible with existing Boeing systems at other remediation sites. The system will be designed to report real time monitoring results; perform automatic system shutdowns or signal an alarm in the event of certain system conditions or failures; perform automatic adjustments in pumping rates to maintain predetermined hydraulic conditions (e.g., groundwater levels in monitoring wells); and allow remote operation of the system. More specific descriptions of the monitoring and control components are described in the following sections.

3.6.1 EXTRACTION WELL AND PUMP MONITORING AND CONTROLS

Extraction wells will be equipped with pressure transducers to monitor groundwater levels within the wells. The central control system will be programmed to read and monitor the levels and alter pumping rates of the extraction pumps, as necessary, to maintain predetermined groundwater elevations in the wells (to maintain hydraulic control of the groundwater plume).

Pressure indicators and transmitters will be installed at the top of the extraction well riser piping (within the well vaults) to monitor for any excess or sudden declines in water pressure that might indicate blockage or a leak in the conveyance system. The central control system will be programmed to signal an alarm in the event of likely blockage and to shut down the system (and alarm) if a leak is detected.

Flow meters and transmitters will also be installed on the piping within the well vaults to monitor flow rates and total extracted volume of water from each well. A flow meter installed at the end of the conveyance piping system (in the treatment building) will perform the same function and by data comparison determine the presence of leaks in the conveyance piping (i.e., sum of individual flow rates from each well versus total combined flow into the treatment system, within a given tolerance, will be used to determine water loss between the wells and treatment system).

Local control panels proximate to the wells will have hand-off-auto pump controls, power disconnects, and lighted displays for pump on and system alarm indication.

3.6.2 AIR STRIPPER AND BLOWER MONITORING AND CONTROLS

The air stripper blower will be equipped with a pressure indicator and transmitter to monitor air flow pressure into the air stripper. The central control system will be programmed to monitor this pressure and to signal an alarm if pressure exceeds ordinary operating parameters that may indicate buildup of mineral scale or biogrowth in the stripper trays and clogging that would reduce treatment efficiency. Abnormally high pressure would result in a system alarm and, ultimately, system (including well pumps) shutoff if a high-high pressure point is reached. Similarly, a sudden pressure drop, indicating a potential system failure (large leak) would trigger a system alarm and shutoff.

The air flow rate from the blower into the stripper will also be monitored with a flow indicator and transmitter. The central control system will monitor and adjust air flow rate (through blower motor speed via VFD) to ensure adequate flow rate to the groundwater treatment system.

The air stripper will be equipped with a sump level indicator and transmitter to monitor water level in the stripper sump. High- and low-level alarms and high-high and low-low level shutoffs would also be programmed into the central control system.

Treatment system discharge piping will be equipped with a flow-totalizing indicator and transmitter, which will be recorded by the central control system.

3.6.3 LEAK OR SYSTEM FAILURE MONITORING AND CONTROLS

Much of the GET system monitoring for leaks or system failures will be integrated into the monitoring or normal operating parameters as described in the sections above. Additionally, the sump in the main treatment system building will be equipped with a leak detection sensor, that if activated will trigger system alarm and shutdown.

3.7 MONITORING NETWORK

In addition to the existing network of monitoring wells, piezometers, and creek staff gauges (and one stream flow gauging station), and the extraction wells associated with the system, the following monitoring points (shown on Figure 2) will be added to provide adequate coverage and resolution for monitoring groundwater and surface water elevation and gradients (to determine hydraulic capture and control, gradients, and quality trends):

- Four piezometer pairs (PMG-P14/PMG-P15, PMG-P16/PMG-P17, PMG-P18/PMG-P19, and PMG-P20/PMG-P21) will be installed along the east bank of Powder Mill Creek (the first just above the ordinary high water mark and the second approximately 10 ft away and perpendicular to the creek). The new temporary piezometers will be constructed by installing ¾-inch pre-pack wells into soil borings advanced with a limited access direct-push drill rig. If access to the edge of the creek is not available to a drill rig at the appropriate locations, the boring may be hand-augered or a drive-point well may be used instead of a pre-pack well. The piezometer screens will be 5 ft in length and the top of the screens will be placed approximately 2 ft beneath the static groundwater table.

- Piezometers (PMG-P8 and PMG-P9) will be installed proximate to each of the two system extraction wells by Seaway Boulevard to monitor actual draw down adjacent to the extraction wells and to evaluate well efficiency (two monitoring wells already exist proximate to extraction well EGW183). Piezometers will be installed to at least one half the depth of the adjacent extraction well and will be screened from the bottom to just below the static groundwater table.
- Two piezometers (PMG-10 and PMG-11) will be installed proximate to the south of Seaway Boulevard (one to the west of extraction well EGW175 and one to the east of EGW182 near the edge of the plume). The piezometers will be installed to measure groundwater elevations in these two locations for evaluating hydraulic control.
- One staff gauge will be installed between SG-2 and SG-2A (designated "SG-2B"). The gauges will be surveyed to a vertical accuracy of 0.01 ft using level-loop surveying method.

The piezometers will be installed in accordance with the *Minimum Standards for Construction and Maintenance of Wells,* Chapter 173-160 of the WAC.

3.8 ENVIRONMENTAL SUSTAINABILITY EVALUATION

3.9 DOWNSTREAM EROSION EVALUATION

Per the request of the Washington Department of Fish and Wildlife (WDFW), and related to the sustainability evaluation (see Section 3.8), a geomorphic assessment was conducted by Confluence Environmental Company (CEC) to estimate the potential for downstream erosional effects on Powder Mill Creek due to the addition of the flow of treated groundwater (using the maximum design flow rate of 225 gpm) at the treatment system outfall. The intent of the evaluation was to determine whether the additional flow would result in undesirable creek bank erosion and/or turbidity in the water that might impact property and/or wildlife in or adjacent to the creek.

