The Boeing Company
P.O. Box 3707
Seattle, WA 98124-2207

September 8, 2017
DAT-2017-065

Mr. Raman Iyer
Section Manager
Washington State Department of Ecology, Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

Subject: Formal Dispute Resolution – Ecology's Final Decision under Informal Dispute Resolution Regarding the Upland Feasibility Study Report, dated July 20, 2017, and Written Statement of Boeing's Position on Disputed Items for the Boeing Everett Facility

Dear Mr. Iyer:

We have carefully reviewed the Washington State Department of Ecology (Ecology) letter dated July 20, 2017, *Final Decision under Informal Dispute Resolution Regarding the Draft Feasibility Study (FS) Report for Upland Areas and Powder Mill Gulch,* dated November 16, 2015 (Ecology 2017) for the Boeing Everett facility. We appreciate the time Ecology took to document its final decision. Ecology's final decision letter has been helpful in thoroughly identifying the basis and key assumptions of Ecology's decision. We appreciate this opportunity under the formal dispute resolution process[1] to further elaborate on the key technical and regulatory issues and more clearly explain where the differences in our understanding of Ecology's decision still lie so that the draft cleanup action plan (CAP) will be fully compliant with the Model Toxics Control Act (MTCA) and the Clean Water Act (CWA) and provide for the most effective protection of human health and the environment. We look forward to meeting with you, Neal Hines, and Darin Rice after you have reviewed the enclosed information with your team so that we can reach mutual agreement on the best solution and move forward with the next phase of the process toward implementation of the final remedy.

To provide a short background for your review, Boeing submitted the Draft FS to Ecology for approval in November 2015 (AECOM/LAI 2015). Boeing provided the FS to Ecology consistent with its obligation to perform corrective action at its Everett facility (see attached FS Figure 1-2). Under the Agreed Order (AO), Boeing conducts corrective action in accordance with Washington's cleanup law, the MTCA, Revised Code of Washington 70.105D. Comments on the FS were received from Ecology in August 2016 (Ecology 2016), and Boeing submitted responses to Ecology's comments and requested informal dispute resolution in September 2016 (Boeing 2016). Since that time, Ecology and Boeing have participated in informal dispute resolution per the process stated in the AO to resolve Ecology's issues with the draft FS. In the informal dispute resolution process, Boeing agreed to implement many of Ecology's requirements, but there remain important issues that could not be agreed upon. Ecology provided a final decision letter to Boeing on July 20, 2017 (Ecology 2017), that requires Boeing to either agree to all of Ecology's requirements or to invoke formal dispute. It is Boeing's position that Ecology's decisions on the remaining unresolved issues are not consistent with the

[1] In accordance with Agreed Order DE-96HS N274 Section VII.10>B as amended 2006, 2011

elements that Boeing has proposed to resolve the dispute and finalize the FS.

The primary issues that remain in dispute include the following:

- Remedy selection for the Powder Mill Gulch trichloroethene (TCE) groundwater plume. Ecology's articulated preference includes bioinjections proximate to the existing groundwater extraction and treatment (GET) system. Boeing's analysis has concluded that these bioinjections will foul the GET system, damaging its ability to successfully treat and contain the TCE plume. Boeing has offered an alternative solution that addresses Ecology's concerns and that does not pose the same level of risk of harmful discharges to the environment.
- Remedy selection for upland solid waste management units (SWMUs) and areas of concern (AOCs); specifically, the terms under which future excavation or soil vapor extraction at certain SWMUs/AOCs will be triggered.
- The application of surface water criteria to groundwater across the site and as the basis for soil cleanup levels at upland SWMUs/AOCs, which is inconsistent with MTCA and unlawful under Washington and applicable federal law.
- Denial of the MTCA-authorized use and application of remediation levels for cleanup approach transition and decision making
- Denial of the MTCA-authorized use and application of conditional points of compliance under appropriate conditions.
- Requests for unnecessary compliance monitoring not required by the MTCA regulation and that are in addition to Boeing's proposed monitoring at points of compliance.

Attachment 1 and Attachment 2 address the disputed elements of Ecology's final decision specific to the Powder Mill Gulch TCE plume and the upland SWMUs/AOCs. These two attachments are organized by specific key topic area (e.g., areas of agreement followed by areas of disagreement, including remedy selection, cleanup standards, monitoring requirements, and other). Attachment 3 provides a legal memo that focuses on Ecology's lack of authority to apply surface water criteria to groundwater and soil cleanup levels under MTCA. Additional supporting documentation is provided as attachments to Attachments 1 and 2 including a third-party technical review of Powder Mill Gulch TCE plume remedy selection; un updated restoration timeframe evaluation, additional biofouling information, and proposed cleanup levels and remediation levels associated with the Powder Mill Gulch TCE plume; and fate and transport modeling for the upland SWMUs/AOCs. The attachments provide new and/or supporting information that are essential to Ecology's evaluation of Boeing's position and the successful resolution of these important issues.

A brief summary of the disputed issues is presented below.

Summary of Remaining Disputed Items

Remedy Selection

Powder Mill Gulch TCE Plume

Boeing has successfully performed several interim actions (IAs) to address the 3,000-foot-long TCE plume at Powder Mill Gulch (see attached Figures 1 and 2). These IAs have included performing electrical resistance heating and supplemental bioremediation in the source area that successfully reduced TCE concentrations from over 30,000 micrograms per liter (µg/L) to less than 400 µg/L (see Figure 3), and installation and operation of an extensive GET system in the downgradient plume that is consistently reducing the TCE levels in the Powder Mill Gulch TCE plume (from around 800 to 1,000 µg/L in the highest concentration areas to around 300 µg/L or less in the last 2 to 5 years; see Figure 4) and in the adjacent surface water of Powder Mill Creek (from over 15 µg/L to less than 4 µg/L; see Figure 5). Because the performance sampling data demonstrate the success of the source area IAs and the ongoing success of the GET system in containing and reducing TCE concentrations in the downgradient plume, Boeing selected FS Alternative 1 (continued GET system operation with institutional controls and supplemental cleanup technologies, as necessary) as the preferred remedy. Although it was demonstrated as using permanent solutions to the maximum extent practicable through the MTCA Disproportionate Cost Analysis (DCA) process and it met the other applicable MTCA criteria for a final cleanup action, Ecology rejected Alternative 1. However, after careful consideration of Ecology's expectations for additional mass reduction through bioremediation, Boeing proposed performing FS Alternative 2 (source area bioremediation and continued GET system operation in the downgradient plume).

In its final decision letter, Ecology rejected Boeing's proposal and instead seeks a modified version of FS Alternative 4 that includes bioremediation throughout the entire plume (as opposed to bioremediation in the source area) with concurrent GET system operation. Ecology's approach presents significant risk of fouling GET system extraction wells and treatment system, which could result in failed hydraulic containment of the TCE plume and likely result in releases of TCE, as well as vinyl chloride, arsenic, and other deleterious substances generated through the bioremediation process, to Powder Mill Creek. Boeing has demonstrated conclusively with site-specific data and nationally recognized bioremediation experts that the combination of bioremediation and groundwater extraction and treatment is risky for the environment and unjustifiably costly. Additionally, preventive measures, maintenance, and mitigation of these impacts is difficult, not cost effective, and ultimately ineffective in the long term. Attachment 1 provides new supporting information regarding the risks of performing bioremediation throughout the plume in conjunction with the GET system for Ecology to review and re-evaluate its position and consider a final remedy (Alternative 2) that includes bioremediation in the source area, but does not conflict with the operation of the GET system or result in risks associated with the combination of technologies in the same areas. Based on the benefits of performing Alternative 2, as compared to the risks of performing Ecology's modified version of Alternative 4 (with an estimated cost of over $9 million more than for Alternative 2), Alternative 2 should be identified as the preferred alternative under MTCA.

Upland Areas

The draft FS proposes "Maintain Containment" as the preferred cleanup action for 11 SWMUs/AOCs because it meets MTCA requirements, there is no risk to human health and the environment under this scenario, and the remedy is permanent to the maximum extent practicable (as determined following MTCA's DCA process). Additionally, as stated in the FS, Boeing has proposed to excavate or otherwise remediate these areas when there is an opportunity for construction access that does not impact facility operations. For 8 of these SWMUs/AOCs, Ecology is requiring that Boeing implement future excavation or future soil vapor extraction (SVE) as the final remedy within a specific timeframe unrelated to construction access (regardless of the impact to on-going facility operations) in conjunction with "Maintain Containment" in the interim.

Consistent with its position in the informal dispute resolution process, Boeing agreed to conduct future excavation or SVE when the areas become accessible without unnecessarily impacting facility operations. Boeing has proposed language that is sufficiently binding and is resubmitted in Attachment 2 for Ecology review. While we cannot commit to excavation or SVE by a certain date, we can agree to mutually agreeable language to incorporate into the draft CAP that defines the requirements for future excavation and future SVE.

Cleanup Standards

Applicability of Surface Water Quality Standards (SWQS) to Groundwater and Soil Cleanup Levels

Consistent with the MTCA regulation, Boeing has proposed the use of MTCA Method B cleanup levels for the site, which include cleanup levels for groundwater and soil based on protection of drinking water and for surface water based on protection of surface water beneficial uses (drinking water and fish consumption). These cleanup levels are consistent with MTCA and are conservative considering that, under existing and likely future site use conditions, there are no risks to human or ecological receptors. For Powder Mill Gulch, Boeing also recognizes that to meet site cleanup standards, the cleanup levels for both surface water and groundwater must be met in their respective media, otherwise the groundwater remedial action will not be considered complete. The application of surface water quality standards (SWQS) as the basis for cleanup levels for groundwater throughout the aquifer and soil in the upland areas, as sought by Ecology, is not authorized under Washington or applicable federal law.

Application of a Conditional Point of Compliance

In informal dispute resolution, in an attempt to develop a MTCA-compliant cleanup level, Boeing proposed a MTCA-based solution that would demonstrate compliance if the SWQS are applied to groundwater by offering the use of a conditional point of compliance (CPOC) for the TCE plume in Powder Mill Gulch. However, Ecology has demurred, stating that the site does not meet the requirements for use of a CPOC (specifically, that the cleanup level can be reached within a reasonable timeframe). Boeing respectfully, but strongly, disagrees. Objectively, the projected difference in achieving cleanup levels is insignificant given the length of the cleanup timeframe (53–59 years) for all remedy options given the site conditions. Boeing's recommended solution of establishing a CPOC should be approved by Ecology as warranted under MTCA and Ecology's authority if, through the formal dispute resolution process, it is determined that SWQS will be applied to groundwater.

Use of Remediation Levels

As authorized and allowed under MTCA, Boeing proposed the use of remediation levels to determine when the cleanup should move from operation of the GET system to monitored natural attenuation. The proposed remediation levels, which are based on a reasonable maximum exposure scenario protective of the actual current and likely future receptors at the site, provide reasonable decision-making criteria for discontinuing use of the GET system at the end of its useful or productive performance period. Ecology did not approve of the use of remediation levels for discontinuing operation of the GET system, reasoning that the GET system will be necessary to protect surface water until the cleanup levels for groundwater and surface water have been met. However, Ecology's concern is addressed by Boeing's proposed contingencies for continuation or restart of system operations in situations where it is evident that the GET system is still necessary for cleanup or protection of the creek. This shutdown and restart of a groundwater treatment system is common at MTCA sites where these systems have reached the end of their useful period of performance. We request that Ecology reconsider the merits of allowing the use of remediation levels so that Boeing is not required to continue operation and maintenance of the GET system beyond when it is beneficial to achieving cleanup levels.

Additional Compliance Monitoring

Soil Gas/Indoor Air

Ecology is requiring routine sub-slab vapor or soil gas sampling and indoor air sampling as part of compliance monitoring at 11 SWMUs/AOCs. Boeing has agreed to conduct routine indoor air monitoring at 7 of these locations where the sub-slab vapor concentrations exceed screening levels, and to conduct sub-slab vapor sampling at 2 additional SWMUs/AOCs to determine whether a complete pathway for vapor intrusion exists. If a complete pathway is demonstrated by sub-slab vapor results, Boeing will conduct indoor air monitoring for these SWMUs/AOCs. Sub-slab vapor or soil gas monitoring is not warranted because (1) sub-slab vapor and soil gas are not considered points of compliance under MTCA, and (2) Boeing has agreed to monitor indoor air at locations at risk for a complete vapor intrusion pathway. For these reasons, Boeing requests that Ecology accept the SWMU/AOC-specific monitoring proposed.

Additionally, Ecology is requiring long-term monitoring of soil gas at Powder Mill Gulch even though a Tier 1 soil gas assessment completed during the remedial investigation identified no soil gas concentrations above screening levels. Boeing has agreed to conduct seasonal sampling to evaluate whether soil gas concentrations remain below Ecology screening levels under varying seasonal conditions. If this evaluation confirms that soil gas is below screening levels, further soil gas monitoring is not required under MTCA because indoor air is not an identified media of concern. Ecology should only require additional sampling if site conditions change in a manner that would result in an increase in soil gas concentrations (e.g., significant increase in groundwater TCE concentrations beneath a building footprint).

Deep Groundwater Monitoring Wells

As part of compliance monitoring, Ecology is requiring additional deep groundwater monitoring wells at 13 SWMUs/AOCs to monitor for potential leaching of contaminants to the deep Esperance Sand aquifer. Ecology and Boeing agreed that new wells are not needed for SWMUs/AOCs 083, 169, or 170 and that other SWMUs/AOCs may be combined for the purposes of monitoring at the same deep well. However, Boeing maintains that installation of deep wells near contaminated soil presents a significant risk of transporting soil contamination to the aquifer that is not warranted for SWMUs/AOCs without perched groundwater because the vadose zone modeling demonstrates that the soil contamination in areas with no groundwater recharge (*i.e.*, impermeable cap) will never reach the Esperance Sand aquifer. Boeing requests that Ecology reduce the requirements for deep groundwater monitoring to SWMUs/AOCs where perched groundwater is present and to use existing deep groundwater monitoring wells where they exist in these areas as further described in Attachment 2.

New Requirements in Final Decision Letter

Ecology added new requirements for cleanup actions in the informal dispute resolution process throughout its final decision letter. We are not aware of an AO or MTCA provision that authorizes Ecology to determine new cleanup action elements through a dispute resolution decision. Instead, the AO's dispute resolution process is to resolve a decision by Ecology. Ecology's current MTCA AO boilerplate dispute resolution section does not alter this process.

- As further described in Attachment 2, Ecology is now, for the first time in its final decision letter, requiring lower soil cleanup levels protective of groundwater cleanup levels equal to surface water Applicable or Relevant and Appropriate Requirements (ARARs) at all SWMUs/AOCs, rather than at only Building 40-56, as required in the agency's original comment letter to the FS. Boeing does not agree that soil cleanup levels need to be protective of groundwater cleanup levels that are equal to surface water ARARs as discussed in the attachments and Memorandum of Law (Attachment 3). Furthermore, this is a significant change that has not been previously discussed by Ecology and Boeing during the informal dispute resolution process and needs further clarification and resolution.
- It is also unclear from Ecology's final decision document whether Ecology has added indoor air and soil gas monitoring for two additional SWMUs/AOCs (No. 165 and UST EV-48-1), which was not required in the agency's original letter. Boeing does not agree to indoor air and soil gas monitoring for these two additional SWMUs/AOCs since no vapor intrusion pathway has been established here and requests clarification on this issue as indicated in Attachment 2.
- Ecology indicates that it is seeking to require additional optimization of the GET system (which has previously included construction of additional extraction wells) to reduce TCE-contaminated groundwater flux to the creek, even though the data from Boeing's quarterly downgradient IA monitoring reports indicate that remedial objectives are being achieved by the current system.

- Lastly, Ecology is now requiring that a standalone CAP be written for the upland and Powder Mill Gulch SWMUs/AOCs, separate from the sediment SWMUs/AOCs. As previously discussed with and agreed to by Ecology, Boeing plans to write a single CAP including the Powder Mill Gulch TCE plume, BOMARC, and the upland and sediment SWMUs/AOCs in order to minimize confusion by the public, expedite the schedule, and minimize costs. Our understanding and experience with CAP development under MTCA is that there is one CAP for the site.

Boeing requests that any new requirements added in the final decision letter be clarified and discussed thoroughly between Boeing and Ecology before a final decision is made.

Unresolved Questions on Original Comment Letter

Boeing requested clarification on several issues in the responses to Ecology's original comments that have not yet been addressed through the informal dispute resolution process. A list of items needing clarification in order to proceed with the draft CAP is included in Attachments 1 and 2.

Closing

Throughout the informal dispute resolution process, Boeing has carefully evaluated each of Ecology's requirements at the upland and Powder Mill Gulch areas. Boeing understands and respects Ecology's important role as regulator for this site. Boeing accepted Ecology's additional requirements where those requirements were required by MTCA and would provide meaningful progress toward cleanup. However, Boeing's technical, scientific, and regulatory analysis is that the remaining unresolved requirements by Ecology are not supported by MTCA, would not provide meaningful cleanup progress, and, in one case, would lead to a worse result for the environment. Boeing is not seeking cleanup actions at this site that are ineffective or that do not require significant investment. Our estimated cost for CAP implementation as submitted by Boeing in the FS is approximately $30 million. The additional requirements included in Ecology's Final Decision letter that are the subject of this dispute resolution process would nearly double this estimate to approximately $60 million. This total cost is in addition to the approximately $6 million Boeing has previously expended on interim actions at the Boeing Everett facility.

Boeing is committed to protecting human health and the environment consistent with the AO and MTCA and to working with Ecology to find technically sound remediation solutions for the Boeing Everett facility that are compliant with MTCA. We appreciate the thorough review by Ecology senior management of the material provided in the attachments and hope you will provide fair consideration of our proposed resolutions. We look forward to meeting with you to discuss resolution of the final scope of the FS.

Please contact me if you have any questions.