As indicated in CEC's report (Appendix I), the additional flow from the treatment system added to the base flow or average flow conditions of Powder Mill Creek "would not exceed the threshold of sediment movement, and would therefore have no physical effect on channel stability." Therefore, it is concluded that the additional flow added to the creek would not cause adverse downstream erosion or sediment/turbidity impacts.

3.10 WASTE MANAGEMENT

Waste will result from system construction, groundwater monitoring, and system operation. Waste will be managed by Boeing in accordance with applicable rules and regulations.

Waste and residuals related to project activities consist of drill cuttings, equipment decontamination water, well development water, well purge water, and various solid waste. Drill cuttings will be characterized and designated in accordance with WAC 173-303. If the soil designates as a dangerous waste, it will managed under WAC 173-303. Water resulting from equipment decontamination, well development, and purging will be managed in accordance with the City of Everett pre-treatment permit. Solid waste will include personal protective equipment (PPE) and construction debris.

4.0 ADEQUACY REVIEW

Amendment No. 5 of the Order identifies requirements for work plan contents including "an adequacy review of the pertinent site data, site conceptual model, and interim action objectives". This section describes the evaluation of data gaps and data adequacy as they relate to whether site data, the site conceptual model, and interim action objectives are sufficiently defined in order to design the groundwater extraction and treatment system described in the section above and to be able to evaluate whether the system is functioning as planned and achieving the objectives. The following sections generally follow the key concepts and practices described in EPA's guidance on evaluating hydraulic capture zones (EPA 2008), including:

- Evaluating the adequacy of site data, the site conceptual model, and project IAOs with respect to the project designs
- Adequately defining the target capture zone
- Developing a plan for interpreting and evaluating hydraulic capture and control.

Additionally, an evaluation is described below of whether there is sufficient data available to perform and evaluate the overall extraction and treatment system design.

4.1 ADEQUACY OF SITE DATA, SITE CONCEPTUAL MODEL, AND INTERIM ACTION OBJECTIVES

As indicated in the EPA guidance, capture zone evaluation typically relies on information such as stratigraphy, hydraulic conductivity, hydraulic gradients, pumping/injection rates and locations, ground-water elevations, and ground-water quality. Based on the site remedial investigation (RI) and supplemental addendum actions taken to date, each of these elements is sufficiently covered.

The site conceptual model must also adequately indicate the source(s) of contaminants, describe geologic and hydrogeologic conditions, explain observed fate and transport of constituents, and identify potential receptors. These elements are also adequately developed and covered in the RI.

Finally, the remedial objectives must be clearly stated and are discussed in in Section 2.1.

4.2 TARGET CAPTURE ZONE

The target capture zone is the vertical and horizontal zone of groundwater that must be captured and controlled to meet the IAOs. At this site, this generally refers to the entire depth of the groundwater column (above the silt layer) bounded horizontally by Seaway Boulevard to the north, and the known edges of the TCE plume (isoconcentration contours greater than 0.49 µg/L) south of Seaway Boulevard extending south along the east bank of Powder Mill Creek.

The modeled capture zone must, therefore, include, at a minimum, the target hydraulic capture zone. The modeled capture zone is shown on Figure 2 and clearly extends beyond the target.

4.3 EVALUATING HYDRAULIC CAPTURE AND ACHIEVING INTERIM ACTION OBJECTIVES

Contouring and interpreting measured groundwater and surface water elevation data will be the primary method of evaluating system hydraulic capture and control. Groundwater elevation measurements will be used to evaluate horizontal flow directions based on groundwater elevation contour maps.

Flow direction and gradient information will be used directly or interpolated to determine whether the target hydraulic capture zone is being adequately established by the system. The monitoring network that will be used to monitor and evaluate groundwater hydraulic capture and control, groundwater quality, and surface water elevations and quality must be able to provide sufficient information to document and demonstrate that each of the IAOs is being met. The following factors were considered in determining whether the existing monitoring network is adequate to provide this demonstration (EPA 2008):

- Adequate number and distribution of measurement locations
- Monitoring points for water levels in vicinity of extraction wells (to account for well inefficiency and losses at extraction wells in interpreting groundwater levels).
- Evaluation of horizontal capture performed individually for all pertinent horizontal units
- Evaluation of bias based on contouring algorithm.
- Transient influences adequately represented (seasonal, tidal, varying pumping rates at other pumping locations).

Based on these factors and considerations in evaluating the achievement of the IAOs, the following items are considered data gaps or deficiencies that require remedy prior to or during the construction and implementation of the remediation system:

- The current monitoring network is not sufficient to evaluate hydraulic conditions across the plume area of the modeled capture zone during operation; therefore, it will be expanded, as indicated in Section 3.7 above, by adding additional piezometers in strategic locations to accurately observe and interpret hydraulic capture and control.
- There are insufficient groundwater and surface water quality and elevation monitoring points along Powder Mill Creek to be able to monitor TCE flux into the creek. Therefore, the monitoring network along the creek will be expanded, as indicated in Section 3.7 above, by adding additional piezometers and staff gauges along the creek to allow for accurate determination of groundwater gradients and TCE concentrations proximate to the creek.

4.4 OVERALL SYSTEM DESIGN

Based on information obtained during the RI and associated addenda and supplemental activities, there is sufficient known information about site hydrology, groundwater quality, surface water quality, and groundwater/surface water interactions to develop and populate the hydraulic model that is the basis of the extraction system configuration and parameters. Additionally, based on the other evaluations detailed in Section 3 above, there is sufficient information to design the specific system components and operations, such that that the system will function as planned and be reasonably expected to successfully achieve the IAOs.

5.0 SYSTEM STARTUP

6.0 SYSTEM OPERATIONS AND MAINTENANCE

7.0 SYSTEM MONITORING AND EVALUATION

Measuring progress and evaluating whether the proposed Phase 1 IA is adequately achieving the IAOs (Section 2.2) will be accomplished through a combination of monitoring activities that are detailed in the following sections.