Sincerely,

Katie Moxley
Manager, Environmental Remediation
The Boeing Company
(425) 237-1905 (office)
(206) 579-2110 (mobile)

CC (electronic copy):

Darin Rice, Ivy Anderson, Neal Hines, Tom Buroker, Dean Yasuda, Ecology
Steve Shestag, Debbie Taege, Brian Anderson, Stanley Alpert, Alan Sugino, Aparna Emerson, Boeing
Scott Lathrop, Exotic Tool Welding Inc.
Roger Hoot, Dianne Riter, BBNC
Edgar Wellbaum, Well Energy Corp
Greg Bertch, Bertch Capital Partners
Bart Brynestad, Willy Accame, Panattoni Development
Mike Palacios, Heather Griffin, Mark Sadler, Wendy McClure, City of Everett
Chris Wilke, Puget Soundkeeper Alliance

Attachments

Figure 1-2	Site plan
Figure 1	Monitoring Well Locations (Powder Mill Gulch)
Figure 2	Powder Mill Gulch – TCE Concentration Maps
Figure 3	TCE Concentrations – Source Area IA Monitoring Wells (Powder Mill Gulch)
Figure 4	TCE Concentrations – Downgradient Monitoring Wells (Powder Mill Gulch)
Figure 5	TCE Concentrations – Surface Water, Powder Mill Creek and Seeps
Attachment 1	Powder Mill Gulch Attachment
Attachment 2	Uplands Attachment
Attachment 3	Memorandum of Law

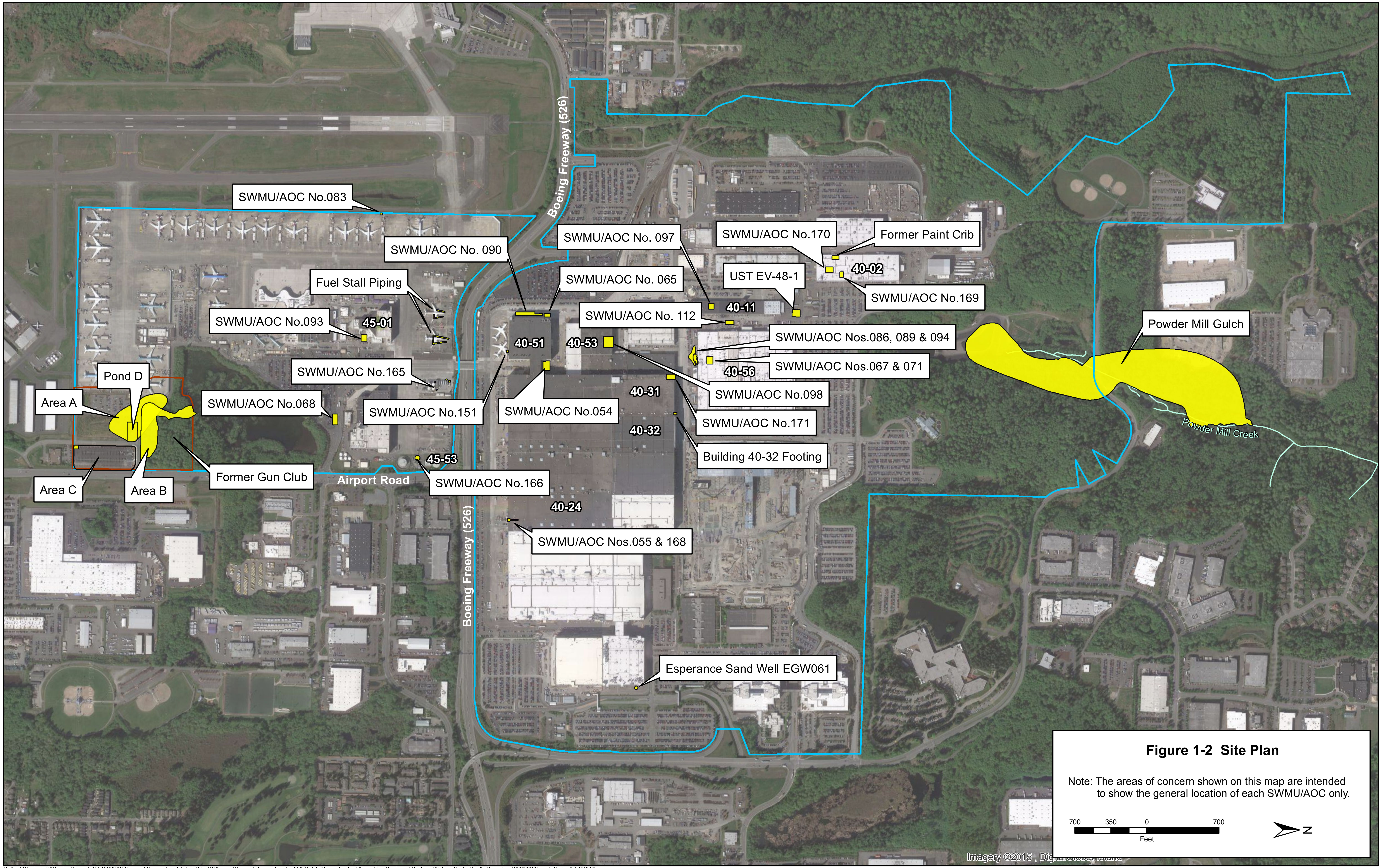
References

AECOM/LAI (AECOM and Landau Associates, Inc.). 2015. *Feasibility Study for Upland Areas and Powder Mill Gulch*, BCA Everett Plant. November 16.

Boeing. 2016. Letter from Deborah Taege (Boeing) to Dean Yasuda (Ecology), Informal Dispute Resolution – Boeing Responses to Ecology's Comments on Draft Uplands and Powder Mill Gulch Feasibility Study Report, dated August 18, 2016. September 19.

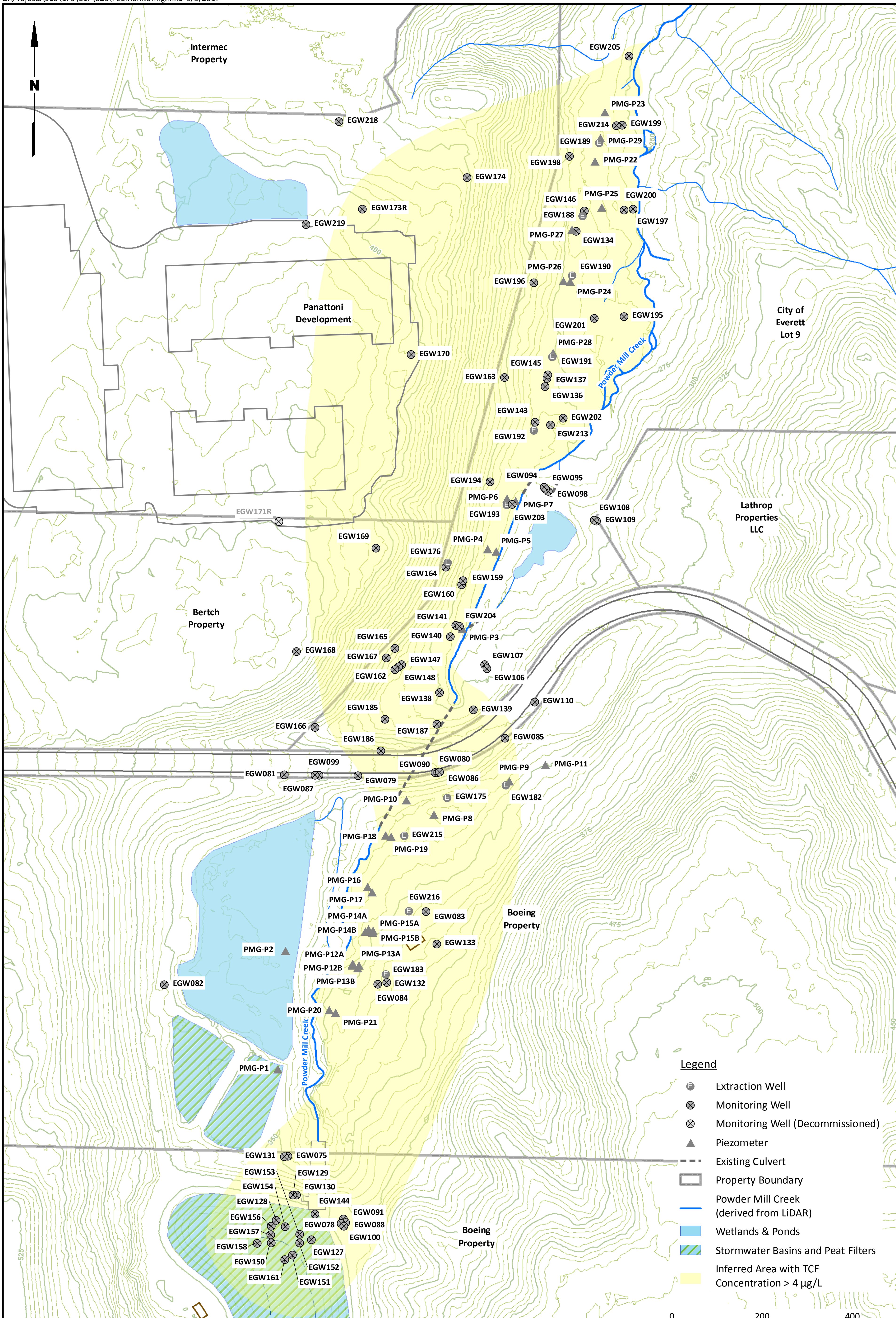
Ecology (Washington State Department of Ecology). 2016. 2016. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Contingent Approval and Modifications to the Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 13, 2015. Washington State Department of Ecology. August 18.

Ecology. 2017. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Final Decision Under Informal Dispute Resolution Regarding the Upland Feasibility Study (FS) Report and Ecology Selected Remedies for the Boeing Everett Site. Washington State Department of Ecology. July 20.



Path: J:\Projects\B\Boeing\Everett CA 2015\09 General Support and Admin\H - GIS\maps\Presentation - Powder Mill Gulch Groundwater Plume Soil Sediment Surface Water _North South Complex_20150908.mxd Date: 9/14/2015

G:\Projects\025\175\117\023\F01Monitoring.mxd 9/5/2017



Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Boeing Commercial Airplanes
Everett, Washington

Monitoring Well Locations

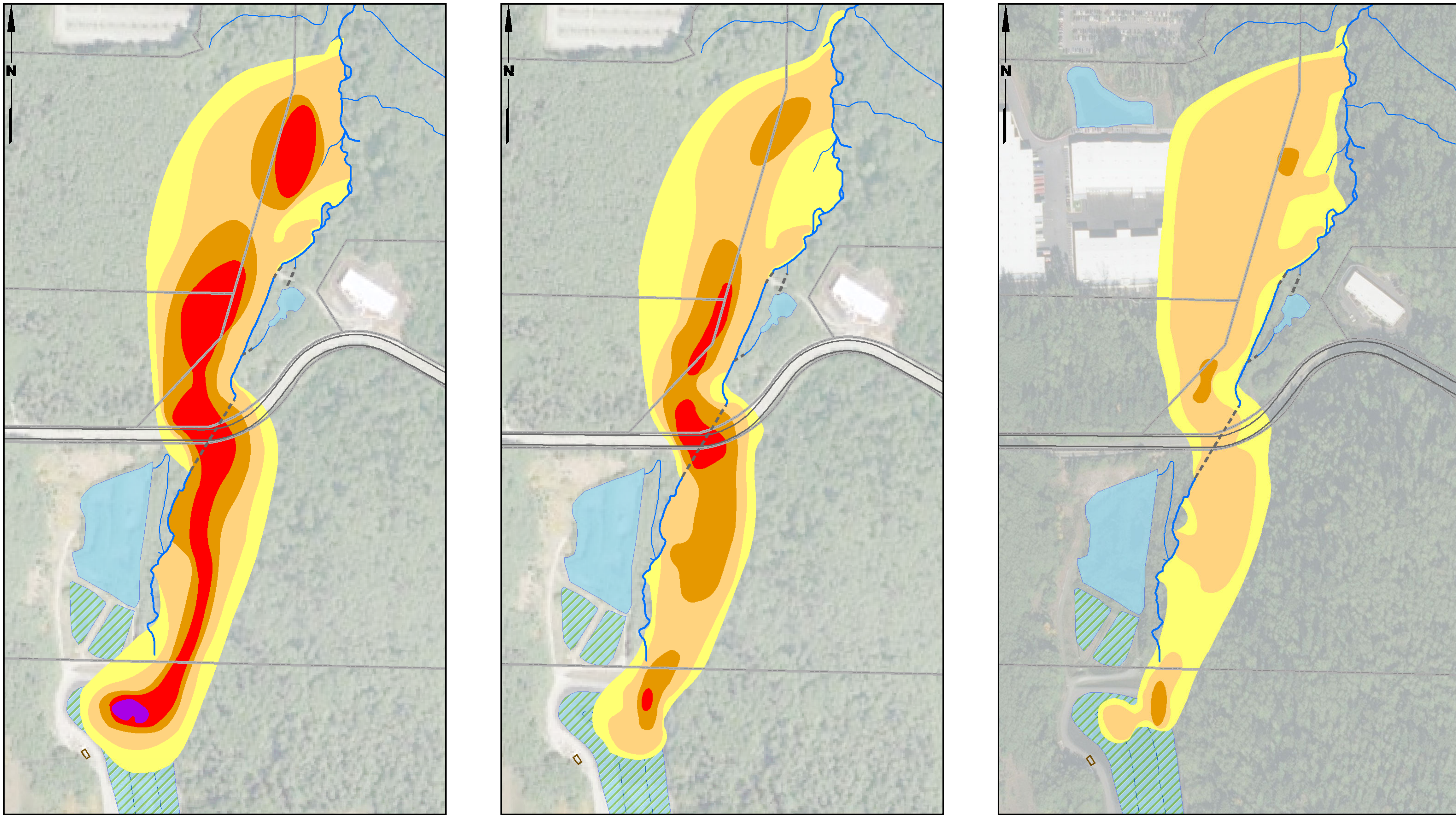
Figure 1

Powder Mill Gulch - TCE Concentration Maps

July 2006 - July 2008
(Prior to ERH/EISB IA in Source Area)

October 2012
(Prior to GET System - Downgradient Plume IA)

October 2016
(GET System - Downgradient Plume IA - Year 4)

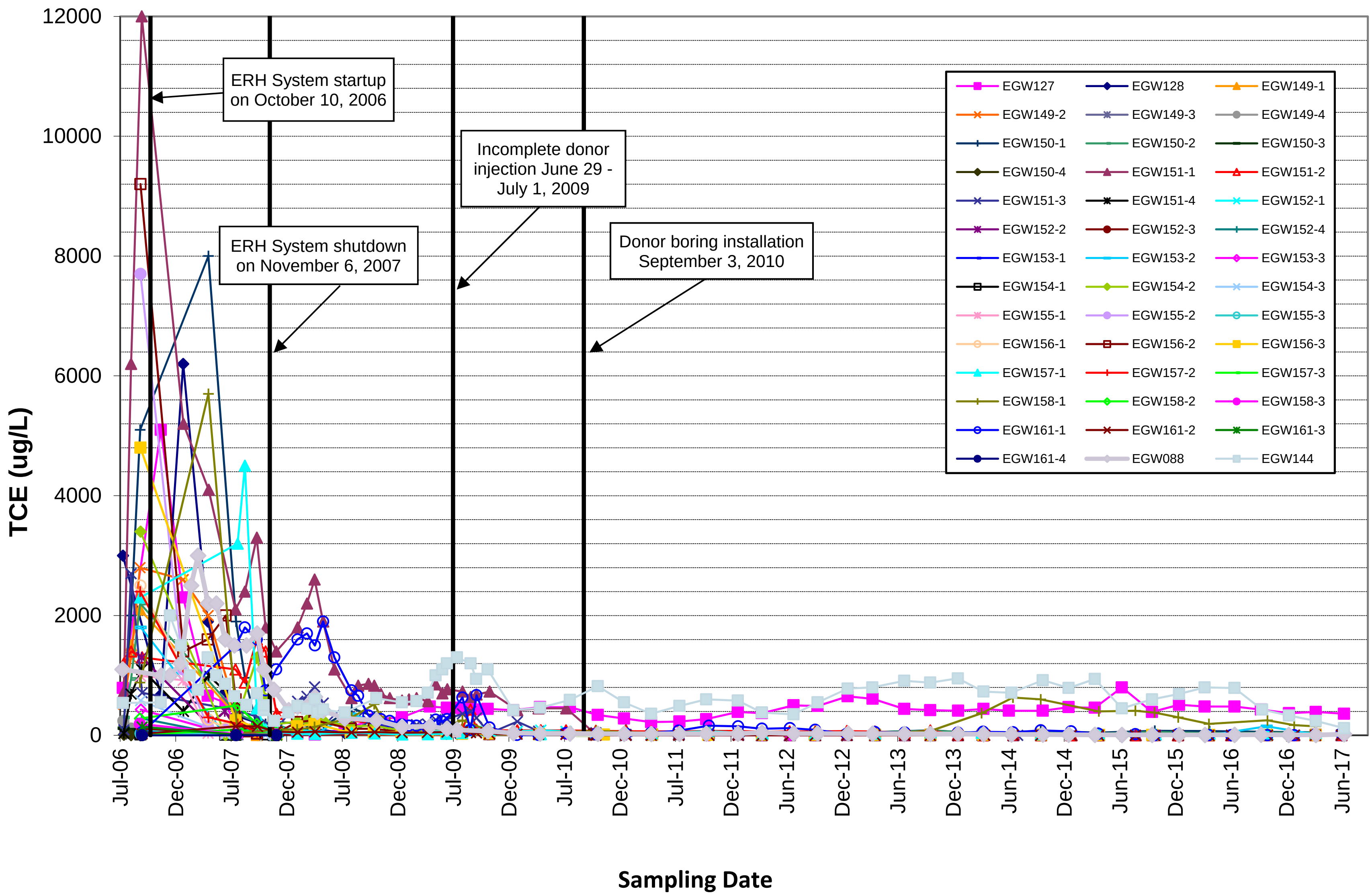


Landau Associates

Legend
4 ≤ TCE <25 µg/L
25 ≤ TCE <250 µg/L
250 ≤ TCE <500 µg/L
500 ≤ TCE <2,500 µg/L
TCE ≥ 2,500 µg/L

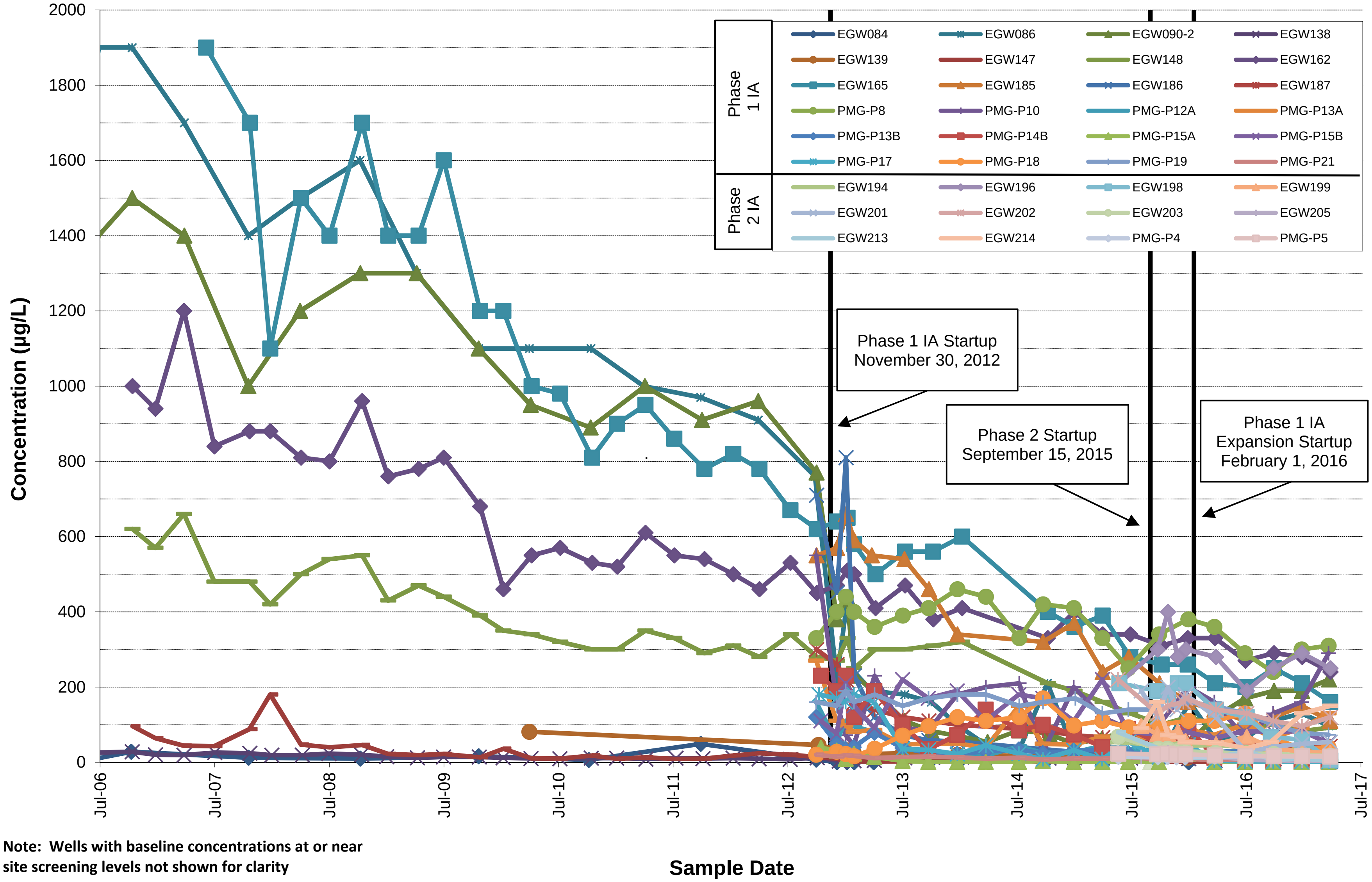
0 350 700
Scale in Feet

Figure 2



LANDAU ASSOCIATES

Source Area Powder Mill Gulch Boeing Everett, Washington	**TCE Concentrations – Source Area IA Monitoring Wells**	Figure 3



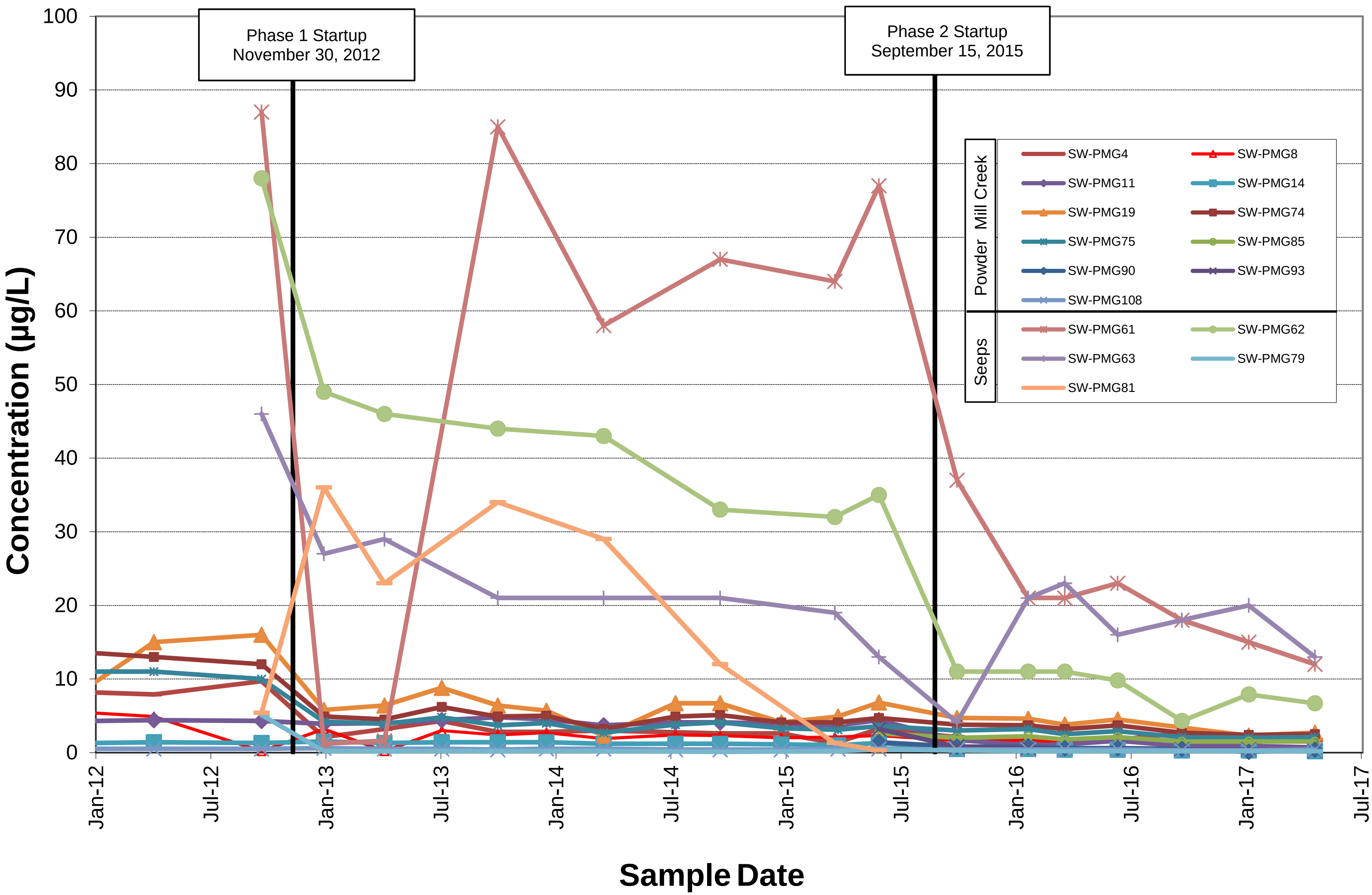
Note: Wells with baseline concentrations at or near site screening levels not shown for clarity

LANDAU ASSOCIATES

Downgradient Plume IA
Powder Mill Gulch
Boeing Everett, Washington

TCE Concentrations – Downgradient Monitoring Wells

Figure 4



LANDAU ASSOCIATES

Downgradient Plume IA Powder Mill Gulch Boeing Everett, Washington	**TCE Concentrations – Surface Water** **Powder Mill Creek and Seeps**	Figure 5

Attachment 1

Powder Mill Gulch Attachment

BOEING

Attachment #1 – Powder Mill Gulch

This attachment addresses Feasibility Study (FS)-related items discussed in the Washington State Department of Ecology's (Ecology's) final decision letter that are specific to the cleanup of the Powder Mill Gulch TCE plume (PMG; see attached Figure 1). Note that quoted or referenced Ecology comments are from Ecology's final decision letter (unless specifically identified as originating from other correspondence) and are annotated with the final decision letter page number and paragraph number and/or comment number (if applicable).

I. Areas of Agreement

Boeing and Ecology have reached agreement in a number of areas. Boeing concurs with or agrees with the following Ecology positions identified in the final decision letter:

- Boeing agrees that the final remedy for PMG will include the use of a *"restrictive environmental covenant and institutional controls to ensure that the extraction of groundwater contaminated with chlorinated volatile organic compounds (CVOCs) is not only prohibited for drinking water purposes but prohibited for any use, unless specifically approved by Ecology"* (page 12, Ecology comment #9), for the Boeing property. Similarly Boeing concurs with Ecology's related statements (page 23, Ecology comment #8 and subsequent bullets), including that Boeing will *"make a good faith effort to request restrictive environmental covenants (RECs) for the Panattoni, Seaway West, and City of Everett (Lot 9) properties from their respective owners."*
- Boeing agrees that the final remedy will include *"Continued efforts to inform the public about site contamination and prevent access to creek surface water and nearby creek bank TCE contaminated groundwater seeps throughout the cleanup process. This includes working with the City of Everett to provide additional signage near Powder Mill Creek access points on City property, warning the public to stay away from the creek (creek bank with groundwater seeps and water in the creek)"* (page 12, Ecology comment #10).
- Boeing agrees that the final remedy will include *"Notification to property owners that the indoor air quality in newly constructed buildings near and above the TCE groundwater plume may potentially be threatened by vapor intrusion. Boeing shall provide all available applicable soil gas and shallow groundwater VOC data to those property owners upon request."* (page 12, Ecology comment #11).
- Boeing agrees that the final remedy will include *"Financial assurance for all near and long term costs for cleanup actions required under RCRA and MTCA, including: maintenance of institutional controls and environmental covenants; ongoing O&M work; and long term repair costs until cleanup levels are met and shown be maintained at those levels"* (page 12, Ecology comment #13).

II. Areas of Disagreement

The following sections provide specific issues on which Ecology and Boeing have not reached resolution regarding PMG. The following sections also provide Boeing's approach for Model Toxics Control Act (MTCA)-consistent cleanup at PMG, based on site-specific data, and Boeing's scientific and technical analysis of that data. These sections also provide discussion of Boeing's understanding of and disagreement with Ecology's positions. These disagreements primarily center around where Ecology is mandating unreasonably aggressive cleanup actions that are not consistent with MTCA, or that do not effect meaningful results because the existing site risks are negligible because current contaminant concentrations are below human health and ecological risk criteria for existing potential exposure pathways, or in certain instances where Ecology's position may change based on more accurate assumptions or complete evaluation of the information Boeing is providing herein.

A. Remedy Selection

Under the Agreed Order for the site, and pursuant to Ecology approval, Boeing has successfully performed several interim actions (IAs) at PMG (see trichloroethylene [TCE] concentration maps over time on attached Figure 2), including electrical resistance heating and supplemental enhanced *in situ* bioremediation (EISB) in the source area, and installation and ongoing operation of an extensive groundwater extraction and treatment (GET) system in the downgradient plume. These source area IAs successfully reduced TCE concentrations from over 30,000 micrograms per liter (µg/L) to current concentrations of less than 400 µg/L; see Figure 3). The GET system has consistently achieved TCE concentration reductions in the downgradient areas of the groundwater plume (and surface water), including reductions in the groundwater areas with the highest TCE concentrations (from around 800 to 1,000 µg/L in the highest concentration areas to around 300 µg/L or less) in only 2 to 5 years[1] (see attached Figures 4 and 5). Based on the success of these source area and groundwater plume IAs in significantly reducing contaminant source mass and in containing and reducing TCE concentrations plume-wide, Boeing selected FS Alternative 1 (continued GET system operation with institutional controls and supplemental cleanup technologies as necessary) as the preferred remedy. Although Boeing's supporting Disproportionate Cost Analysis (DCA) demonstrated, under the factors in Washington Administrative Code (WAC) 173-340-360(3)(e), that FS Alternative 1 is permanent to the maximum extent practicable, Ecology rejected Alternative 1. After careful consideration of Ecology's comments in the agency's original contingent approval letter (Ecology 2016), which provided Ecology's expectation of additional mass reduction through EISB and further treatment to remove the source area as an ongoing contributor to downgradient contamination, Boeing proposed FS Alternative 2 (EISB source area remediation and continued GET system operation in the downgradient plume) as the preferred alternative.

In its final decision letter, Ecology also rejected FS Alternative 2. Instead, Ecology seeks to require a new, modified version of FS Alternative 4 that includes EISB throughout the entire

---

[1] Phase 1 IA extraction wells (south of Seaway Boulevard) began operating in November 2012; Phase 2 IA extraction wells (south of Seaway Boulevard) began operating in September 2015.

plume, with concurrent GET system operation. Ecology's modified Alternative 4 approach requires electron donor injections upgradient and proximate to the GET system extraction wells. Ecology's approach presents significant risk of impacting the GET system operation, which could result in failed hydraulic containment of the plume and contaminant releases to Powder Mill Creek and potential receptors within the creek. Boeing's analysis is based on a detailed evaluation of conditions observed downgradient of the treatment area after bioremediation injections in the source area. In addition, Boeing retained an expert, third-party review of both Boeing and Ecology's preferred remedies. This review was conducted by an objective, nationally recognized bioremediation expert. Boeing also evaluated its direct experience at other Boeing sites where EISB and GET were performed concurrently. Based on its analysis and the expert's review, Boeing has concluded that Ecology's preferred course of action requiring EISB throughout the plume will likely result in potential impacts to human health and the environment and will not provide any cleanup benefit above FS Alternative 2. Specifically, Ecology's approach is inadvisable because it includes the risks of:

- reducing or irreversibly compromising the GET system's ability to perform its primary functions of capturing and containing the groundwater TCE plume from discharging to Powder Mill Creek and enhancing flushing of the aquifer as a result of biofouling or mineral (i.e., iron and manganese) fouling of the extraction wells and the treatment system as a direct result of EISB injections proximate to operational extraction wells, which is of particular concern given the demonstrated success of the GET system in significantly reducing TCE in the plume;
- generating new hazardous constituents (i.e., arsenic and vinyl chloride [VC]) and other deleterious substances, like high total organic carbon (TOC) groundwater in close proximity to the creek, not currently present in the downgradient plume, and creating a very plausible release scenario in which these constituents/materials might discharge directly to the creek; and
- introducing new materials and contaminants generated by the EISB process into the groundwater and GET system treatment train that the system was not designed and engineered to treat (i.e., TOC and arsenic), which will require otherwise unnecessary and expensive redesign/engineering, construction, and operation of a pre-treatment system to prevent fouling of the existing treatment system and to prevent discharge of these constituents into Powder Mill Creek that would violate the conditions of the site's National Pollutant Discharge Eliminations System (NPDES) discharge permit and/or other water quality regulations.

As discussed above, Boeing's concerns with Ecology's approach are based on the data collected from the site, from Boeing's direct experience with similar situations at other sites, and on the independent review of the expert. After careful review of Ecology's position, it appears that Ecology has dismissed Boeing's concerns related to this risk based on invalid assumptions or an incomplete evaluation of available data. With this letter, Boeing is providing additional information regarding the risks of performing plume-wide EISB in conjunction with GET so that Ecology can re-evaluate its position and consider a final remedy that includes EISB in the source area and does not conflict with the operation of the GET system or result in the above-identified risks from the combination of technologies in the same areas.

The following sections provide further details on points of disagreement related to remedy selection and Boeing's analysis of Ecology's positions.

1. Unacceptable Risk of Performing Ecology's Modified Alternative 4

In the informal dispute process, Boeing demonstrated that there are significant risks involved with performing EISB injections proximate to and in conjunction with an operating GET system (see Attachment 1A). Boeing also provided technical data identifying the risks and disproportionate costs of performing Ecology's preferred remedy (Draft FS, Boeing response to Ecology's original contingent approval letter, and Landau's November 2016 and April 2017 technical memoranda). Additionally, Boeing has direct experience at other sites (Boeing facilities in Portland, Oregon, and in Torrance, Compton, and Long Beach, California) where unanticipated and severe biofouling directly attributable to bioinjections occurred in wells and GET systems that resulted in significant operational and maintenance problems. However, it appears that Ecology has dismissed these concerns based on incorrect or insufficient technical justifications. Boeing next discusses and evaluates the Ecology statements that are not technically supported or are incorrect:

a) Ecology Statements and Boeing Analysis

In its final decision letter (Ecology 2017), Ecology states that [based on information provided in Landau's technical memorandum (LAI 2017a)[2] and information provided in the Suthersan air stripper fouling reference (1999)] *"we believe that . . . extraction well and groundwater treatment fouling can be adequately mitigated during downgradient and off-Boeing property EISB injections (remedial alternative 4)"* (page 7, Ecology comment #3).

i. To support its position, Ecology uses Suthersan's rules of thumb for iron, manganese, and TOC concentrations in comparison to the data supplied for wells 75-160 feet away from the source area EISB injection area as a basis for concluding that mineral and "*biofouling of near downgradient extraction wells and the groundwater treatment system is significantly reduced"* (page 7, Ecology comment #3a – second paragraph).

- **Boeing's Response:** While Suthersan provides general guidelines for basic fouling evaluations for air stripping systems, the reference does not specifically address the combination of multiple impacts of bioremediation (which is designed to promote and propagate high levels of bacterial colonies) on an aquifer and consequently on an extraction and treatment system. Suthersan does, however, mention that the presence of biofilm grown by bacteria "can clog up the entire system rapidly" (which Boeing has directly experienced at the other sites mentioned above). Suthersan also goes on to say that "If the problem is very severe, periodic cleanup will be very costly." This further supports Boeing's analysis. Boeing also notes that in Ecology's evaluation, Ecology does not take into consideration that repeated EISB injections[3] could propagate dissolved iron,

[2] Ecology references the January 20, 2017, version several times, although it was superseded by the April 4, 2017, version.

[3] In Ecology's original 2016 contingent approval letter, it stated that "*Ecology's preferred alternative (Alternative 4) requires . . . at least two to three EISB injection phases."*

manganese, and TOC (and bacterial colonies) to much greater distances than those observed after only one injection event in the source area. Additionally, injections in the downgradient plume suggested in Ecology's modified version of Alternative 4 may be much closer to existing extraction wells than the downgradient monitoring wells evaluated in the source area (e.g., within approximately 50 feet of one of the extraction wells) and are likely to impact up to 5 or 6 of the system's 12 extraction wells (not 3 as suggested by Ecology; page 8, Ecology comment #3e), as well as the treatment system itself. As Ecology notes, Landau has stated *that "EISB injections should not be performed within* <u>*at least*</u> [emphasis added] *200 feet from downgradient extraction wells or creek discharge points,"* (page 9, Ecology comment #3f) and we emphasize that this was considered a <u>MINIMUM</u> distance needed to sufficiently reduce risk, but as indicated by the independent expert (see Section II.A.1.b below), much greater distances may be required to protect wells and surface water.

ii. Ecology concludes, based on the dissolved iron, manganese, and arsenic data provided for wells downgradient of the source area injection location, that "*altered groundwater redox conditions, have not migrated far from the treatment wells (160 ft). Based on groundwater geochemical parameters measured downgradient of the interim action TCE groundwater EISB zone, we believe that groundwater will become re-oxidized (under remedial alternative 4) in a relatively short distance downgradient (less than 100-120 feet) away from the injection well"* (page 8, Ecology comment #3c).

- **Boeing's Response:** The conclusion of Ecology's evaluation of the geochemical parameter data for the source area (provided in Landau's technical memorandum and the Source Area Interim Action quarterly progress reports over the past 8 years) is simply incorrect. Geochemical and redox data from EGW088 (~160 feet downgradient of the EISB injection area) have indicated dissolved manganese concentrations as high as 2.9 milligrams per liter (mg/L; background = <0.001 mg/L), dissolved oxygen levels as low as 0.5 mg/L (background 3 to 6 mg/L), oxidation/reduction potential values as low as -282 millivolts (mV; background = +100 to +300 mV), and methane concentrations as high as 4 mg/L (background = <0.0007 mg/L). These data clearly indicate that prevalent and strongly reducing conditions are present well downgradient of the source area injection locations. The data also indicate that reducing conditions continue to persist at this location over 7 years after a single EISB injection event.

iii. Ecology states that *"The aeration effect can be minimized by a carefully designed and operated groundwater pumping system. The groundwater pumping system can, and should, be designed such that aquifer potentiometric surface or drawdown created by pumping will never fall below the top of the well screen or close to the submersible pump intake"* (page 8, Ecology comment #3b).

- **Boeing's Response:** Ecology does not take into account other hydraulic principles at work at extraction wells in aerobic aquifers where EISB is performed; therefore, its statement provides no support for its plume-wide EISB requirement. Even if well screens and pump intakes are completely submerged (which they already are at

PMG), at a location downgradient or within a reduced area of an aquifer, that extraction well will also pull in water from downgradient or cross-gradient aerobic zones of the same aquifer. The mixing of the aerobic water with anaerobic water will result in "aeration effects" at the well regardless of the lack of atmospheric air reaching the well screen/pump intake, thereby precipitating metals or creating bacterially active zones in and around the wells and creating fouling conditions. Therefore, it is not possible to "carefully design and operate the system" to avoid these impacts. Furthermore, even if only reduced groundwater is extracted at the well, the water will become highly aerated within the air stripper system, resulting in fouling of the air stripper. Only through expensive, unreliable, and difficult to operate pre-treatment of the extracted groundwater is there a chance of mitigating fouling of the treatment system.

iv. *"Ecology believes that careful design of the bioremediation action, including stoichiometric dosing of carbons sources (similar to the interim action groundwater work in 2010), should minimize this potential"* for *"stagnant vinyl chloride (VC) concentration conditions due to incomplete TCE to ethane degradation"* (page 8, Ecology comment #3d).