The criteria used for making modifications to the system or operation thereof, based on the monitoring data, are also discussed. Note that evaluation activities are an iterative process, which includes ongoing evaluation of whether there are data gaps in the monitoring network or data gathering activities/methodology.

7.1 MONITORING AND EVALUATION OF IAO 1

As previously indicated, IAO 1 is to establish hydraulic containment and prevent further migration, to the maximum extent practicable, of chlorinated solvent-contaminated groundwater beyond Seaway Boulevard and off Boeing property. This will be accomplished by creating a hydraulic barrier to offsite migration of TCE-impacted groundwater.

The effectiveness of the system and progress toward achieving this remedial objective will be assessed through demonstration of hydraulic control and groundwater monitoring, as discussed below in Sections 7.1.1 and 7.1.2, respectively.

Achievment of IAO 1 will also provide the additional benefit of accelerating restoration of groundwater beneath the Boeing Everett Site and offsite properties by directly removing TCE-impacted groundwater from beneath the site and (as described above), thereby allowing flushing of the offsite aquifer with clean groundwater. Progress in restoring groundwater beneath the Boeing Everett Site and offsite properties will be tracked through ongoing implementation of the overall site groundwater monitoring plan.

The data collected from offsite will be valuable for a site feasibility study and making future determinations regarding final remedy selection. However, based on anticipated restoration timeframes for offsite properties (e.g., at least 10 years), no specific metrics or goals pertaining to offsite restoration will be established or evaluated for this interim action.

7.1.1 DEMONSTRATION OF HYDRAULIC CONTROL

Before and after initiation of groundwater extraction, groundwater elevation measurements will be collected from new and existing monitoring wells to determine the actual effect of sustained pumping. Field measurements will be used to determine actual groundwater table drawdown and interpolate groundwater contours. Well clusters, where applicable, will also be used to identify vertical gradients.

Specifically, the following wells/piezometers, which are either within the extraction well capture zone and sufficiently close that the extraction wells are reasonably expected to have a measureable effect or are just beyond the anticipated influence of the extraction wells, will be gauged monthly for the first 3 months after system operation and then semi-annually thereafter in conjunction with the current April and October groundwater level monitoring events.

TABLE 7-1 TARGET HYDRAULIC CONTROL MONITORING POINTS (IAO 1)

Existing Monitoring Wells/Piezometers		New Piezometers	Powder Mill Creek Staff Gauges
EGW079 EGW80* EGW081 EGW083 EGW085 EGW86* EGW087 EGW90* EGW106	EGW110 EGW133 EGW132 EGW138 EGW139* EGW147 EGW148 EGW162 EGW165 EGW166	New piezometer PMG-P8 adjacent to EGW175 New piezometer PMG-P9 adjacent to EGW182 New piezometer PMG-P10 west of EGW175 New piezometer PMG-P11 east of EGW182	SG-3 SG-4

*Potentially within a downgradient stagnation zone created by the two extraction wells at Seaway Boulevard

If groundwater elevation contour maps based on monitoring data indicate that the plume is not adequately being captured after 6 months of continuous or near-continuous groundwater pumping, system optimization actions will be taken to remedy the situation. Initial actions will likely take the form of operational modifications such as increasing pumping rates at one or more of the three extraction wells. If pumping rates are maximized and groundwater elevation data still indicates a lack of adequate hydraulic control , system modifications may be considered to obtain optimal results, such as replacement of extraction pumps with higher flow capacities or installation of additional extraction well(s).

Adequate plume capture will be defined by evaluating groundwater elevation contour maps generated from the above-specified groundwater level monitoring events. The groundwater extraction system capture area will be defined by delineating the area where a conservative groundwater flow particle would be captured by one of the three extraction wells based on the plotted groundwater elevation contours. Adequate plume capture will be achieved if this capture area encompasses the width and depth of the plume on Boeing property south of Seaway Boulevard.

7.1.2 GROUNDWATER QUALITY MONITORING

At Ecology's request, achievement of the hydraulic control IAO (IAO 1) will also be assessed by determining if the concentration of TCE in monitoring wells located immediately downgradient and cross gradient of Boeing's northern property line yield a decreasing TCE concentration trend, as a result of preventing upgradient migration of TCE-impacted groundwater to these wells. This approach to assessing achievement of IAO 1 presents three key technical challenges:

- *Interpreting groundwater quality data to differentiate between redistribution of contaminated groundwater in compliance monitoring wells and non-achievement of IAO 1.* Pumping of extraction wells EGW175 and EGW182 will likely result in the re-distribution of contaminated groundwater north of Seaway Boulevard including the development of reverse (i.e., southerly) flow gradients and a potential stagnation zone some distance north of Seaway Boulevard. Because the concentration of TCE in groundwater north of Seaway Boulevard is similar to concentrations near Seaway Boulevard (maximum concentration measured north of Seaway Boulevard = 1,900 µg/L, maximum concentration measured near Seaway Boulevard = 2,000 µg/L), the concentration of TCE at one or more of the compliance wells may not decrease and could increase as a result of re-distributing contaminated groundwater that is already north of Seaway Boulevard. Therefore, hydraulic control could be achieved, but a decreasing trend in TCE concentrations may not be observed.
- *Limited ability to accurately predict aquifer response to flushing with clean groundwater and development of an expected TCE concentration reduction trend.* Groundwater modeling indicates that monitoring wells proposed for this evaluation that are located near the edge of the plume (e.g., EGW085 and new piezometers PMG-P10 and PMG-P11, should begin to be flushed with clean groundwater from outside of the plume within a few months after the start of pumping. How these wells respond to this flushing cannot be accurately predicted due to aquifer heterogeneities that can generate slow diffusion-limited reductions in contaminant concentrations. Therefore, it is not possible to develop an expected TCE concentration reduction trend that could be used to compare to actual groundwater quality data for assessing achievement of IAO 1.
- *Interpreting groundwater quality data to differentiate between naturally occurring temporal variability in groundwater concentrations in plume wells (as seen in historical groundwater monitoring data) and data indicative of achievement or non-achievement of IAO 1.* Historically, TCE concentrations in some of the wells proposed for monitoring have varied as much as 50 to 80 percent over periods of less than a year. Over the near-term (i.e., one to two years), it may not be possible to differentiate these natural variations from variations that might otherwise be considered inadequate plume capture.