- **Boeing's Response:** During the evaluation, Boeing identified VC generation from EISB as a risk for potential discharge to surface water, but notes that "stagnant VC concentration conditions" was never indicated as a concern in our communications or submittals to Ecology. Boeing simply recognizes that VC is a degradation product of biologically-mediated reductive dechlorination, which is not an instantaneous process with EISB. Therefore, no matter how carefully the bioremediation action is designed, VC will be generated and present for some period of time as a result of EISB prior to further degradation. The likelihood of this happening is supported by the presence of VC within and downgradient of the source area EISB treatment zone (e.g., VC in EGW088 at 7.4 µg/L in April 2017). Boeing's point regarding the presence of VC is that it is more toxic than TCE and if not completely captured by the GET system (which cannot be guaranteed under optimal conditions and is significantly less likely if extraction wells become fouled and inoperable), there is a high risk of discharge directly to surface water.

v. Ecology makes the point that "*Boeing's cost estimates for alternative 4 appear to overemphasize the worst case scenario – i.e., requiring pretreatment of groundwater prior to entering the groundwater air stripper in order to prevent fouling and metals precipitation*" (page 8, Ecology comment #e). However, elsewhere Ecology states that Ecology assumes that construction of a TOC and metals groundwater pre-treatment facility, GET system replacement, and biofouling equipment maintenance/replacement will be incorporated into Alternative 4 (page 11, Ecology comment #7) and that *"Ecology considers these to be reasonable system design elements"* (page 10, footnote 20).

- **Boeing's Response:** These statements are clearly inconsistent. Boeing's cost estimate is based on its best assessment of how the system would need to be designed in order to have any reasonable chance of preventing harmful impacts of plume-wide EISB injections. Provision of this estimate does not imply that these system modifications are reasonable or appropriate.

vi. Finally, *"Ecology believes that the [Boeing] reports of success or failure from other sites should be weighed against the existing data [from Boeing Everett]"* (page 9, Ecology comment #g).

- **Boeing's Response:** Boeing agrees and has done precisely that by evaluating the risk of fouling of the GET system using both existing site data and its significant experience at other cleanup sites. Boeing's experience at multiple other sites (e.g., Boeing facilities in Portland, Compton, Long Beach, and Torrance) is that the result of performing EISB in conjunction with operation of a GET system has resulted in severe fouling in every instance. Those separate but supporting lines of evidence led Boeing to the clear conclusion that there is a high likelihood of the system fouling under Ecology's modified Alternative 4. Boeing requests any technical data or information Ecology might have to support its position and to demonstrate that the combination of these remedial technologies can be cost-effectively performed together and will not result in undue fouling of the GET system.

b) Independent Expert Review

In addition to Boeing's analysis described in Section II.A.1.a. above, in order to more thoroughly explore the issue, Boeing retained a nationally recognized expert in bioremediation and remediation systems, Mr. Dean Williamson of CH2M Hill, to provide an unbiased and independent evaluation of the feasibility of concurrent bioremediation and groundwater extraction and treatment at PMG. After review of site-specific groundwater quality, aquifer geochemistry, site hydrogeologic conditions, and the results of the interim actions conducted to date, Mr. Williamson concluded that "implementing EISB within the capture zone of the GETS has a significant probability of creating conditions that would induce biofouling of the extraction wells, pumps, piping, and groundwater treatment equipment." Mr. Williamson goes on to say:

> Given the relatively short time that the GETS has been operational, its success to-date in reducing groundwater plume concentrations, and its ability to adequately control exposure of receptors to groundwater contaminants, it would be prudent to continue to run the GETS to better establish the degree of its effectiveness without implementing any additional remedial approaches. Implementing any remedy within the capture zone of the GETS that results in significant detrimental impact to the GETS performance would be inconsistent with best engineering practices.

Mr. Williamson's complete evaluation (and resume) is documented in the attached (Attachment 1B) technical memorandum (CH2M Hill 2017).

Based on these multiple analyses, Ecology's preference for downgradient EISB injections under Ecology's modified Alternative 4 represents an unacceptable risk to the GET system operations and to Powder Mill Creek through the potential discharge of toxic or deleterious materials to the creek. Boeing's analysis found no cleanup advantage to performing plume-wide EISB injections, as opposed to the source area-targeted EISB injections in FS Alternative 2. Furthermore, Ecology would require that the GET system, the design of which was reviewed and approved by Ecology, be operated under conditions under which it was never intended to operate. A very detailed evaluation of the fouling potential of the aquifer was performed during the initial engineering design of the system (as documented in the Phase 1 IA work plan [LAI 2011]). The original fouling evaluation identified conditions with minimal risk of system fouling, which over the course of nearly 5 years of operation has been demonstrated to be true; system fouling and cleaning has been almost completely unnecessary due to the naturally aerobic aquifer conditions and very low background dissolved iron, manganese, and TOC concentrations. Conducting EISB proximate to the extraction wells radically changes these conditions with the injection of TOC and the resulting dissolution of iron and manganese and enhanced stimulation of microbial colony growth in the aquifer.

Thus, Boeing respectfully, but strongly, disagrees with Ecology's selection of modified, new Alternative 4 for the PMG. As Boeing and its independent expert both concluded, the use of EISB injections throughout the plume will lead to unnecessary and significant risk of hazardous and/or deleterious substance discharge to Powder Mill Creek and of damage to the very successful GET system. Instead, Boeing requests that Ecology adopt FS Alternative 2 as the preferred remedy for PMG. FS Alternative 2 does not pose nearly the level of risk and includes EISB injections, targeted to the source area where they will be most impactful.

2. Dismissal of Alternative 2

In addition to our analysis above in Section II.A.1 that shows Ecology's modified Alternative 4 is unduly risky and provides no cleanup benefits, in this section Boeing discusses Ecology's rejection of FS Alternative 2. Alternative 2 provides a MTCA-compliant reasonable alternative remedy that includes performing EISB in the source area to address Ecology's directive to further actively reduce contaminant concentrations and mass while also reducing the risks of performing EISB near GET system extraction wells (as discussed above). Boeing respectfully disagrees with Ecology's dismissal of Alternative 2. There was an inadequate evaluation of the risks and costs of Ecology's modified Alternative 4 compared to Alternative 2.[4] A proper evaluation of these two alternatives results in Ecology's modified Alternative 4 being disproportionately costly in comparison to Alternative 2. Further:

a) Ecology cites the ability of Alternative 4 to achieve *"a shorter and reasonable restoration timeframe"* (page 5, Ecology comment #1.a) as one of the reasons why Alternative 4 is preferable over Alternative 2. In Ecology's discussion of the comparison of restoration timeframes between Alternative 2a (see footnote 5) and Alternative 4, Ecology incorrectly indicates that *"Alternative 2a uses a CPOC . . . and is expected to require approximately 61 years to complete"* compared to Alternative 4 which *"will require approximately 47 years to compete"* (page 26, first paragraph).

---

[4] As distinguished from "2a." In the final decision letter, Ecology packages FS Alternative 2 with other topics of discussion and negotiation, such as requests to use remediation levels and conditional points of compliance, and refers to an "Alternative 2a," even though the alternative and these other issues were mutually exclusive topics of discussion related specifically to the long-term operation of the GET system under any selected alternative due to the very low groundwater cleanup levels being identified by Ecology. Boeing did *not* propose or evaluate "Alternative 2a" as described by Ecology.

- **Boeing's Response:** Ecology has misinterpreted these restoration timeframes. Updated Biochlor and batch-flush modeling results (see Attachment 1C[5]) indicate that Alternative 4 will take 50 years to complete AFTER the EISB injections are completed, which will take approximately 3 years. The resulting total restoration timeframe for Ecology's modified Alternative 4 is 53 years[6] from 2017 (or possibly longer depending on when bioinjections begin and are actually completed). The updated modeling results indicate that Alternative 2 is currently expected to take 57 years to complete from 2017 (regardless of when EISB is performed in the source area). This insignificant 4-year difference is not meaningful in the restoration timeframe analysis in WAC 173-340-360(4).

b) Ecology also states that Alternative 2 *"relies on less certain dispersion and dilution mechanisms (versus destructive technologies)"* (page 26, first paragraph).

- **Boeing's Response:** Boeing does not agree and finds this statement to be inaccurate and mischaracterizes Alternative 2. Dispersion is the tendency of a "solute to spread out from the path that it would be expected to follow according to the advective hydraulics of the flow system" (Freeze and Cherry 1979), and dilution is the decreasing of the concentration of a solute in solution by mixing with more solvent. Alternative 2 relies on neither of these mechanisms. The GET system is designed to hydraulically contain and capture contaminants by concentrating flow into discrete areas (at the extraction wells), which is the opposite of dispersion, and use flushing (not dilution) of water through the saturated soil pore matrix to stimulate desorption of contaminants which are adsorbed to or absorbed into the soil matrix. The contaminants are then further concentrated *ex situ* through capture on granular activated carbon for destruction or disposal. Ecology's statement cannot therefore support its rejection of Alternative 2.

c) Ecology states that *"Enhanced biodegradation is a well-established technology for in-situ treatment of TCE contaminated groundwater and a more reliable alternative for the downgradient and off-Boeing property plume"* (page 26, second paragraph).

- **Boeing's Response:** As detailed above and in previous Boeing communications and submittals, the combination of EISB with GET system operation is also highly problematic and there are significant site-specific risks related to the locations Ecology is requiring EISB to be performed (i.e., areas with elevated TCE concentrations proximate to extraction wells). Ecology has not provided case studies or other technical data that demonstrate that the

---

[5] Biochlor and batch flush models were updated based on current groundwater conditions and the Ecology-specified TCE cleanup level of 0.3 µg/L.

[6] As indicated in CH2M Hill's evaluation, this timeframe also assumes that the GET system is fully and optimally operational during this entire period, which is highly unlikely if extraction wells and the proximate aquifer matrix become fouled.

combination of technologies can be cost-effectively performed and would not result in severe fouling of the GET system, but Boeing has proven conclusively with appropriate experts that the combination is risky for the environment and unjustifiably costly. Please refer to discussion of this issue in Section II.A.1.a. and b. above.

d) Ecology states that *"Alternative 2a has an over-reliance on institutional controls"* (page 33, paragraph 2).

- **Boeing's Response:** All of the alternatives presented in the FS rely on ICs, and Alternative 2 does not "over-rely" on ICs as part of the remedy. Ecology's statement is also not supported when the difference between Alternative 2 and Alternative 4 use of ICs is only 4 years.

e) Ecology uses the DCA process to support its modified Alternative 4 as permanent to the maximum extent practicable and preferable over Alternative 2. However, Ecology does not adequately evaluate many elements of the DCA as provided in MTCA.

i. Protectiveness – Ecology states for the DCA criterion of protectiveness *"This criterion is intended to compare each remedial alternative's time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality"* (page 28, last paragraph).

- **Boeing's Response:** The first element of MTCA's definition of protectiveness (WAC 173-340-360(3)(f)(i)) is "The degree to which existing risks are reduced," which Ecology's statement ignores. This omission is particularly critical in comparing the alternatives for PMG because, as described earlier, the existing risks are negligible because current contaminant concentrations are below human health and ecological risk criteria for existing potential exposure pathways at PMG; therefore, the degree that existing risks can be reduced is also negligible. Ecology also states that Alternative 4 would result in *"faster reduction of off-Boeing property risk to walkers that . . . encounter those contaminated groundwater seeps and creek surface water"* (page 29, first paragraph); however, the current chlorinated volatile organic compound (cVOC) concentrations in the seeps and surface water do not represent a risk to walkers as they are already well below human (and ecological) direct contact risk values, so the risks cannot be meaningfully reduced. This suggests that Ecology's later statement that the protectiveness of Alternative 4 *"far exceeds alternative 2"* (page 29, third paragraph) is not correct. By contrast, *"on-site and off-site risks resulting from implementing the alternative"* are actually increased by Ecology's modified Alternative 4 due to the likelihood of generating and discharging arsenic and VC to Powder Mill Creek, as described above. In addition, *"the overall environmental quality"* of the creek may also be diminished due to the risk of discharging TOC in the form of carbon donor substrate to the creek during EISB. Depending on the duration and extent of EISB implementation, it is possible that dissolved arsenic may persist at elevated concentrations in groundwater after the cleanup standards have been achieved for cVOCs, which would further extend the restoration timeframe for Alternative 4. Thus, as Boeing demonstrated in the previous section, Ecology's modified Alternative 4 likely *decreases* protectiveness when compared with Alternative 2.

ii. Permanence – Ecology states that *"Alternative 4 more permanently reduces toxicity of contaminated groundwater"* (page 29, fifth paragraph).

- **Boeing's Response:** While TCE concentrations may be decreased more rapidly (which is not a factor of the permanence criterion) in some areas of the plume by reduction of concentrations through performance of EISB, it is not decreased "more permanently" because the end result of both alternatives will be the decrease of TCE concentrations to below the cleanup levels. Ecology further neglects the risk of generating and discharging VC (which is more toxic than TCE) and dissolved arsenic (a toxic substance) to the creek at concentrations above the surface water cleanup level. Therefore, the statement that the permanence of Alternative 4 *"far exceeds alternative 2"* (page 30, first paragraph) is not correct.

iii. Cost – Ecology attempts to downplay the significant cost difference between Alternatives 2 and 4 and makes several statements that do not comport basic engineering economics and FS cost estimating procedures.

(1) Ecology states that *"the approximately $7 million dollar difference between alternatives 4 and 2a is not cost disproportionate given the benefits [of alternative 4]"* (page 32, last paragraph).

- **Boeing's Response:** Based on the estimates provided in Landau's November 2016 technical memorandum, the estimated cost difference between these alternatives was actually over <u>$8 million</u> ($16.69M for Alternative 2 and $24.76M for Ecology's modified Alternative 4). The current updated costs (see Attachment 1D), based on the updated modeling results and lower assumed cleanup level,[7] are nearly <u>$11 million</u> ($25.26M for Ecology's modified Alternative 4 and $14.48M for Alternative 2). Ecology's conclusory statement that the comparative costs are not disproportionate fails to provide any analysis based on the MTCA standard. WAC 173-340-360(3)(e)(i) defines when costs are disproportionate as "Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative." As Boeing demonstrated above, Ecology's modified Alternative 4 is likely to cause unnecessary and significant risk of hazardous and/or deleterious substance discharge to Powder Mill Creek and to do damage to the very successful GET system. And, as discussed above and

---

[7] The restoration timeframe modeling in November 2016 was based on an assumed TCE cleanup level of 0.38 µg/L; updated modeling was based on the US Environmental Protection Agency (EPA)-approved TCE value of 0.3 µg/L).

below, there is no incremental cleanup benefit to Alternative 4 over Alternative 2. The additional $11 million in cost for Alternative 4 is therefore very disproportionate because of the significant cost increase that provides no incremental benefit over Alternative 2.

(2) Ecology makes the statements that "*Boeing indicates its cost estimates are only accurate to within a range of -30% to +50% uncertainty. This uncertainty range alone results in the total costs for remedial alternatives 4 and 2a being essentially equivalent"* (page 30, fourth paragraph) and that *"The cost estimates of both alternatives are approximately equal (within-30%/+50% uncertainties. . ."* (page 32, third paragraph). These are also similar to statements made in Ecology's contingent approval letter.

- **Boeing's Response:** As previously pointed out, the -30% to +50% range of cost uncertainty applied to the FS cost estimate is the standard range assigned for FS estimates as designated by the EPA/Army Corps of Engineer's guidance (EPA 2000) on cost estimating during the FS. The base cost estimate is the accepted reasonable estimate for that alternative (based on the conceptual approach presented in the FS) against which to compare against other alternatives. It is unreasonable to compare the high end of Alternative 2's uncertainty range against the low end of Alternative 4's and make the conclusion that the costs are "essentially equivalent" or "approximately equal." Using Ecology's same logic of applying the range of uncertainty for comparison, the difference in costs for the two alternatives could be as much as $27M (i.e., using the low-end estimate for Alternative 2 and high end for Alternative 4), which would similarly not be a reasonable point of comparison.

(3) Ecology states that *"the cost of additional groundwater monitoring (beyond what may be expected under alternative 2a) near the end of the 46 year restoration timeframe for alternative 4 is heavily discounted in the net present value cost estimate"* (page 30, footnote 48).

- **Boeing's Response:** Net present value and discounting is a non-factor among the alternatives because long-term monitoring is discounted for all the alternatives, so net present value discounting makes little difference between alternatives where the durations are only separated by 4 years, and none of the alternatives would be considered "heavily discounted" when using only a 1.5 percent discount rate. All of the alternatives use the same 1.5 percent discount rate.

(4) Ecology states that *"The cost estimate for alternative 2a does not include the possible added expenses for reimbursing off property owners for damages"* (page 30, footnote 49).

- **Boeing Response:** Ecology's statement finds no support anywhere in MTCA. In addition to being pure speculation, such hypothetical damages are not costs of cleanup that are part of Ecology's purview. In fact, Ecology routinely declines to become involved in private-party cost reimbursement at all MTCA sites. It is simply not appropriate for Ecology to consider such costs.

(5) Ecology states in several locations that Ecology's modified Alternative 4 includes *"Further optimization of the interim action groundwater pump and treat system to reduce TCE contaminated groundwater flux to the creek to the maximum extent practicable (IA objective)"* (page 8, Ecology comment #d; page 11, Ecology comment #4).

- **Boeing's Response:** Additional optimization of the GET system is not included in the FS cost estimates for Alternative 4 and would consequently make the cost estimate for Alternative 4 even higher, which is not considered in the DCA. Boeing also notes that this is the first we have heard of this required action from Ecology even though the data from Boeing's quarterly downgradient interim action monitoring reports indicate that this IA objective is being achieved by the current system (since completion of the Phase 1 IA expansion). Boeing also reiterates that although implemented as an IA, the design of the GET system for the Downgradient Plume IA was always intended to accelerate groundwater restoration in the downgradient plume (a final remedial action objective). Operation of the groundwater extraction wells steepens gradients and shortens groundwater flow paths in the plume, thereby increasing pore-volume flushing rates. As stated in the Ecology-approved Phase 1 IA Work Plan (LAI 2011) "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." The GET system has consistently been accomplishing this objective since system operations commenced, as demonstrated by consistent TCE concentration reductions in the downgradient areas of the plume, including reductions in the areas with the highest TCE concentrations on the order of 50 to 75 percent in only 2 to 5 years.[8]

iv. Effectiveness over the long term – Ecology states that the degree of effectiveness of Alternative 4 *"to permanently degrade and destroy TCE and daughter products [is] higher than relying on dilution, dispersion and discharge (alternative 2) to the creek"* (page 31, first paragraph).