Some of these same concerns are described in applicable EPA guidance (EPA 2008), which states that "Interpretation of capture based on concentration trends at monitoring wells located downgradient of the Target Capture Zone is complicated by several other factors [including] interpretations of concentration data related to capture may take years . . ." Therefore, interpretation of groundwater quality monitoring data to evaluate achievement of IAO 1 will be a secondary indicator relative to the method presented in Section 7.1.1, which relies on the demonstration of hydraulic control.

The table below indicates the specific wells where groundwater quality will be evaluated for making this assessment. Specifically, groundwater samples will be collected from the following locations prior to system startup and then on a quarterly basis for the first year. Additional monitoring at these locations, if needed, will be per the schedule presented in the effectiveness review document to be submitted to Ecology one year after system startup (and as approved by Ecology).

TABLE 7-2 TARGET GROUNDWATER QUALITY MONITORING POINTS (IAO 1)

Existing Monitoring Wells/Piezometers	New Piezometers
EGW079 EGW080 EGW085 EGW086 EGW087 EGW90* EGW138 EGW139 EGW165	New piezometer PMG-P10 west of EGW175 New piezometer PMG-P12 east of EGW182

*same intervals will be sampled as under current PMG groundwater monitoring plan.

Groundwater quality monitoring data from these wells (and other wells inside and outside the capture zone monitored per the site groundwater monitoring plan) will be tabulated and evaluated after each sampling event for indications of a groundwater quality trend that could potentially indicate achievement or non-achievement of IAO 1. However, it should be noted that at least three successive monitoring events will be needed to establish a data trend and additional monitoring events may be necessary to distinguish trends resulting from the hydraulic capture system from those caused by natural standard deviations at the wells.

If groundwater quality data indicates no reduction in TCE concentrations in target wells, given sufficient time to distinguish between system and naturally derived trends, this data will be considered along with hydraulic data to determine whether the plume is being adequately captured. The location of the monitoring well(s), the anticipated conditions created by the system at the well(s), data trends for nearby wells, and the technical challenges described above will be considered as part of the evaluation process. If these factors all support a conclusion that there is inadequate capture, then system optimization actions will be taken to remedy the situation. Initial actions will likely take the form of operational modifications, such as increasing pumping rates at one or more of the three extraction wells. Because a groundwater quality response is not nearly as rapid as a hydraulic response, timeframes similar to those indicated in the table above will be required to evaluate the success of the optimization actions on groundwater quality.

7.2 MONITORING AND EVALUATION OF IAO 2

As previously indicated, IAO 2 is to reduce, to the maximum extent practicable, migration of chlorinated solvent-contaminated groundwater to the surface waters of Powder Mill Creek, south of Seaway Boulevard. This will be accomplished by intercepting and hydraulically controlling or diverting groundwater flow paths of the contaminant plume from discharging to Powder Mill Creek on Boeing property, thereby reducing TCE flux into the stretch of creek upstream of the culvert. Reduction in TCE flux to the creek will be accomplished by one or both of the following conditions:

- Reduction of hydraulic gradient toward the creek including potential elimination of the gradient toward the creek whereby flux goes to zero and the creek becomes a losing stream (from the plume side)
- Reduction in concentration of TCE in groundwater discharging to the creek.

It is plausible that the first condition could be observed but not the second because the reduction in gradient will likely be coupled with a change in gradient direction, which could introduce groundwater with a similar or higher TCE concentration to the well. If groundwater pumping produces a losing stream, one would expect concentrations in wells located near the creek to gradually decrease as cleaner creek water is flushed through the aquifer.

The effectiveness of the system and progress toward achieving this remedial objective will be tracked by evaluating TCE flux to the creek and by measuring TCE concentrations within the creek as described in sections 7.2.1 and 7.2.2, respectively.

7.2.1 EVALUATION OF TCE FLUX TO CREEK

The flux of TCE to the creek will be evaluated both before and after initiation of extraction system operations. The TCE flux will draw from elements of hydraulic measurements and groundwater quality as described in the sections below. Using hydraulic gradient data, groundwater quality data, and hydraulic conductivity data (established through grain size analysis of newly installed wells and piezometers), TCE flux will be calculated as follows:

The TCE flux to the creek at a given location can be defined as follows:

$$\mathbf{\Phi_{TCE} = vc} \qquad \text{(Eqn. 7-1)}$$

Where,

$\mathbf{\Phi_{TCE}}$ = hydraulic flux of TCE into the creek (µg/ft^2*sec)

v = groundwater specific discharge or volumetric flux (ft/sec) = -Ki

where,

i = hydraulic gradient perpendicular to the creek (determined from piezometers pairs adjacent to the creek, and monitoring wells), and K = hydraulic conductivity (determined through grain size analysis, aquifer testing, or previously identified conductivity – i.e., from RI report)

c = groundwater concentrations from well or piezometer adjacent to the creek (µg/L).

From Equation 7-1 and as discussed earlier, flux to the creek can be reduced by either reducing the hydraulic gradient toward the creek or by reducing the concentration of TCE in the groundwater discharging to the creek. Hydraulic gradient monitoring is described below in Section 7.2.1.1 and groundwater quality monitoring for flux evaluation is described in Section 7.2.1.2.