- **Boeing's Response:** This statement mischaracterizes the implementation of Alternative 2. As previously stated (Boeing Comment II.A.2.b above), Alternative 2 does not use dispersion or dilution as part of the remedy and does not rely on discharge to the creek to achieve cleanup. Ecology's conclusory statement provides no reference to any portion of Alternative 2 that relies on "dilution, dispersion, and discharge." Again, Ecology's statement in the long-

[8] Phase 1 IA extraction wells (south of Seaway Boulevard) began operating in November 2012; Phase 2 IA extraction wells (south of Seaway Boulevard) began operating in September 2015.

term effectiveness section that Alternative 4 *"far exceeds alternative 2"* (page 31, first paragraph) is not correct.

v. Technical and administrative implementability – Ecology states that *"Ecology does not see significant technical or administrative hurdles to implementing either alternative [2a or 4], given engineering design modifications proposed by Boeing"* (page 31, third paragraph).

- **Boeing's Response:** As previously indicated, the combination of GET system operation and use of EISB throughout the plume has proven to be detrimental at other Boeing sites and has not been adequately demonstrated by Ecology as being reasonably implementable. Preventing injection fluids surfacing and/or discharging to surface waters of the creek, wetlands, and seeps during EISB implementation; long-term operations of metals and TOC treatment/removal systems; rehabilitating or replacing fouled wells; replacing fouled pumps; maintaining hydraulic containment; and ensuring that NPDES permit discharge requirements continue to be met under reduced efficiency or impaired extraction and treatment systems represent extraordinarily "significant technical hurdles." Additionally, modifying the NPDES permit to account for the change in conditions, operations, and contaminants of concern, and permitting the new treatment system construction that would be necessary are not insignificant administrative hurdles. Boeing notes that none of these issues would be required to be addressed under Alternative 2. Moreover, the DCA analysis favors Alternative 2 over Alternative 4 under the implementability criterion.

vi. Management of short-term risks – Ecology states *that "the construction and implementation of alternatives 4 and 2a can be designed to effectively manage these risks"* (page 32, first paragraph).

- **Boeing's Response:** The ability to manage risk is not the same thing as removing risk. As correctly identified by Ecology, the short-term risk criterion compares the risk to human health and the environment <u>during construction and implementation</u>. Alternative 4 includes a significant construction component and significantly more use of drilling and pressurized pumping equipment, which all have inherent risk to workers. Also, as identified above, EISB and injection have inherent risks for discharge of the donor substrate directly to the environment or generating toxic substances that may discharge to the environment. Boeing would manage these risks as effectively as possible, but this does not and cannot eliminate the additional risks Ecology's alternative creates. Moreover, the DCA analysis favors Alternatives 1 and 2 over Alternative 4 under the short-term risk criterion.

vii. Consideration of public concerns – As correctly stated in Ecology's letter, *"Ecology can only anticipate public sentiment during the formal FS public comment period"* (page 27, first paragraph).

- **Boeing's Response:** Boeing concurs with this statement and, therefore, disagrees with Ecology's speculation regarding this criterion based on our interactions with and input from the impacted property owners and the Boulevards Bluff Neighborhood Coalition. However, rather than guessing at the appropriate ranking before the public comment period, in the revised DCA provided to Ecology, Boeing ranked each of the alternatives the same for this criterion to avoid speculation on this topic.

In conclusion on this topic, Ecology's stated positions present an inaccurate, scant analysis in support of modified Alternative 4 as preferable over Alternative 2. Ecology's analysis relies on incorrect restoration time frames, underestimates the fouling potential of EISB on an active GET system, overstates Alternative 2's reliance on institutional controls, and presents a flawed and unsupported DCA on multiple grounds. Ecology's qualitative DCA over-emphasizes Alternative 4's advantages related to protectiveness, permanence, and long-term effectiveness and downplays the technical and implementability challenges, the risks to discharge of hazardous constituents and deleterious materials to Powder Mill Creek, and the risks to workers during construction and implementation. When these criteria are properly evaluated, the downside risks of Ecology's modified Alternative 4 outweigh the potential benefits. Finally, Ecology's DCA evaluation misrepresents and downplays the difference in cost between Alternatives 2 and 4, which is significant and, under the MTCA definition, disproportionate. Boeing's analysis (see Attachment 1D) concludes that the significantly higher cost of implementing Ecology's modified Alternative 4 is disproportionate compared to Alternative 2 and that the benefits of Alternative 2 (as described in the FS) are slightly higher than for Ecology's modified Alternative 4. Therefore, under WAC 173-340-360(3)(e)(i), Alternative 2 uses permanent solutions to the maximum extent practicable in comparison to Ecology's modified Alternative 4.

B. Cleanup Standards

1. Unreasonable or Misapplication of Cleanup Levels

Both the groundwater cleanup levels (based on protection of drinking water) and surface water cleanup levels (based on protection of drinking water and consumption of organisms) proposed by Boeing are highly conservative. Under current conditions, there are no risks to human or ecological receptors. Groundwater, which would be protected under the proposed cleanup levels, is not being used as a drinking water source and is unlikely to be a future source, as the City of Everett is required to provide drinking water to all residents and businesses. Surface water, which would also be protected under the proposed cleanup levels, is not being used as a drinking water source and is unlikely to be in the future because Powder Mill Creek is a low-flow urban stream, and is not a source of food for human consumption because it does not contain any documented migratory or resident fish or shellfish upstream of Mukilteo Boulevard (approximately 2/3-mile downstream of the impacted portion of the creek). Additionally, current surface water concentrations are already well below any human direct contact or ecological exposure risk values under MTCA.

Despite this data, Ecology has identified the cleanup levels for groundwater for TCE and VC will be equal to the surface water quality criteria identified in Ecology's surface water quality regulation, WAC 173-201A (0.3 µg/L for TCE and 0.02 µg/L for VC) and stated that *"Groundwater cleanup levels [shall be] based on the more stringent of the new water quality criteria (WQCs), MTCA Method B cleanup levels and other ARARs. For TCE, the WQCs are the* *most stringent ARAR for setting the groundwater cleanup level (0.3 µg/L)"* (page 4, footnote 4). This statement is not only an unreasonable application of this Applicable or Relevant and Appropriate Requirement (ARAR) for the site (where there is no current risk to human or ecological receptors), but is also not consistent with the application or cleanup level development process under MTCA.

In addition to legal authority issues that Boeing presents in a separate document, the following discussion further details Boeing's position on Ecology's position and statements related to groundwater and surface water cleanup levels:

a) Ecology states that *"Groundwater cleanup levels [shall be] based on the more stringent of the new water quality criteria (WQCs), MTCA Method B cleanup levels and other ARARs"* (page 4, footnote 4).

- **Boeing's Response:** This is not consistent with the MTCA regulations. MTCA does not require selection of the "more stringent of. . . MTCA Method B cleanup levels" when compared against ARARs. The MTCA Method B groundwater cleanup level development process (WAC 173-340-720) includes identifying applicable ARARs and seeing if they are sufficiently protective for both acute and chronic exposures, as compared relative to Method B standard formula values, and then adjusting those values as necessary and allowable. Ecology's use of an ARAR to set the cleanup levels for groundwater is not supported by the MTCA regulation.

b) Ecology states that "*For TCE, the WQCs are the most stringent ARAR for setting the groundwater cleanup level (0.3 µg/L)"* (page 4, footnote 4). MTCA states that potable groundwater cleanup levels must be at least as stringent as state and federal ARARs including "Protection of surface water beneficial uses" (WAC 173-340-720(4)(b)(i&ii)). The technical and procedural requirements required by state and federal law (see WAC 174-340-700(6)(a) and 173-340-710(3&4)) in the surface water quality standards in WAC 173-201A-240(5)(b) specifically identify that the toxic substances criteria for human health protection, found in Table 240, are subject to the following requirement: "All waters shall maintain a level of water quality **when entering** [emphasis added] downstream waters that provides for the attainment and maintenance of the water quality standards of those downstream waters . . ."

- **Boeing's Response:** This requirement means that the quality of the water entering the surface water of Powder Mill Creek must be of sufficient quality as to be protective of the surface water quality criteria (WQC) and does not require that all groundwater meet WQC equal to the concentration protective of surface water. Further and more detailed discussion on this point and Boeing's proposed cleanup levels for the site are found in the attached technical memoranda (LAI 2017b) (Attachment 1E). Therefore, with respect to surface water, Boeing must clean up groundwater sufficiently that the discharge of groundwater to the creek (measured at the point of discharge into the creek) is at concentrations that are protective of surface water criteria (measured in the surface water body). However, it is only required that the groundwater cleanup level protective of drinking water be met throughout the plume (at the standard point of compliance). Boeing is also required to clean up surface water to the surface water cleanup standards. Further to this point, and as stated by Ecology *"this site will have established (1) groundwater cleanup levels; and (2) surface water cleanup levels. Both must be met in their respective media* [emphasis added]*"* (page 10, first paragraph). Boeing agrees with this statement and recognizes that in order to achieve cleanup at the site, both the groundwater cleanup standards and the surface water standards must be met; however, Boeing differentiates that this does not require the cleanup levels in both media be the same, and it is common at MTCA sites for groundwater and surface water to have differing cleanup levels.

c) Ecology also indicates that the groundwater cleanup levels for standard points of compliance must be the same for the entire aquifer (even at different solid waste management units [SWMUs]/areas of concern [AOCs] separated by large distances). Ecology states that at Boeing Everett, "*all contaminated groundwater at the site must meet a single cleanup level at the SPOC (per WAC 173-340-720(8)(b))"* (page 6, last paragraph).

- **Boeing's Response:** Ecology's statement does not accurately reflect this MTCA citation. WAC 173-340-720(8)(b) states "The standard point of compliance [emphasis added] shall be established throughout the site" (i.e., for a standard point of compliance [SPOC], cleanup levels must be met throughout the saturated zone at the site). It does not say that the established cleanup levels must be the same throughout the site. MTCA is silent on the point of whether different cleanup levels are allowable for different areas of the same site; however, Boeing is aware of sites where different cleanup levels for the same contaminant in the same media have been established and approved by Ecology. Therefore, it is not necessary to apply the same cleanup level to PMG groundwater and for groundwater at the upland SWMUs/AOCs if a more conservative cleanup level is established for PMG. Permitting different cleanup levels in different areas allows for evaluations and selection of appropriate cleanup approaches that more accurately reflect and address the risks to applicable receptors at a given SWMU/AOC.

d) On the cleanup level tables provided on page 13 of Ecology's final decision letter, Ecology has erroneously provided surface water and groundwater cleanup levels for 1,1-dichloroethene (1,1-DCE) of 3.2 µg/L based on *"National Toxics Rule, 40CFR131 for organism consumption."*

- **Boeing's Response:** We are aware that the EPA withdrew Washington from the National Toxics Rule (40 Code of Federal Regulations [CFR] 131.36) and that Washington's water quality criteria were replaced in November 2016 by values provided under 40 CFR 131.45 (*Revision of certain Federal water quality criteria applicable to Washington*), which for 1,1-DCE are 700 µg/L for consumption of water and organisms and 4,000 µg/L for consumptions of organisms only. Therefore, the most stringent ARARs for 1,1-DCE are 300 µg/L for surface water from Section 304 of the Clean Water Act and 7 µg/L for groundwater from federal and state Maximum Contaminant Levels.

In conclusion, Boeing has proposed MTCA-consistent, reasonable, and conservative cleanup levels protective of human and ecological receptors at the site. Boeing is not in agreement with Ecology's proposed use of surface water cleanup levels set as groundwater cleanup levels across the site (or the specific surface water cleanup level for 1,1-DCE). Boeing also does not agree that the same cleanup levels must be applied for all SWMUs/AOCs across the site. Therefore, we request the Ecology reconsider the cleanup levels that will be applied to groundwater (and surface water for 1,1-DCE) at PMG.

2. Conditional Point of Compliance

As identified above, in the Memorandum of Law, and in Attachment 1E, surface water quality standards are not applicable to groundwater. Accordingly, the drinking water standard should be applied to groundwater and the surface water quality standards should be applied to surface water, and Boeing recognizes that both must be met in order to consider cleanup complete. However, if through the formal dispute resolution process, Ecology insists on improperly applying the surface water standards to groundwater, the use of a conditional point of compliance (CPOC) is authorized by MTCA and would become applicable to address the long restoration timeframes (over 50 years) that would be necessary to achieve cleanup levels for <u>any</u> of the FS alternatives. The use of CPOCs would also meet the regulatory and guidance criteria for being adequately protective of surface water beneficial uses. Unfortunately, Ecology did not approve the use of CPOCs based on overly conservative and inconsistent application of the MTCA reasonable restoration timeframe criteria among the remedial alternatives.

a) Ecology states that in order to approve a CPOC "*it must be demonstrated under WAC 173-340-350 through WAC 173-340-390 that it is not practicable to meet the cleanup level throughout the site within a reasonable restoration timeframe" (*page 6, Ecology comment #2, second paragraph).

- **Boeing's Response:** Using Ecology's improperly applied surface water criterial as the cleanup level for groundwater, the difference between restoration timeframes (53 to 59 years) for all the alternatives is negligible. Thus, it has been demonstrated that it is not practicable to meet Ecology's proposed groundwater cleanup level throughout the site under any of the alternatives in a reasonable restoration timeframe.

b) Ecology states that it *"must also be demonstrated that all practicable methods of treatment are to be used in the site cleanup"* (page 6, Ecology comment #2, second paragraph).

- **Boeing's Response:** As demonstrated above, EISB throughout the plume in combination with GET system operation is not practicable; therefore, this stated criteria by Ecology for use of CPOCs would be satisfied.

In conclusion, Ecology's rationale for denying a compromise CPOC is not justified if surface water quality standards are applied to groundwater. Under this scenario, Boeing would propose the use of a CPOC for groundwater located in the surface water body (Powder Mill Creek) as specified under WAC 173-340-720(8)(d)(i).

C. Denial of Remediation Levels

As MTCA authorizes (WAC 173-340-355), Boeing has proposed a reasonable set of remediation levels (RLs), based on an alternate reasonable maximum exposure (as allowable by regulation and based on actual potential site exposures (WAC 173-340-705(7), -708(3)(d) & -708(10)(b)), that would be used to allow for discontinuing operation of the GET system when it is no longer productively reducing contaminant concentrations or beneficially protecting receptors (i.e., the creek). However, Ecology has denied the use of RLs based on invalid regulatory rationale.

a) Ecology makes the following statements with respect to RLs:

Regarding the groundwater remediation levels (RLs)[16], Ecology has determined that a groundwater standard point of compliance (SPOC) applies to the entire TCE groundwater plume. Therefore, we do not approve the use of Boeing's proposed groundwater remediation levels as concentrations to be used in lieu of meeting the groundwater cleanup levels" (page 9, Ecology comment #4).

"[16] . . . an RL would not be considered the equivalent of meeting a CUL so that no further action is needed" (page 9, footnote 16).

- **Boeing's Response:** These statements are not correct as Boeing never suggested or requested using RLs in place of or as equivalent to cleanup levels. These statements are not supported by regulation and do not reflect Boeing's intentions for the use of RLs. Per WAC 173-340-355(2) "Remediation levels are not the same as cleanup levels . . . Remediation levels, by definition, exceed cleanup levels," and per WAC 173-340-355(1) "Remediation levels are used to identify the concentrations (or other methods of identification) of hazardous substances at which different cleanup action components will be used." In other words, RLs are not used in lieu of meeting cleanup levels; rather, they are used as a logical point at which to discontinue or change technologies or approaches used for cleanup (based on concentrations, site conditions, or other applicable criteria) in favor of another technology or approach which is more appropriate for that stage, area, or period of the cleanup. As previously described (LAI 2016), the RLs proposed by Boeing are for discontinuing use of the GET system at the point at which it is no longer serving a useful function in cleaning up groundwater and protecting the creek. Ultimately, Boeing must still meet the cleanup level. For clarification, Boeing's provides additional detail on proposed use of remediation levels for the site in the attached technical memoranda (LAI 2017b) (Attachment 1E). In addition to numeric RLs, Boeing provides proposed contingencies for continuing operation or restarting the GET system if necessary for cleanup or protection of surface water. Boeing is also willing to discuss further modifications to these contingencies to address Ecology's concerns.

b) Ecology states that the *"Boeing proposed groundwater RL would result in violations of (a) groundwater cleanup levels based on a standard point of compliance; and (b) surface water cleanup levels at the discharge area and within the creek" (*page 10, first paragraph).

- **Boeing's Response:** Again, Ecology's statement does not properly reflect the interaction between RLs and cleanup levels. An RL does not "violate" a cleanup level; as discussed immediately above, RLs are not used in lieu of meeting cleanup levels, rather they are used as a logical point at which to discontinue or change technologies or approaches used for cleanup (based on concentrations, site conditions, or other applicable criteria) in favor of another technology or approach that is more appropriate for that stage, area, or period of the cleanup. Furthermore, by discontinuing use of the system many years in the future when groundwater concentrations are much lower and approaching the cleanup levels across the plume, it is likely that concentration reductions resulting from the GET system will be approaching asymptotic decline and that protection of surface water will not be dependent upon operation of the GET system. And as stated above, Boeing has proposed contingencies for continuing operation or restarting the system if it is demonstrated that the GET system is necessary for meeting cleanup levels in surface water.

c) Ecology states that *"Ecology anticipates that a groundwater RL would be established to determine when to move from enhanced bioremediation to MNA. However, that exact numeric groundwater RL cannot be determined now and will be based on review of site specific groundwater data indicating the effectiveness of the enhanced bioremediation and likelihood of MNA meeting MTCA requirements"* (page 9, footnote 16).

- **Boeing's Response:** Boeing first notes that discontinuing EISB while still operating the GET system is not monitored natural attenuation (MNA). Per WAC 173-340-200, natural attenuation is "a variety of physical, chemical or biological processes that, under favorable conditions, act without human intervention [emphasis added] to reduce the mass, toxicity, mobility, volume, or concentration of hazardous substances in the environment." Second, Boeing should not be required under MTCA to enter into an open-ended process of implementing EISB without specific criteria (numeric and/or performance-based) by which to identify when EISB will be discontinued. This process of establishing decision points later, based on Ecology's sole discretion, has previously resulted at this site in significant unnecessary and unreasonable effort and cost to achieve an undefined endpoint (e.g., Ecology required additional operation of the electrical resistance heating system in the source area for 3 months after the previously agreed upon treatment goal had already been reached, until Ecology, at its sole discretion, concurred that shutdown was appropriate).

In conclusion, the use of RLs for the GET system is reasonable, allowable by regulation, and justified based on current and likely site risks and should be approved by Ecology, especially if mutually agreeable contingencies for GET system operation and shutdown can be established. Ecology has denied the use of RLs for discontinuing the GET system operation for invalid reasons that are not supported by regulation, while "allowing" RLs for discontinuing EISB (but with undefined endpoints that would be replaced by an invalid technology (i.e., MNA with human intervention). This is subjective and inconsistent with MTCA. Therefore, Boeing requests that Ecology reconsider these positions and approve the use of RLs for the GET system (and of defined RLs for EISB as applicable).