7.2.1.1 Hydraulic Gradient Monitoring for Flux Evaluation

The reduction in flux to Powder Mill Creek due to reductions in the groundwater hydraulic gradient toward the creek will be estimated by evaluating overall groundwater flow patterns toward Powder Mill Creek and by comparing before pumping and after pumping calculated hydraulic gradients at individual well pairs located along the east bank of Powder Mill Creek. Similar to the hydraulic control demonstration for IAO 1 (and as part of the overall TCE flux evaluation described above), groundwater elevation measurements will be collected before and after initiation of groundwater extraction from the new and existing monitoring wells and piezometers to determine the actual effect of sustained pumping at the three extraction wells. Field measurements will be used to determine actual groundwater table drawdown and interpolate groundwater contours.

Groundwater elevation maps will be prepared to qualitatively compare gradients toward Powder Mill Creek before and after the initiation of pumping. To accurately prepare these maps, the additional wells, piezometers, and staff gauges (i.e., those not already specified as IAO 1 Target Hydraulic Control Monitoring Points in Table 7-1) included in Table 7-3 below will be gauged monthly for the first 3 months after system operation and then semi-annually in conjunction with the current April and October groundwater level monitoring events.

TABLE 7-3 TARGET GROUNDWATER HYDRAULIC CONTROL MONITORING POINTS (IAO 2)

Existing Monitoring Wells	New Creekside Piezometer Pairs	Powder Mill Creek Staff Gauges
EGW082 EGW083 EGW084 EGW132	New piezometer pair PMG-P12 and PMG-P13 adjacent to creek WSW of EGW183 New piezometer pair PMG-P14 and PMG-P15 adjacent creek NW of EGW183 New piezometer pair PMG-P16 and PMG-P17 adjacent to creek NNW of EGW183 New piezometer pair PMG-P18 and PMG-P19 adjacent to creek SW of EGW175	SG-2 SG-2A New staff gauge SG-2B SG-3

To obtain a more quantitative assessment of the hydraulic gradient reduction due to pumping, the hydraulic gradient between the two piezometers that make up each piezometer pair in Table 7-3 above will be calculated for before and after pumping conditions. The percent reduction in the before pumping and after pumping hydraulic gradients will be used to assess the percent reduction in flux due to changes in the gradient because flux is directly proportional to the gradient.

Based on hydraulic gradient changes created by the extraction system, TCE flux should be reduced or eliminated relatively quickly over most of the target area of the creek after initiation of system operations due to a reduction in the gradient toward the creek or establishment of a gradient reversal such that TCE-contaminated groundwater no longer discharges to the creek. Unless physical or operational changes are made to the system, this gradient induced flux reduction should remain relatively constant. If groundwater conditions, based on groundwater elevation monitoring data (along with TCE flux calculations as described above), indicate that the plume is not adequately being controlled from discharging to the creek, system optimization actions (as previously described) will be taken to remedy the situation.

7.2.1.2 Groundwater Quality Monitoring for Flux Evaluation

Groundwater quality will be monitored adjacent to Powder Mill Creek to evaluate whether the extraction system is having a direct impact on groundwater prior to potential discharge to the creek.

Specifically, groundwater samples will be collected from the following locations once prior to system startup and then on a quarterly basis for the first year. Additional monitoring at these locations, if needed, will be per the schedule presented in the effectiveness review document (and as approved by Ecology):

TABLE 7-4 TARGET GROUNDWATER QUALITY MONITORING POINTS (IAO 2)

Monitoring Well/Piezometer
EGW084
New piezometer PMG-P12 adjacent to creek WSW of EGW183
New piezometer PMG-P14 adjacent creek NW of EGW183
New piezometer PMG-P16 adjacent to creek NNW of EGW183
New piezometer PMG-P18 adjacent to creek SW of EGW175

Groundwater quality monitoring data will be tabulated and evaluated after each sampling event for indications of statistically significant changes. If no reduction in TCE concentrations in groundwater quality is observed (along with TCE flux evaluation as described above), physical and/or operational modifications to the system (as previously described) will be considered to optimize TCE flux reduction to the creek.

7.2.2 SURFACE WATER QUALITY MONITORING

Surface water quality will be monitored prior to startup of the groundwater extraction system, quarterly for the first year of system operation, and then will continue to be monitored during normally scheduled semiannual creek sampling events to evaluate the direct impact that the extraction system is having on TCE concentrations in the creek. Creek surface water samples will be collected using procedures consistent with the current protocols used during semiannual PMG surface water sampling events. If schedule and weather permit, sampling will generally be conducted when baseflow conditions prevail (i.e., after at least 2 days without precipitation) to maximize comparability of new data with historical Powder Mill Creek surface water data.

In addition to the currently monitored creek sampling locations, surface water quality samples will be collected at seep sampling location SW-PMG108 and just upstream of the treatment system outfall at surface water sampling location SW-PMG108N. The results from each surface water sampling location will be evaluated in relation to the remedial objective.

It is recognized that the groundwater treatment system will be discharging to the creek between creek sampling location SW-PMG108N and staff gauge SG-2 and that the effluent will dilute TCE concentrations in the creek. Therefore, the samples collected upstream and downstream of the mixing zone of the treatment system outfall into Powder Mill Creek (SW-PGM108N and SW-PMG4, respectively) will be used as a "background" sample for each sampling event against which downstream samples will be compared to observe for inputs of TCE into the creek. Additionally, a new stream flow gauging station will be installed just upstream of the culvert under Seaway Boulevard in order to provide a consistent and relatively accurate flow measurement at the stream sampling point at SG-3 (SW-PMG19). This flow measurement can be used to calculate a corrected TCE concentration in the stream at this location for comparison against historical data collected at this location.