D. Monitoring

1. Long-Term Soil Gas Monitoring

Based on the discussion during the November 2, 2016, meeting between Boeing and Ecology, Boeing understood that Ecology needed several lines of evidence to be confident that vapor intrusion would not be an issue at the Panattoni and Bertch properties. Consequently, Boeing verbally indicated willingness to perform 1 year of seasonal (summer and winter) soil vapor sampling at the existing vapor monitoring wells to confirm the previous results that indicated that soil vapor volatile organic compound (VOC) concentrations were below screening levels. However, Ecology is seeking to require long-term soil gas monitoring on the Panattoni and Bertch properties (see page 12, Ecology comment #12; page 20, Ecology comment #b and following bullets) regardless of the results of the seasonal sampling. Boeing stands by its proposal to conduct seasonal monitoring, to be terminated if the results are consistent with the previous results showing that VOCs are below Ecology screening levels, for the following reasons:

a) This type of ongoing monitoring is not required under Ecology guidance (Ecology 2009) since a Tier 1 assessment has been performed and will have been verified that no reasonable risk of vapor intrusion exists because soil gas concentrations are below screening levels.

b) Ongoing soil gas monitoring is not required under MTCA regulations for groundwater cleanup sites where indoor air/soil gas have not been determined to be media of concern (which is the case at PMG). Under WAC 173-340-750(1), air cleanup standards are only necessary "if air emissions at a site pose a threat to human health and the environment," which the seasonal sampling will have established is not a concern. Soil vapor monitoring is also not required for compliance monitoring for groundwater cleanup under WAC 173-340-740.

c) Under this site scenario, general compliance monitoring requirements (WAC 173-340-410) also do not necessitate long-term/ongoing soil gas monitoring:

   i. Ecology states that soil vapor monitoring *"is necessary for* protection *monitoring to verify that future indoor air concentrations in the nearby Panattoni warehouse buildings stay below acceptable cleanup levels"* (page 20, Ecology comment #b, second bullet).

      - **Boeing's Response:** Under WAC 173-340-410(a), protection monitoring is performed to "Confirm that human health and the environment are adequately protected during construction and the operation and maintenance period of an interim action or cleanup action as described in the safety and health plan." This is not applicable for PMG because 1) existing data indicates soil gas concentrations are well below concentrations what would result in indoor air contamination; therefore, workers in nearby buildings are not at risk for exposure and protection monitoring is not necessary; and 2) there will be no construction or operation and maintenance that could possibly result in air emissions at the Panattoni or Bertch properties at levels harmful to human health or the environment (the site-specific health and safety plan already covers monitoring for potential worker exposures related to the GET system treatment system).

ii. Ecology states that soil vapor monitoring *"is also needed during* performance *monitoring to verify that the groundwater cleanup action is also reducing soil gas concentrations in the sub-surface vadose zone, a remedial action objective"* (page 20, Ecology comment #b, second bullet).

- **Boeing's Response:** Under WAC 173-340-410(b), performance monitoring is required to "confirm that the interim action or cleanup action has attained cleanup standards." As previously noted, there are no cleanup standards for soil gas, indoor air has not been identified as a medium of concern, and soil gas will not be used to determine whether the final remedy is reducing groundwater concentrations; therefore, performance monitoring for soil gas is not required. Additionally, because soil gas and indoor air were not identified as complete exposure pathways and soil gas concentrations have not been identified above screening levels, reducing soil gas concentrations is *not* a remedial action objective for PMG.

iii. Ecology states that *"During* confirmational *monitoring, the sampling results will be used to verify that soil gas concentrations after the groundwater remediation is shut off continue to be protective of Panattoni warehouse indoor air quality"* (page 20, Ecology comment #b, second bullet).

- **Boeing's Response:** Under WAC 173-340-410(c), confirmational monitoring is performed to "Confirm the long term effectiveness of the interim action or cleanup action once cleanup standards . . . have been attained." This is also not applicable for PMG as there are no regulatory cleanup standards for soil gas, soil gas has been demonstrated to be below screening levels (i.e., no risk to indoor air at Panattoni or Bertch properties), and indoor air has not been identified as a media of concern.

In conclusion, Boeing will commit to initial seasonal soil gas sampling as required by Ecology. However, if the seasonal sampling verifies that soil gas VOC concentrations are below screening levels, long-term monitoring is not required by regulation or guidance. It should also be noted that as groundwater concentrations across the plume continue to go down, there will be further decreases in the source of potential contamination that might have led to elevated soil gas (but that did not, even under current concentrations in groundwater).

E. Other/Miscellaneous

1. Pilot Study

As indicated by Ecology in Footnote 19 in its final decision letter, a pilot study for EISB was *"Discussed very generally during March 22, 2017 meeting"* (page 11, footnote 19). Now, without further consultation with Boeing, Ecology has made it a requirement *"that Boeing should perform phase 1 (pilot) EISB injections north and south of Seaway Blvd. during the implementation of the cleanup action plan (CAP)/ Engineering Design Report (EDR)"* (page 10, third paragraph).

- **Boeing's Response:** The initial discussion was not a formal proposal and was offered in the spirit of negotiation as a possible step to demonstrate Boeing's position that donor substrate was likely to reach extraction wells and surface water. Since this initial conversation with Ecology, Boeing has evaluated the idea of a pilot study and has concluded that there is a similar level of risk of detrimental consequences to that of full scale implementation. Performing any injection of donor substrate in sufficient quantities to demonstrate a) the effectiveness of the EISB groundwater treatment technology in this area of the plume, and/or b) whether donor substrate or other consequent redox conditions or byproducts will reach extraction wells or surface water is akin to full-scale implementation, especially if performed both north and south of Seaway Boulevard, and runs the same risks of extraction well/treatment system fouling or unlawful discharge to surface water. Boeing also contends that the observations previously discussed regarding conditions observed downgradient of the source area injection site are adequate to assess potential changes in water quality downgradient of proposed EISB injection wells, and therefore a pilot study is unnecessary.

2. Other Ecology Statements

Ecology makes other statements in its final decision letter, the meaning or intent of which Boeing does not understand.

a) In footnote 50 (page 30), in reference to groundwater needing to meet surface water cleanup levels before shutting off extraction wells, Ecology states *"Based on the current contaminant distribution in the groundwater, Ecology doesn't believe that there will be any reason to expect a significant decreasing TCE concentration gradient near the creek based on operation of the groundwater extraction wells alone such that –for example – TCE groundwater concentrations 10 feet from the creek decrease significantly to below 0.3 µg/L TCE (WQC) before entering the creek."*

- **Boeing's Response:** Boeing does not understand the meaning or intent of this statement.

b) In the conclusions, Ecology states that *"If EISB injections on downgradient and off-Boeing property were reduced, revised, (or eliminated) based on the phase 1 (pilot) EISB injection results, the DCA would still favor this modified alternative 4 (where groundwater cleanup levels are still met at the groundwater SPOC) for the same reasons alternative 4 is favored over alternative 2a"* (page 33, first paragraph).

- **Boeing's Response:** Boeing does not understand this statement or its intent; Alternative 4 becomes Alternative 2 if there is no downgradient EISB. Also as previously stated, Boeing is not proposing Alternative 2a (CPOCs were an independent point of discussion).

Boeing requests clarification of these statements if they are pertinent to the other discussions above or have a direct bearing on approach or implementation to the final selected remedy.

III. Outstanding Issues

In Boeing's response to Ecology's original contingent approval letter, Boeing requested clarification of several miscellaneous items that were not addressed in Ecology's final decision letter. We reiterate our request for the following:

a) Boeing requests that Ecology allow the use of passive diffusion bags for future groundwater sampling at PMG (and upland) monitoring locations. This technology has been demonstrated and accepted for use by Ecology at another Boeing facility and by EPA at two locations in Washington State. The studies that have been performed to date sufficiently justify the use of this technology, and Boeing would like Ecology to consider approving this technology without a side-by-side study.

b) Boeing reiterates the request that Ecology meet with Boeing prior to preparing the draft CAP, as agreed to by Ecology in informal dispute resolution meetings, to determine a reasonable level of compliance monitoring (location, frequency, and duration) for long-term sampling of groundwater, surface water, and soil gas/indoor air (where applicable), based on data quality objectives.

IV. ATTACHMENTS

Attachment 1A	Powder Mill Gulch Source Area Biofouling Evaluation
Attachment 1B	Evaluation of Potential for In-Situ Bioremediation Concurrently with Groundwater Extraction and Treatment
Attachment 1C	Updated Restoration Timeframe Summary
Attachment 1D	Updated Disproportionate Cost Analysis
Attachment 1E	Proposed Cleanup Levels and Use of Remediation Levels for Groundwater and Surface Water at Powder Mill Gulch

V. References

CH2MHill. 2017. *Evaluation of Potential for In-Situ Bioremediation Concurrently with Groundwater Extraction and Treatment; Boeing Everett Washington Facility*. June 12.

Ecology (Washington State Department of Ecology). 2009. *Review Draft: Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remediation.* Publication No 09-09-047. Toxics Cleanup Program, Washington State Department of Ecology. Olympia, Washington. October.

Ecology. 2016. Letter to Ms. Debbie Taege, The Boeing Company, from Mr. Dean Yasuda, Ecology, Re: Ecology Contingent Approval and Modifications to the Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 12, 2015. August 18.

Ecology. 2017. Letter to Ms. Debbie Taege, The Boeing Company, from Mr. Dean Yasuda, Ecology, Re: Ecology Final Decision Under Informal Dispute Resolution Regarding the Upland Feasibility Study (FS) Report and Ecology Selected Remedies for the Boeing Everett Site. July 20.

EPA (US Environmental Protection Agency). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study.* EPA 540-R-00-002; OSWER 9355.0-75. US Environmental Protection Agency and US Army Corps of Engineers. July 2000.

Freeze and Cherry. 1979. Groundwater. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

LAI (Landau Associates, Inc.). 2011. *Work Plan, Phase 1 Downgradient Plume Interim Action, Powder Mill Gulch, Boeing Everett Plant, Washington*. October 14, 2011.

LAI. 2016. *Proposed Use of Conditional Point of Compliance and Remediation Levels, and Revised Cost Estimates and Disproportionate Cost Analysis, Powder Mill Gulch – Boeing Everett Plant, Everett, Washington*. November 2.

LAI. 2017a. *Powder Mill Gulch Source Area Biofouling Evaluation – Revision 1*. April 4.

LAI. 2017b. *Proposed Cleanup Levans and Use of Remediation Levels for Groundwater and Surface Water at Powder Mill Gulch, Boeing Everett Plant, Everett, Washington*. September 8.

Attachment #1 – Powder Mill Gulch

Suthersan, S.S. 1999. "Pump and Treat Systems." Remediation Engineering: Design Concepts. CRC Press LLC. Boca Raton, Florida.

Attachment 1A

Technical Memorandum

Powder Mill Gulch Source Area Biofouling Evaluation – Revision 1

Technical Memorandum

TO: Debbie Taege, The Boeing Company

FROM: Piper Roelen, PE

DATE: April 4, 2017

RE: **Powder Mill Gulch Source Area Biofouling Evaluation – Revision 1**

Extraction Well/Air Stripper Fouling

Fouling of extraction wells and/or the air stripper system is a significant concern where electron donor is injected to enhance reductive dechlorination. Of concern are elevated total organic carbon (TOC) and reduced metals (e.g., manganese and iron) that may extend to extraction wells. Where reduced water with elevated TOC or dissolved metals extends to extraction wells, biological growth and/or precipitation of metals will occur due to the aeration/introduction of oxygen to groundwater at the point of extraction or treatment. Suthersan (1999) indicates that "the oxidation of iron and manganese, the growth of biofilms, and the deposition of calcium carbonate are all by-products of the aeration process, regardless of the aeration mechanism used." Furthermore, Suthersan indicates that significant maintenance and/or pre-aeration and filtration are necessary to control fouling if the following groundwater conditions are present:

- iron and manganese concentrations greater than 10 milligrams per liter(mg/L) (even at concentrations greater than 5 mg/L, increased maintenance is likely)
- total biodegradable organics (TOC) concentrations of more than 10 mg/L.

Suthersan further notes that varying levels of these constituents can result in fouling that can significantly diminish the duration of system operability and that "at very high inorganic levels the system can fail within days of operation."

At Powder Mill Gulch (PMG), background (i.e., naturally occurring) concentrations of iron and manganese identified in historical groundwater sampling at the site are less than approximately 0.1 mg/L (and below detection in many locations), and TOC concentrations are generally less than 1.5 to 2 mg/L**.** These background levels are not likely to cause significant fouling issues [which has proven true since operation of the Groundwater Extraction and Treatment (GET) system began in 2012]**.** However, below are examples of conditions resulting from bioremediation in the source area at monitoring wells within the treatment zone and downgradient of the donor borings installed in 2010.

Analyte	Max. Concentration in Monitoring Well After Donor Injection				
	EGW161 *(treatment zone)*	**EGW151** *(20' DG)*	**EGW127** *(75' DG)*	**EGW144** *(115' DG)*	**EGW088** *(160' DG)*
Iron (Fe2+)	**5.2 mg/L**	**5.4 mg/L**	0.0 mg/L	0.2 mg/L	0.0 mg/L
Manganese (Mn2+)	**8.6 mg/L**	**6.7 mg/L**	0.22 mg/L	0.14 mg/L	**2.9 mg/L**
TOC	**1,380 mg/L**	**39.9 mg/L**	1.67 mg/L	3.59 mg/L	2.2 mg/L

Notes:
Bold values exceed levels likely to result in significant fouling.
DG indicates distance downgradient from nearest donor boring.

These data indicate that even at wells over 150 feet away from the injection points, reducing conditions created by the donor injections can cause increases in soluble inorganic concentrations (such as manganese) that could result in precipitation and severe fouling of systems at the point oxygen is introduced. Based on these data, elevated dissolved metals concentrations continue to persist at this distance over 6 years after the injection events. These data and other data collected before and after the injection events also identified elevated TOC concentrations in wells 50 to 100 feet downgradient of injection wells for upwards of 1-½ years or more after donor injections.

Generation of Contaminants of Concern

In addition to potential well and treatment system fouling, as indicated by the table below, regulated contaminants, generated through reductive dechlorination of trichloroethene (TCE; i.e., vinyl chloride) or mobilized through increasing solubility of naturally occurring minerals in a reducing environment (i.e., arsenic), can be found well downgradient of the treatment area. Similar to above, arsenic and vinyl chloride continue to be present at concentrations above pre-injection levels at distances over 150 feet downgradient of the donor borings over 6 years following donor injection. These contaminants could discharge to surface water from groundwater (especially if extraction wells are inoperable or their efficiencies are reduced due to fouling or by discharging through the groundwater treatment system to surface water if not adequately captured and treated.

	Max. Concentration in Monitoring Well Before and After Donor Injection				
Analyte	**EGW161** *(treatment zone)*	**EGW151** *(20' DG)*	**EGW127** *(75' DG)*	**EGW144** *(115' DG)*	**EGW088** *(160' DG)*
Vinyl Chloride (pre-injection)	<0.2 µg/L	<0.2 µg/L	<0.2 µg/L	0.16 µg/L	<0.2 µg/L
Vinyl Chloride (post-injection)	**57 µg/L**	**43 µg/L**	**8.1 µg/L**	**7.9 µg/L**	**9.3 µg/L**
Arsenic (pre-injection)	2.8 µg/L	11.4 µg/L	3.4 µg/L	1.3 µg/L	2.5 µg/L
Arsenic (post-injection)	**9.9 µg/L**	**19.2 µg/L**	3.8 µg/L	2.6 µg/L	4.1 µg/L

Notes:
Bold values exceed cleanup level and pre-injection concentrations.
DG indicates distance downgradient from nearest donor boring.
µg/L = micrograms per liter.

These site data support Boeing's original conclusions presented in the FS, that bio-injections should not be performed within at least 200 feet, or greater, upgradient of extraction wells or surface water bodies in order to prevent fouling of the extraction wells and/or treatment system, and inadvertent discharge of contaminants of concern to surface water. Misapplication of bioremediation would threaten the current groundwater treatment and containment achieved with the GET system.

LANDAU ASSOCIATES, INC.

Piper M. Roelen, PE
Project Manager

PMR/tam
[P:\025\175\FILERM\R\FEASIBILITY STUDY\2015 FS\ECY RESPONSE IMPACT\BIO & GET RESEARCH\REVISION 1\BOEING__PMG_LANDAU_040417_FINAL BIOFOULING TM_REV1.DOCX]

References

Suthersan, S.S. 1999. "Pump and Treat Systems." *Remediation Engineering: Design Concepts*. CRC Press LLC. Boca Raton, Florida.

Attachment 1B

Third Party Review

Evaluation of In-Situ Bioremediation Concurrently with Groundwater Extraction and Treatment

CH2MHill

TECHNICAL MEMORANDUM

Evaluation of Potential for In-Situ Bioremediation Concurrently with Groundwater Extraction and Treatment; Boeing Everett Washington Facility

PREPARED FOR:	Debbie Taege/The Boeing Company
PREPARED BY:	Dean Williamson/CH2M HILL
DATE:	June 12, 2017
PROJECT NUMBER:	693910.TM.CS

Purpose and Background

This memorandum provides an independent, 3rd party technical evaluation of the expected compatibility of an enhanced in-situ bioremediation (EISB) system implemented concurrently with an existing groundwater extraction and treatment system (GETS) at the Powder Mill Gulch (PMG) portion of the Boeing Company's Everett Washington facility. Groundwater at PMG is impacted with trichloroethene (TCE). Previous groundwater remediation activities implemented include in-situ thermal treatment (ISTT) and EISB in the source zone and implementation of the GETS in the downgradient plume.

Boeing submitted a Feasibility Study (FS) report (AECOM/LAI, 2015) to the state of Washington Department of Ecology (Ecology), describing four remedial alternatives for further remediation of TCE-impacted groundwater. Alternative 1 involves continuing to operate the existing GETS as currently configured, which has been successful in significantly reducing TCE plume concentrations. The GETS also successfully mitigates discharge of TCE-impacted groundwater to Powder Mill Creek. A general layout of the existing system is provided in the attached Figure 1.

After reviewing the FS report, Ecology selected Alternative 4, which involves continued operation of the GETS plus focused EISB within the capture zones of the GETS extraction wells (Ecology 2016). A conceptual layout for EISB system implementation based on current site conditions is shown in Figure 2. Ecology prescribed significant changes to the manner in which Alternative 4 should be implemented, compared to the implementation concept presented in the FS report, including:

- Groundwater extraction wells must be operated continually (rather than shut down temporarily after organic substrate injection as proposed in the FS report) to preclude TCE-impacted groundwater from reaching Powder Mill Creek
- 2 to 3 rounds of substrate injection should be conducted
- Injection well locations should be installed where needed to provide adequate groundwater treatment and minimize groundwater restoration time frame (without consideration of impacts to the GETS).

Basis for Evaluation

This independent technical evaluation is based on the author's experience in designing and implementing over 20 GETSs for underground storage tank, hazardous waste, and landfill sites as well as designing and implementing over 30 ISB systems, over more than 35 years of professional practice.

Many of these GETS and ISB systems are similar in nature to the GETS and contemplated EISB system at the Everett facility.

The author also contributed a chapter on the topic of "Combined Remedies" to the peer-reviewed monograph entitled "Chlorinated Solvent Source Zone Remediation" produced by SERDP/ESTCP (Keuper et al, 2014). The chapter covers the current state-of-the-practice for chlorinated solvent remedial approaches that concurrently or sequentially apply two or more commonly used in-situ remediation technologies. The implementation of EISB within the capture zones of the GETS is an example of a Combined Remedy. The author is intimately familiar with the engineering principles involved in designing both GETS and ISB systems as well as the issues and concerns that are essential for consideration when applying multiple concurrent remedial technologies for chlorinated solvent remediation.