The measured TCE concentrations at SG-3 (SW-PMG19) will be corrected in order to compare against pre-interim action creek concentrations as follows:

$$C_{corrected} = (C_{measured} \times Q_{measured})/Q_{baseflow} \quad \text{(Eqn. 7-2)}$$

Where,

$C_{corrected}$ = creek TCE concentrations corrected for dilution (µg/L)

$C_{measured}$ = creek concentrations measured by laboratory at sampling location (µg/L)

$Q_{measured}$ = creek flow measured at sampling location [cubic feet per second (ft^3/sec)], the new stream gauging station at SG-3 will provide a consistent and relatively accurate $Q_{measured}$

$Q_{baseflow}$ = creek flow at sampling location without treatment system outfall contributions (ft^3/sec), i.e., $Q_{measured} - Q_{outfall}$ where, $Q_{outfall}$ = flow from treatment system outfall

The new stream gauge station to be installed just upstream of the culvert under Seaway Boulevard will provide a consistent and relatively accurate $Q_{measured}$ at the stream sampling point at SG-3 (SW-PMG19).

Because there will not be gauging stations or stream gauging flow measurements collected at each of the other sampling locations downstream of the outfall during each sampling event, the specific flows of the creek at a given sampling location (i.e., $Q_{measured}$ and $Q_{baseflow}$) will not be known. Therefore, this correction will not be applied at the other sampling locations unless discharge measurements are collected at that specific sampling location at the time sampling occurs.

Recognizing that there are inherent uncertainties in this methodology, surface water quality data will be used only as a general indicator of the impact of the groundwater extraction system on surface water quality and will likely not be used directly to make decisions on the operations or configuration of the system.

7.3 IAO EVALUATION SUMMARY

8.0 REPORTING

The following reports are currently agreed upon and required submittals associated with this interim action.

8.1 CONSTRUCTION REPORT

8.2 BI-MONTHLY STATUS REPORTS

8.3 ANNUAL SUMMARY REPORT

9.0 SCHEDULE AND SUBMITTALS

The final schedule for design and construction will be dependent on Ecology administrative proceedings (i.e., comment/approval of this work plan), and approval of the NPDES and other pertinent permit applications. However, the current estimated schedule for implementation is:

- TBD

9.1 PERMITS AND APPROVALS

Based on the system design described herein, the following permits and approvals will be needed to implement the selected IA:

- NPDES permit – Ecology (Water Quality Division)
- NPDES permit application and Engineering report to be submitted to Ecology – Water Quality for discharge of treated groundwater to Powder Mill Creek
- Joint Aquatics Resource Permits Application (JARPA)
- U.S. Army Corps of Engineers – Nation Wide Permit (NWP) No. 6 (Survey Activities) for monitoring well installation within boundaries of wetland
- WDFW – HPA for outfall construction
- Critical Areas/Wetlands Buffer Work Authorization – City of Everett
- For work within wetland buffer zone
- State Environmental Policy Act (SEPA) review – Ecology.

Based on WAC 197-11-250 through -268, as adopted by City of Everett municipal code (EMC 20.04), a SEPA threshold determination [i.e., determination of significance (DS) or determination of non-significance (DNS)] is required to be made by the SEPA lead agency. For remedial actions conducted under an agreed order, Ecology is the lead agency. Ecology shall make a threshold determination "at the point at which adequate information is available to evaluate the environmental impacts of the remedial action, but no later than the draft cleanup action plan." For an IA, issuance of a DNS may be combined with the public notice of the IA:

- Building/Electrical/Mechanical Permits – City of Everett
- Required for commercial construction projects within City of Everett
- Public Works Permit – City of Everett.

9.2 OTHER PERMITTING

Depending on the final location and design of the system, these additional permits and approvals may also be required:

- TBD

9.3 CONSTRUCTION SCHEDULE

9.4 MAINTENANCE SCHEDULE

9.5 MONITORING SCHEDULE

Monitoring of the system operations and performance will be performed on the following schedule:

9.5.1 MONITORING OF SYSTEM EFFLUENT (WATER AND AIR)

Water samples from the treatment system effluent will be collected initially as described under the startup procedures in Section 5; weekly for one month after startup, then monthly thereafter (or as otherwise specified in the NPDES permit conditions). Air discharge samples from the air stripper effluent stack will be collected on a monthly basis.

9.5.2 GROUNDWATER QUALITY MONITORING

Groundwater sampling and analysis at the wells will be conducted as identified in Section 7 and in conjunction with the PMG Groundwater Quality Monitoring program.

9.5.3 SURFACE WATER QUALITY MONITORING

Surface water sampling and analysis at the staff gauges and sampling points will be conducted as identified in Section 7 and then concurrently with groundwater sampling activities.

9.5.4 HYDRAULIC MONITORING

Groundwater and surface water elevation data at the piezometers, wells, and staff gauges will be manually gauged and measured as identified in Section 7and then in conjunction with the overall PMG monitoring schedule. Groundwater levels within the extraction wells will be monitored continuously by the PLC with groundwater level probes (pressure transducers).

10.0 CONDITIONS FOR TERMINATING INTERIM ACTION

The IA described herein is intended as a bridge from the RI to the final remedy, and it is anticipated that the GET system will be incorporated into or supplanted by the final remedy. Therefore, this IA will be considered complete upon formal initiation of the final remedy; when it is demonstrated that the IAOs are being met without operation of the system; or when it is otherwise agreed upon by Boeing and Ecology that the interim action is no longer serving a useful, necessary, or practical function. Demonstration that the IAOs are being met would include showing that TCE concentrations in groundwater on Boeing property have diminished to the point that groundwater discharge off the Boeing property and into Powder Mill Creek south of Seaway Boulevard are no longer a risk to human health and the environment.