Key Elements of the Existing GETS

Key elements of the existing GETS that must be considered in evaluating the potential for compatibility with an EISB system implemented within its capture zone include:

- Hydrogeologic setting - The shallow hydrogeologic setting in the Everett area includes a complex succession of glacial and non-glacial deposits (Trooth and Booth, 2008). Quaternary deposits are predominant at land surface in the area. Multiple glaciation periods and other significant geologic processes have created a variety of lithologies with abundant horizontal and vertical facies changes, which create significant spatial heterogeneity in aquifer characteristics. The shallow impacted groundwater at the site migrates primarily through the Esperance Sand lithologic unit, comprised largely of medium grained sand, horizontally cross-bedded, and which may have silt beds present. This formation exhibits a range of hydraulic conductivities, from 0.7 to 14 ft/day at the site.
- The aquifer portion north of Seaway Boulevard exhibits generally lower hydraulic conductivity than the portion south of Seaway Boulevard. The shallow aquifer exhibits other indications of heterogeneity, as shown by the range in extraction rates from groundwater extraction wells (from less than 1 to approximately 30 gallons per minute [gpm]) and variability in the plume response to groundwater extraction over time. This heterogeneity and the uncertainty of its effects on the expected distribution and hydraulic transport of injected reagents and groundwater constituents that will be generated through the EISB process (e.g., increased dissolved iron and manganese) should be carefully considered when evaluating the EISB remedy.
- Groundwater seepage velocity in the area south of Seaway Boulevard has been estimated at 3.4 ft per day under non-pumping conditions and 6.7 ft per day under pumping conditions. North of Seaway Boulevard, seepage velocities are estimated to range from 0.3 ft/day under non-pumping conditions and 0.64 ft/day under pumping conditions. Hydraulic gradients at the site vary spatially and range from 0.016 to 0.16 ft/ft over much of the plume but may increase over short distances close to extraction wells.
- In the area at which ISB implementation is being considered, the groundwater depth to top of water table ranges from 5 to over 30 feet below ground surface (bgs), with the saturated thickness ranging from approximately 5 to 75 ft, generally decreasing in the downgradient direction.
- The natural aquifer geochemistry at the site is aerobic/oxic with dissolved oxygen detectable throughout the formation (except where it has been impacted by previous injection of organic substrate). Oxidation-reduction potential (ORP) is positive. Nitrate concentrations are generally well below 1 milligram per liter (mg/L) or below the method detection limit. Sulfate concentrations are relatively low, with most wells exhibiting sulfate concentrations less than 10 mg/L. Sulfide concentrations are also below detectable limits. Dissolved iron and manganese are low (well below 1 mg/L), indicating that little iron or manganese reduction is occurring. Groundwater pH is relatively neutral. Total organic carbon [TOC]) is low (less than 5 mg/L). The aerobic nature of the aquifer is of

primary importance in evaluating the compatibility of an EISB system within the capture zone of an existing GETS.

- Extraction well design is variable, depending on the saturated thickness of the impacted aquifer zone being recovered, with well screen lengths ranging from 5 to 15 feet and extending from 18 to 62 feet below land surface (bls).
- Groundwater extraction rates from individual wells are controlled using pumps equipped with variable frequency drive (VFD) controllers. Drawdown created within the extraction wells under pumping conditions is conducted such that the water level within the well is maintained approximately 1 foot or more above the top of the well screen.
- Aboveground treatment for extracted groundwater is achieved using an air stripper. Treated groundwater is discharged to Powder Mill Creek under an NPDES permit.

Key Elements of EISB System Being Considered for Implementation

Key elements of an EISB system that would be implemented within the capture zone of the GETS that should be considered include:

- Proposed injection locations, methods, substrate type and substrate loading
- Potential duration and number of injection events for EISB implementation
- Existing redox and geochemical conditions of the target aquifer
- Groundwater seepage velocity and travel time from EISB treatment zone to extraction wells
- Potential consequential impacts of groundwater geochemistry changes to extraction wells, extraction pumps, conveyance lines, treatment system, and discharge

These factors are considered in the following sections.

A conceptual approach for EISB implementation is presented in Figure 2. Two TCE plume "warm spots" (peak TCE concentrations greater than 250 ug/L but less than 500 micrograms per liter [ug/L) have been identified as target treatment zones for EISB, as well as a target treatment zone in the source area. The two plume areas are the subject of this evaluation. One treatment area is south and one is north of Seaway Boulevard. A row of substrate injection wells would be placed near the upgradient edge of each treatment area. For the treatment area south of Seaway Boulevard, seven injection points would be used. Each point would have two 20-ft-long well screens to target approximately 55 vertical feet of TCE-impacted saturated zone. For the treatment area north of Seaway Boulevard, seven injection points would be used. Each injection point would have a single 20-ft-long well screen to target approximately 30 vertical feet of saturated zone.

The total injectate volumes for the south and north treatment zones, based on this injection well array, would be 65,500 and 45,000 gallons, respectively. This is approximately 230 to 320 gallons per ft of injection well screen. Assuming the mobile porosity of the formation is in the range of 0.1 to 0.15 (Payne, et al 2008), the expected radius of influence would be approximately 8 to 10 feet. Proposed injection point spacing is approximately 15 feet apart. Thus the target injectate volume would be expected to achieve a relatively complete EISB treatment zone (biobarrier) transverse to groundwater flow direction.

The substrate expected to be used is LactOil, a combination of 35% vegetable oil, 35% ethyl lactate plus emulsifiers and water. According to its manufacturer, JRW Bioremediation, LactOil forms a true microemulsion when mixed with water, which promotes significant mobility when injected into the saturated zone, i.e., the small stabilized colloidal particles of vegetable oil as well as the dissolved ethyl lactate can be expected to drift with groundwater advection to a greater degree than other emulsified vegetable oil (EVO) substrates. My experience in using LactOil at several sites as well as past observations from its use at the site support this claim. The proposed dose of LactOil in the injectate is 5% (50,000 mg/L), a dose within the range commonly used for EISB systems. Approximately 2 to 3 injection events would be conducted over a 2 to 3 year period, depending on the observed effects of the substrate injection events.

At the southern treatment area, groundwater extraction wells in closest proximity to the EISB injection well locations are EGW216 (located generally cross gradient but only approximately 50 feet from proposed injection wells and potentially within the area of influence of the injection wells) and EGW215, EGW175, and EGW182, located on the order of 150 to 230 feet downgradient of the proposed injection well locations. Given the estimated seepage velocity of 6.7 feet/day in this area and distances noted above, groundwater transport time from the injection wells to the downgradient extraction wells could be on the order of 22 to 34 days and possibly within a week for EGW215 if the injection wells are located within its capture zone. The presence of higher permeability preferential pathways within the aquifer could provide for more rapid migration of injected materials to the wells. Well construction details for these well are summarized below:

Well	Screen length (ft)	Screened interval (ft bgs)
EGW216	15	43 to 58
EGW215	5	13 to 18
EGW175	15	33 to 48
EGW182	15	31 to 46

At the northern treatment area, groundwater extraction wells in closest proximity to the EISB injection well locations are EGW176 and EGW193, at distances of approximately 300 and 500 feet, respectively. Given the estimated seepage velocity of 0.64 feet/day in this area and distances noted above, groundwater transport time from the injection wells to the downgradient extraction wells could be on the order of 470 to 940 days. The presence of higher permeability preferential pathways could provide for more rapid migration of injected materials to the wells. Well construction details for these well are summarized below:

Well	Screen length (ft)	Screened interval (ft bgs)
EGW176	10	46 to 56
EGW193	10	12 to 22

Expected Changes in Aquifer Geochemical Conditions After Injection

With the site conditions and proposed EISB implementation concept as described, the types of geochemical changes that would result after injection of the organic substrate can be predicted based on extensive technical literature (e.g., Chapelle, 1993) and past experience at this and other sites. The injection of a readily fermentable organic carbon, such as LactOil, will provide a rich supply of electron donor material to the abundant native groundwater microbial populations in the aquifer. The limited amount of dissolved oxygen can be expected to be consumed relatively quickly by aerobic bacteria and the aquifer will rapidly become anaerobic.

After the oxygen is consumed and given the absence of nitrate in the aquifer, bioavailable manganic- (Mn +4) and ferric- (Fe +3) containing minerals in the subsurface will begin to provide electron acceptors for naturally occurring iron-reducing bacteria, such as Geobacter or Shewanella, resulting in increases in dissolved concentrations of the reduced forms of these metals (Mn+2 and Fe+2). Increases in concentrations of these dissolved metals were observed during the previous application of EISB in the residual source zone and similar increases can be expected to occur during future EISB applications.

As iron reduction proceeds, dissolved arsenic concentrations in groundwater may also increase, due to the common occurrence of arsenic adsorbed to iron hydroxide minerals (Cozzarelli et al, 2016). As the iron-containing minerals are reduced by iron-reducing bacteria, adsorbed arsenic within those minerals is often found to be released to groundwater. Increases in dissolved arsenic were previously observed during EISB implemented within the source zone. Arsenic's mobility in groundwater will be generally similar to that of ferrous iron under anaerobic conditions; provided that the groundwater remains anaerobic, it can be expected to have significant mobility in groundwater. This is particularly true if the arsenic is reduced to As +3, in the form of arsenite.

As groundwater redox continues to decline due to the effects of the organic substrate injection, sulfate reduction and methanogenesis may also begin to occur. Because of the generally low concentrations of sulfate (less than 10 mg/L in most wells), little sulfide production is expected to occur. The lack of sulfide production has significant implications for the mobility of the dissolved iron in groundwater. Sulfide produced within EISB systems has been found to react very quickly with reduced iron (USEPA, 2009), creating ferrous sulfide (FeS) precipitates. For this reason, in aquifers with naturally elevated sulfate, precipitation of FeS may mitigate the migration of ferrous iron. In addition, the FeS precipitates have been found to have the capability to abiotically degrade TCE. However, given the low sulfate concentrations, ferrous iron generated after EISB implementation can be expected to be highly mobile where the aquifer redox conditions are anaerobic. Reduced manganese and arsenic will also exhibit similar high mobility under reducing conditions.

Methane produced from injected substrate can also be expected to exhibit significant mobility within site groundwater under anaerobic conditions.

Concurrent with bioavailable iron and manganese minerals being used as electron acceptors, TCE can also be expected to be used as an electron acceptor, producing cis-1,2-DCE as a degradation product. A wide variety of groundwater bacteria are capable of degrading TCE to cis-1,2-DCE and previous site EISB experience indicates that some of these bacteria are naturally present in site groundwater. As groundwater redox conditions continue to decline to the range suitable for sulfate reduction and methanogenesis, cis-1,2-DCE will also begin to be used as an electron acceptor, provided that appropriate bacteria (e.g., *Dehalococcoides*) are present in groundwater, producing VC as a degradation product. With adequately low redox conditions, VC may also be degraded to ethene by *Dehalococcoides.* Previous site EISB experience indicates that *Dehalococcoides* are naturally present in site groundwater. Complete degradation of TCE to ethene is the objective of the EISB system.

Potential Impacts of Groundwater Geochemistry Changes to Existing GETS

Based on the configuration of the GETS and proposed EISB system and the expected changes in groundwater geochemistry as noted above, potential impacts of the EISB system to the GETS can be considered. These include the following

- **Fouling caused by transport of injected substrate or residual organic carbon to groundwater extraction wells** – As noted above, the groundwater transport times from the EISB injection well locations to the hydraulically closest groundwater extraction wells may range from 22 to 34 days and 470 to 940 days for the southern and northern EISB areas respectively. Given the mobility and longevity of the organic substrate solution that would be injected (on the order of up to 2 or more years), organic carbon related to the injected substrate has the potential to reach extraction wells in the southern EISB area, such as wells EGW215, EGW175, and EGW182, within as little as several months after injection, and possibly much sooner at well EGW216, and arrival of organic carbon at these wells would be reasonably expected to occur at some point after substrate injection. The arrival of organic carbon at these wells can be expected to create significant well fouling, since organic carbon is known to be a prime source for growth of heterotrophic microorganisms in well fouling (Alford and Cullimore, 1999). Well fouling leads to reduced specific capacity and yield, reduced well efficiency, and even complete well production loss (Smith, 1995). It is important to note that well fouling does not occur simply at the well screen but rather within a region outside the well that can extend for several feet beyond the well screen, within an aerobic “redox fringe” created within the zone of drawdown outside the extraction well (Mansuy, 1998). The redox fringe is a zone within the capture zone in which oxygen diffusion occurs, due to the groundwater drawdown within the cone of depression around the extraction well and due to cycling of the extraction well pumps on and off. This fouling outside of the well is extremely difficult to address or mitigate with currently available well rehabilitation technologies.

- Although the transport time from the injection wells to the extraction wells in the northern EISB treatment area is greater than in the southern area, similar impacts to the extraction wells downgradient of the northern EISB area also likely to eventually occur, given the multiple injections of substrate planned and the long duration (over 50 years) that the GETS is expected to be operated. While it may take one to several years before impacts to these extraction wells becomes manifest, the long term effects on the production efficiency of these wells could be similar to those in the southern EISB area, depending on the number of injections and mass of organic carbon injected during each event. With periodic injections of significant substrate doses over an extended time period, there is likely not a “safe distance” that EISB can be implemented within the capture zone of the GETS without the risk of creating impacts to the GETS.

- **Fouling caused by transport of dissolved iron and manganese to extraction wells** – As the organic carbon migrates downgradient from the injection wells via advection, groundwater redox within this organic carbon plume will become increasingly anaerobic. Under anaerobic conditions, several groundwater species produced as a result of substrate injection, such as dissolved iron, manganese, arsenic, and methane, are highly mobile and stable. These parameters can be expected to migrate with the organic carbon and eventually arrive at the downgradient extraction wells. As the dissolved metals enter the aerobic redox fringe surrounding the extraction wells, they will begin to be oxidized. As noted above, biofouling by iron and manganese oxidizing bacteria occurs not only on the well screen but outside the well, within the redox fringe induced within the groundwater cone of depression. Smith, 1995 describes a variety of spatial patterns for iron bacteria fouling occurring outside the well screen, including dispersed, tight regular and irregular spiculate, and concentric detached patterns of biofouling growth. Growth of biomass from outside the wells screen through the well screen into the casing, in the form of mucoid tubercles, has also been found to help colonize the growth of iron bacteria inside the extraction wells. As well fouling occurs and the specific capacity declines, the amount of drawdown required within the well to sustain the extraction rates needed for plume containment increases. As fouling proceeds, it may reach a point at which the well screen becomes exposed to air, further exacerbating well fouling leading to even greater declines in well efficiency.

- **Fouling of well pumps and lines** - In addition to fouling of the extraction well screen and surrounding aquifer, fouling of well pumps and piping also commonly occur in groundwater extraction systems with elevated organic carbon, iron, and manganese. The attached photographs depict extraction well pumps used in a groundwater aquifer with dissolved iron on the order of 3 to 10 mg/L. Periodic cleaning and replacement of the extraction well pumps is required to maintain effective system operation.

- **Need for Extraction Well Rehabilitation** – The need for and methods to accomplish extraction well rehabilitation to mitigate the effects of well fouling have been discussed in a variety of publications (for example, Alford and Cullimore, 1999; Mansuy, 1998; and Smith, 1995). Available methods include mechanical well cleaning (brushing, jetting), chemical (acids, oxidants, detergents, chelating agents), and thermal methods (heat or carbon dioxide for extreme cooling). Experience has shown that the degree of effectiveness for different well rehabilitation methods is variable and the benefits for wells experiencing a significant degree of fouling are often temporary. In addition, these rehabilitation methods often have little effect on biofouling that occurs within the redox fringe locate outside the well within the cone of depression created during pumping. For this reason, wells that experience chronic biofouling may eventually have to be replaced with new wells.
- **Impact of Organic Carbon, Iron, and Manganese on Groundwater Treatment Equipment –** As organic carbon and dissolved iron and manganese begin impacting the extraction wells, impacts to the air stripping equipment used to remove VOCs from site groundwater can also be expected to occur. The nature of the impacts (biofouling from organic material and from iron and manganese oxidizing bacteria) would be expected to be similar to those in the wells. Biofouling of the air stripper will require more frequent system shutdowns due to the need for more frequent cleaning of the air stripper. Downtime of the groundwater treatment equipment could create periods of uncontrolled groundwater capture, further noted below. Additional impacts could include the need for further treatment of extracted groundwater to remove organic carbon related to the injected substrate (such as volatile fatty acids) prior to discharge or filtration of the groundwater to remove solids related to biofouling. These additional unit processes, if needed, would significantly increase the complexity and cost of operating the GETS.

- **Impacts on Receiving Surface Water –** Impacts to receiving surface waters would not be expected to be significant provided that the groundwater extraction and treatment facilities continue to operate as they currently do. However, biofouling of extraction wells, pumps, piping, and treatment equipment can be expected to lead to decreased well efficiency, with the potential for incomplete plume capture, and greater system downtime for cleaning and maintenance. While the GETS is shut down for these activities, impacted groundwater containing VOCs (including vinyl chloride), organic carbon derived from LactOil, and dissolved iron, manganese, and arsenic could migrate into receiving surface water.

Other Considerations

The GETS was designed by a professional engineer (P.E.) with a specialization in environmental engineering and registered as a P.E. in the state of Washington. The GETS appears to be a well-designed system that is currently operating effectively and without experiencing biofouling issues. The Engineer of Record for the system and their affiliated company have a significant vested interest and professional responsibility for maintaining and operating the system in the manner in which it was originally designed, i.e., within a groundwater environment that is aerobic, in which the system operates as designed, and in which biofouling is not a factor. Revising the design of the existing GETS system to include an additional remedy that has the potential to create significant biofouling issues and degradation of performance may be considered inadvisable by the responsible engineer, their firm, or any other engineer since it could potentially expose them to liability for operational issues encountered by the additional remedy. It would not be unreasonable, in my opinion, for the Engineer of Record for the GETS to decline a request to design an EISB addition to the system if the engineer believed that such an addition could compromise the integrity of the GETS design or its operations. For these reasons, a decision to incorporate additional remedies within the capture zone of the existing GETS should be made cooperatively with Boeing, its design engineers, and Ecology and with a detailed consideration of the range of impacts that an additional remedy could incur on the existing GETS.

Conclusions

The existing GETS has demonstrated its effectiveness in remediating TCE-impacted groundwater at the Everett site. TCE plume concentrations have declined considerably during the past 4 years of operation. As part of this 3rd party evaluation, Boeing had their engineer, Landau Associates, update the groundwater modeling using current groundwater conditions to estimate the time to reach target cleanup goals. An updated estimate for the time to achieve groundwater target cleanup standards with the GETS alone is approximately 60 years, based on modeling. Modeling of the addition of EISB to operate in conjunction with GETS shows a conceptual decrease in the time to achieve target groundwater cleanup standards of only 7 years. However, this estimate for addition of EISB assumes that the GETS would not be adversely impacted by the EISB system. In reality, the assessment presented above indicates that implementing EISB within the capture zone of the GETS has a significant probability of creating conditions that would induce biofouling of the extraction wells, pumps, piping, and groundwater treatment equipment. Considering GETS shut downs for equipment cleaning, well rehabilitation and replacement, and other issues, the actual time to achieve groundwater cleanup goals with a combined EISB and GETS would likely be longer than estimated by the model.

Given the relatively short time that the GETS has been operational, its success to-date in reducing groundwater plume concentrations, and its ability to adequately control exposure of receptors to groundwater contaminants, it would be prudent to continue to run the GETS to better establish the degree of its effectiveness without implementing any additional remedial approaches. Implementing any remedy within the capture zone of the GETS that results in significant detrimental impact to the GETS performance would be inconsistent with best engineering practices. Landau Associates has previously indicated that in their opinion, it would be inadvisable to proceed with the EISB system within the capture zone of the GETS. I concur with that opinion.