11.0 USE OF REPORT

This Downgradient Plume Interim Action (Phase 1) Work Plan has been prepared for the exclusive use of The Boeing Company for specific application to the PMG project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

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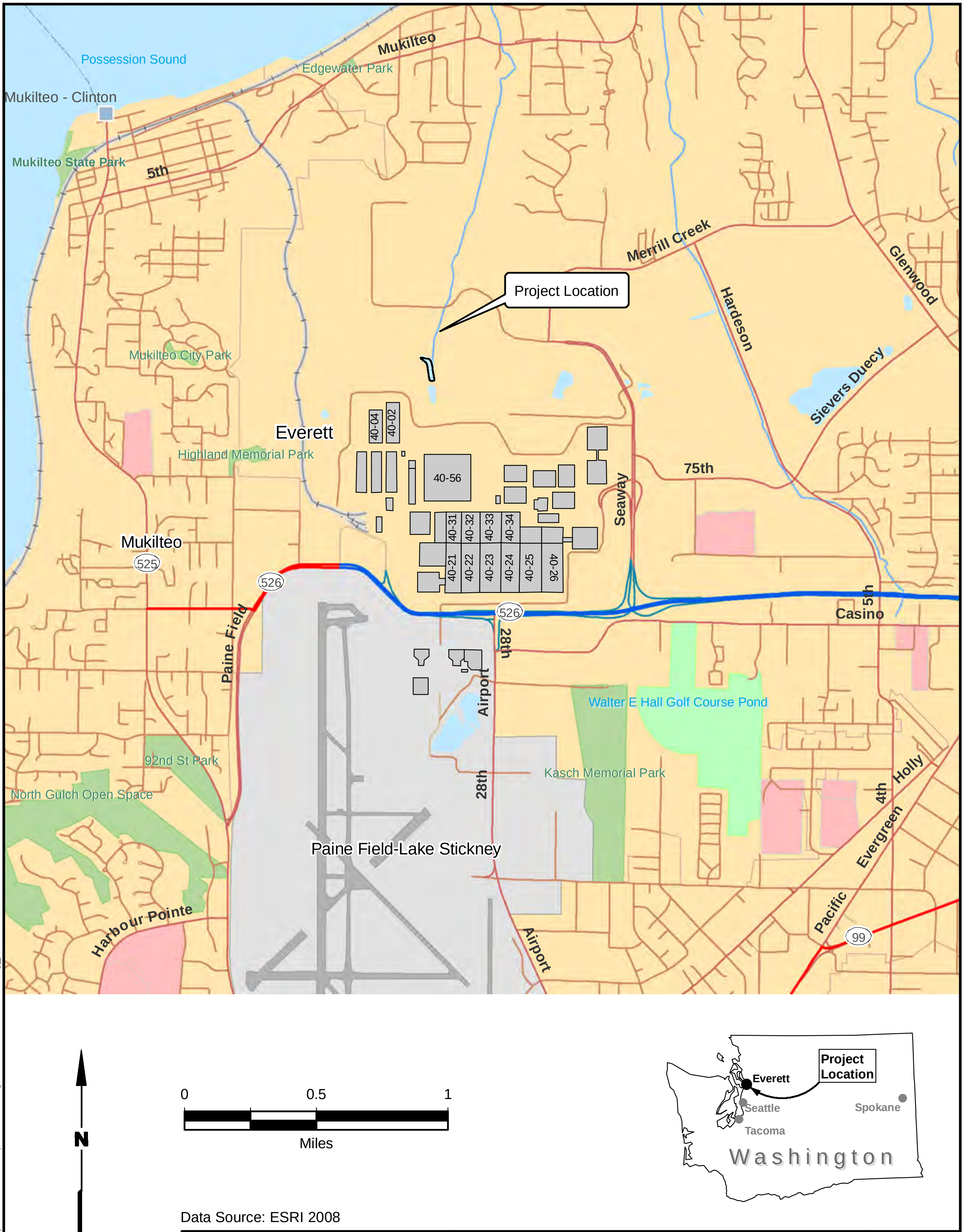

Data Source: ESRI 2008

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Landau Associates

Powder Mill Gulch Boeing Everett, Washington	**Vicinity Map**	Figure 1

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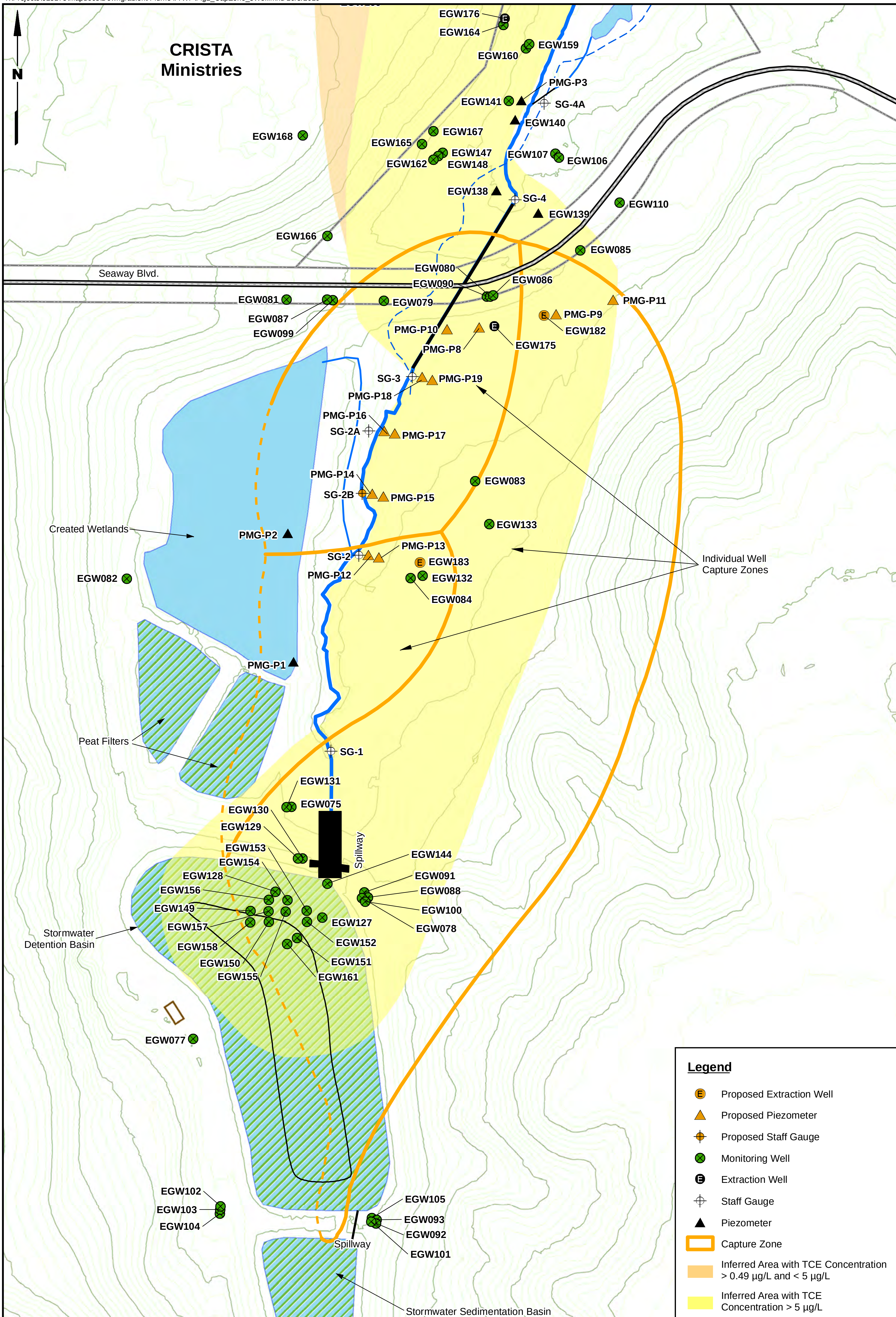

0 150 300

Scale in Feet

Base map sources: URS 2005; City of Everett 2005
LIDAR data source: URS 2005 (Data collected November 2005)

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Powder Mill Gulch
Boeing Everett, Washington

Conceptual Design of Proposed Interim Action

Figure 2

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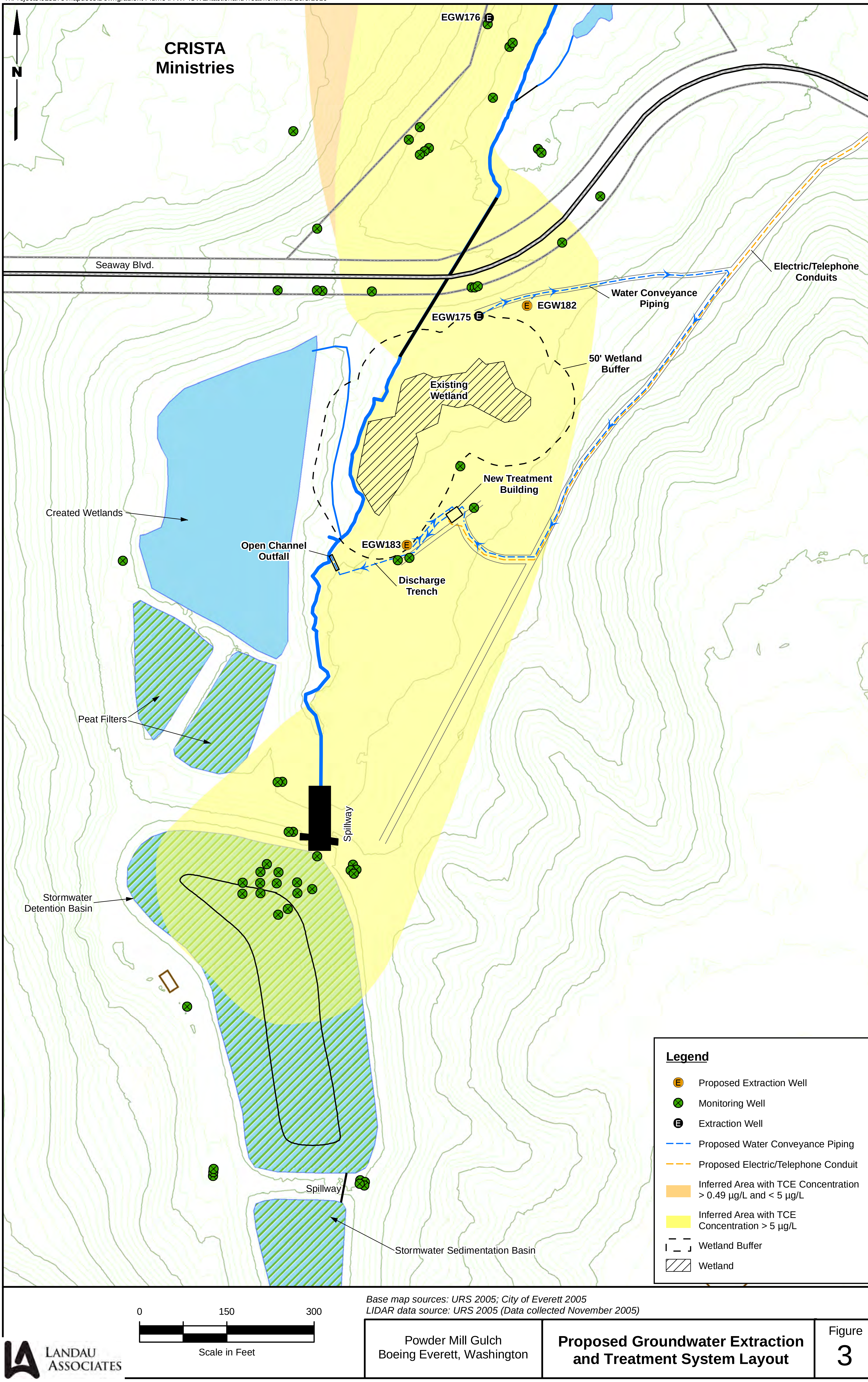

Base map sources: URS 2005; City of Everett 2005
LIDAR data source: URS 2005 (Data collected November 2005)

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Powder Mill Gulch
Boeing Everett, Washington

Proposed Groundwater Extraction and Treatment System Layout

Figure 3