References

Alford, G., and Cullimore, R. 1999. The Application of Heat and Chemicals in the Control of Biofouling Events in Wells. Lewis Publishers

Chapelle, F., 1993. Ground-water Microbiology and Geochemistry. John Wiley and Sons.

Cozzarelli, I., Schreiber, M., Erickson, M., and Zieglar, B. 2016. Arsenic Cycling in Hydrocarbon Plumes: Secondary Effects of Natural Attenuation. Groundwater. Vol. 54, No 1. January-February, pp 35 - 45

Keuper, B., Stroo, H., Vogel, C., and Ward, H. 2014. Chlorinated Solvent Source Zone Remediation. Springer. DOI 10.1007/978-1-4614-6922-3

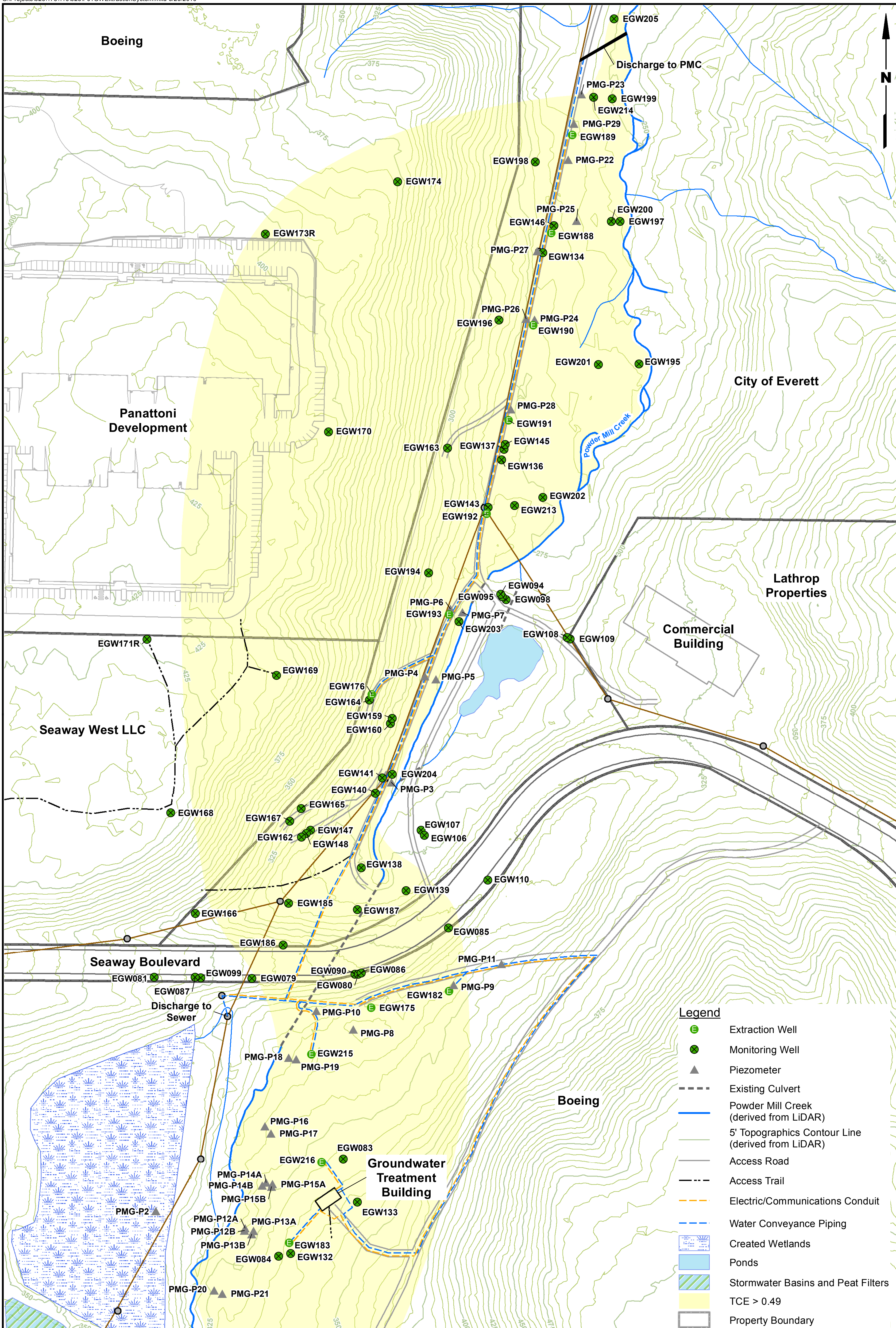
Mansuy, N., 1998. Water Well Rehabilitation – A Practical Guide to Understanding Well Problems and Solutions. Lewis Publishers

Payne, F., Quinnan, J., and Potter, S. 2008 Remediation Hydraulics. CRC Press.

Smith, S., 1995. Monitoring and Remediation Wells – Problem Prevention, Maintenance, and Rehabilitation. Lewis Publishers

Troost, K., and Booth, D. 2008. Geology of Seattle and the Seattle Area, Washington. In Baum, R.L., Godt, J.W., and Highland, L.M., eds., Landslides and Engineering Geology of the Seattle Washington Area: Geologic Society of America Reviews in Engineering Geology, v. XX, p 1-35

USEPA, 2009. Identification and Characterization Methods for Reactive Minerals Responsible for Natural Attenuation of Chlorinated Organic Compounds in Ground Water. EPA 600/R-09/115, December



Base Map Sources: URS 2005; City of Everett 2005
LiDAR Data Source: URS 2005 (Data Collected November 2005)

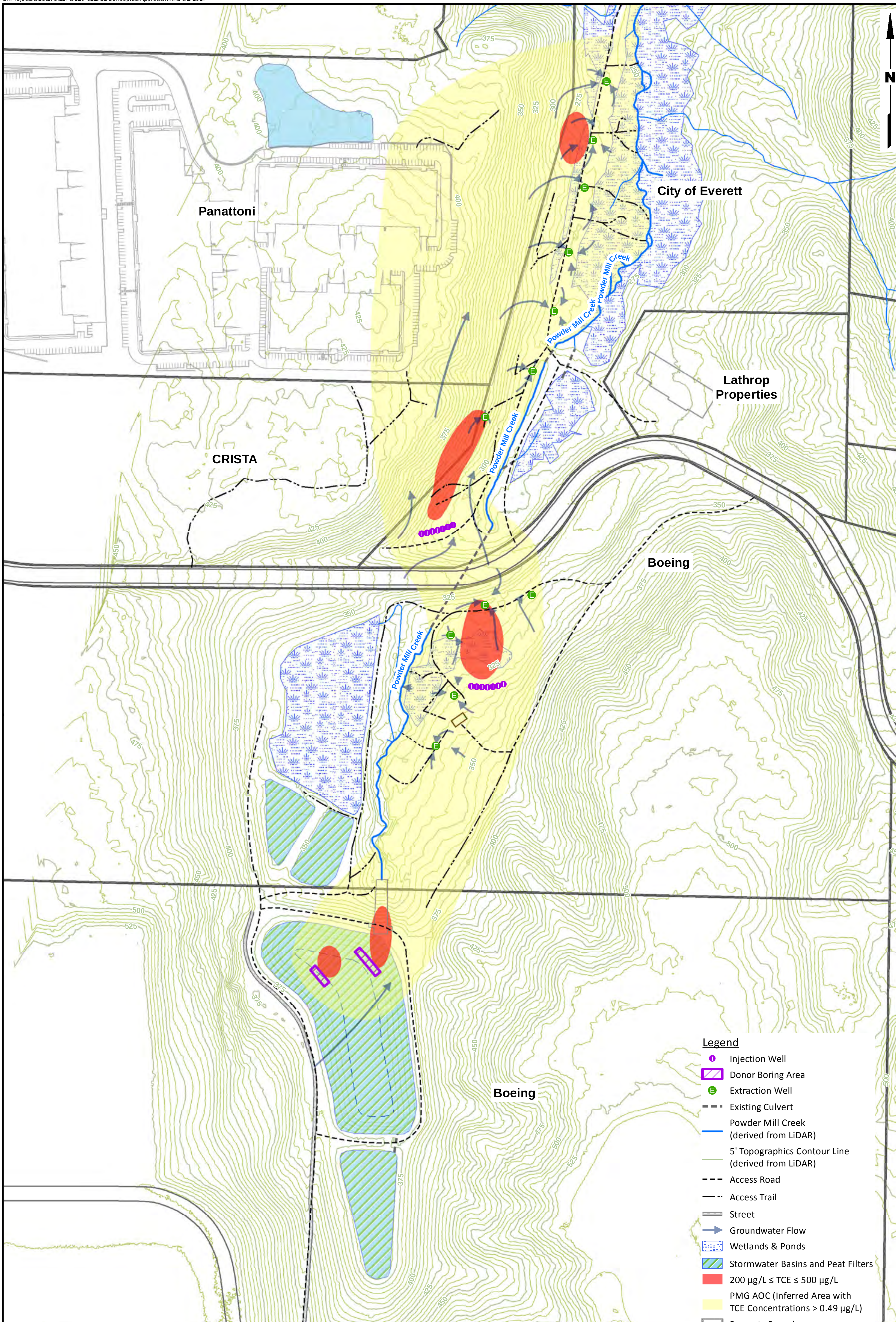
LANDAU ASSOCIATES

Powder Mill Gulch
Downgradient Plume IA
Boeing Commercial Airplanes
Everett, Washington

Groundwater Extraction and Treatment System Layout

Figure 1

G:\Projects\025\175\117\012\F02EISBConceptualApproach.mxd 6/2/2017



Base Map Sources: URS 2005; City of Everett 2005
LiDAR Data Source: URS 2005 (Data Collected November 2005)

0 250 500
Scale in Feet

Landau Associates

Boeing Commercial Airplanes
Everett, Washington

Powder Mill Gulch SWMU/AOC EISB Conceptual Approach

Figure 2

Dean F Williamson
Principal Remediation Technologist

Education

M.S., Environmental Engineering, Stanford University, 1985
B.S., Environmental Engineering, University of Florida, 1978

Professional Registrations

Professional Engineer: Florida; South Carolina

Distinguishing Qualifications

- 38 years experience in environmental engineering, consulting, and remediation; 30 years at CH2M HILL. Provides senior technical direction to a wide variety of remediation projects across the US and internationally.
- CH2M HILL Subject Matter Expert for in-situ bioremediation, natural attenuation, and remediation geochemistry
- Has led the development and implementation of over $200 million of remediation construction during past 20 years
- Experienced in designing and implementing a wide variety of remediation technologies including in-situ aerobic and anaerobic bioremediation, in-situ thermal treatment, various forms of in-situ chemical oxidation, in-situ chemical reduction, air sparging, soil vapor extraction, soil mixing, pump and treat, permeable reactive barriers, excavation, physical containment, and monitored natural attenuation
- Contributing author to textbook entitled "Chlorinated Solvent Source Zone Remediation", produced by SERDP/ESTCP. Author of chapter addressing "Combined Remedies for Source Zone Remediation".

Relevant Experience

As a Principal Technologist, Mr. Williamson is a leader for a wide variety of site management strategies and remediation technologies, particularly those related to in situ soil, sediment, and ground water restoration. He provides technical direction and leadership for complex and challenging remediation projects across the company, in all regions and internationally.

As one of CH2M HILL's leading subject matter experts for in situ bioremediation, has led the development of over 30 full-scale in situ bioremediation systems and many additional pilot studies. These systems have been implemented for remediation of a variety of chlorinated solvents (chloroethenes, chloroethanes, and chlorobenzenes), petroleum products (LNAPL and dissolved hydrocarbon plumes), as well as inorganics (such as hexavalent chromium, cobalt, and lead). Technologies employed have included biostimulation, bioaugmentation, biosparging, bioventing, soil composting, and addition of a variety of supplemental reagents (pH amendments, zero valent iron, and tracers).

In-situ bioremediation systems he has been involved in designing and implementing include the following sites:

- Charleston Naval Complex, Charleston, SC, 5 sites – Trichloroethene (TCE), chlorinated benzenes
- Private sector site, Manhattan Beach, CA – TCE
- Private sector site, Gardenia, CA – Tetrachloroethene (PCE)
- Savannah Air National Guard, GA, Sites 8 and 10 - TCE
- Private Developer, Mare Island, CA, Site IR-15 – PCE and TCE
- Private Sector client, Palestine, TX – 1,1-Dichloroethene (1,1-DCE) and Vinyl Chloride (VC)
- Grants Dry Cleaner Superfund site, NM - PCE
- Private sector client, Clearwater, FL and Crystal River, FL - TCE

- Richards-Gebaur AFB, MO – TCE
- Private Sector client, Northern Ireland – Benzene, Dichlorobenzene
- Robins AFB, GA, Site 17 and DC34 – TCE, Chlorobenzenes, 1,2-Dichloroethane
- Private Sector Site, Milan, Italy - TCE
- Marine Corp Air Station Cherry Point, OU 1 – TCE
- Marine Corp Base Parris Island, Sites 45 – PCE
- Naval Surface Warfare Center White Oak, MD, Site 4 - TCE
- NAS Pensacola, Sites 19 and 25 – Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), fuels
- Naval Air Station Patuxent River, Sites 39 and 493 – PCE and BTEX
- Joint Expeditionary Base Little Creek, Sites 11, 11a, 12, and 13 – TCE, Pentachlorophenol, 1,1,1-Trichloroethane
- Naval Station Norfolk, Sites 18 and 20 - TCE
- Portland ANG, OR - Site 11 - TCE
- Private sector client, Jacksonville, FL - TCE
- Allegheny Ballistic Laboratory, MD – Sites 11 and 12 – TCE, DCE, VC
- OMC Plant 2 Superfund site, WI - TCE
- King Salmon Air Force Station, AK – TCE
- Private sector client, Indianapolis, IN – PCE, TCE, 1,1-DCE

These sites are located in a wide variety of geologic and hydrologic settings. Systems installed included both source zone treatment and plume containment systems. Pilot testing was conducted at several of these sites to support full-scale design.

Mr. Williamson is also a key CH2M HILL subject matter expert for developing documentation and lines of evidence supporting the adequacy of natural attenuation remedies. In this capacity he provides guidance on contaminant plume stability evaluations, evaluation of geochemical data and redox condition interpretation, use of compound specific isotope analysis for assessing biodegradation, use of quantitative polymerase chain reaction (qPCR) data for understanding the microbial consortia present, and other approaches.

Membership in Professional Organizations

National Ground Water Association

Publications and Presentations

Real-time Sampling and High Resolution Characterization Using the FROG-4000 Portable GC; Presented at Tenth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2016, Palm Springs, California

Costs for Full-Scale Implementation of In-situ Thermal Treatment, Chemical Reduction, Chemical Oxidation, and Bioremediation at a Former Naval Shipyard; Presented at Eighth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2012, Monterey, California

Residual Impacts of Full-scale ISCO Implementation on Subsequent Remedial Alternatives; Presented at Eighth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2012, Monterey, California

Overview of Combined Remedies for DNAPL Site Remediation. Keynote Presentation at REMTec Remediation Technology Summit, Chicago, IL May 2011.

DNAPL Source Zone Treatment Using an In-Situ Air Sparging and Enhanced In-Situ Bioremediation Treatment Train. Presented at Seventh International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2010, Monterey, California

Effective Enhanced In-situ Bioremediation at A Former Dry Cleaner to Treat a DNAPL Source Zone and VOC Plume. Presented at Seventh International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2010, Monterey, California

Comparison of Potential CO2 Emissions from Alternative Remedial Technologies at a VOC-contaminated Groundwater Site. Presented at Sixth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2008, Monterey, California

Full-scale DNAPL Removal At Three Sites – Was It Worth It? Presented at Fourth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2004, Monterey, California

In-situ Chromium Reduction with ZVI Under an Active Building. Presented at Fourth International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2004, Monterey, California. Co-author with P. Favara.

Tetrachloroethene Source Area Reduction Using Electrical Resistance Heating. Presented at Third International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 20–23, 2002 · Monterey, California

Practical Considerations for In-situ Source Area Treatment Interim Measures. Presented at Treatment of NAPL: Fundamentals and Case Studies. Sponsored by EPA, Chicago, IL. December 2002.

Construction of a Funnel-and-Gate Treatment System for Pesticide-Contaminated Groundwater Presented at Second International Conference Remediation of Chlorinated and Recalcitrant Compounds, May 2000, Monterey, California

Construction of a Funnel-and-Gate Treatment System for Pesticide-Contaminated Groundwater. Presented at Remediation Technologies Development Forum (RTDF) Permeable Reactive Barriers (PRB) Action Team Meeting. February 16–17, 2000. Melbourne, Florida

Expedited Completion of Superfund Site Remediation through an Innovative Collaboration with EPA. With Karl Hoenke/Chevron Chemical Company, Jeff Wyatt/Chevron Chemical Company, Annie M. Godfrey/USEPA Region IV. Presented at University of Massachusetts Soil and Groundwater Remediation Conference, Amherst, MA, 1999

With William J. McElroy. *Cleaning Up Jet Fuel Contamination at a Former Soviet Air Field*. Presented at the 86th Annual Meeting and Exhibition for the Air and Waste Management Association. Denver, Colorado. June 13-18, 1993.

Bench-Scale Testing of Reverse Osmosis to Remove Technetium 99 and Trichloroethylene from Groundwater. Presented at HMCRI Research and Development Conference, San Francisco, California, February 4-6, 1992.

Leachate Treatment at Two Lined Florida Landfills. Presented at 1988 Joint CSCE-ASCE National Conference on Environmental Engineering. Vancouver, B.C., Canada. July 13-15, 1988.

Vadose Zone Gas Analysis for Tracking a Contaminated Groundwater Plume: A Case History. Presented at 1987 ASCE National Conference on Environmental Engineering, Orlando, Florida. July 7-9, 1987.

With J.E. Singley. *Aeration for Removal of Volatile Synthetic Organic Chemicals*. Proceedings of the First Atlantic Workshop. Nashville, Tennessee. 1983.

With J.E. Singley and A.L. Ervin. *Aeration (Plus Resins) Doing Job Removing VOC*. *Water and Sewage Works*. September 1979.

With J.C. Thurott, H. Zwart-Duryea, and J.R. Sloane. *Trihalomethane Removal by Coagulation Techniques in a Softening Process*. EPA-600/S2-83-003. U.S. EPA Municipal Environmental Research Laboratory. Cincinnati, Ohio. March 1983.

Attachment 1C

Restoration Timeframe Summary

Powder Mill Gulch

TABLE 1
RESTORATION TIMEFRAME SUMMARY
POWDER MILL GULCH
BOEING EVERETT PLANT, EVERETT, WASHINGTON

	Restoration Timeframe (years)					Year
Alternative	Batch-Flushing	Biochlor	Average	Total*	Comment	Complete
Alt 1 to GW CULs	28	45	36.5	37	GW CUL = 4 µg/L	2054
Alt 1 to GW/SW CULs	45	73	59	59	UPDATED FOR SW CUL = 0.3 µg/L (AS GW CUL)	2076
Alt 2 to GW CULs	28	41.5	34.8	35	GW CUL = 4 µg/L	2052
Alt 2 to GW/SW CULs	45	69	57	57	UPDATED FOR SW CUL = 0.3 µg/L (AS GW CUL)	2074
Alt 4 to GW CULs	21.5	32.5	27.0	30	CUL = 4 µg/L	2047
Alt 4 to GW/SW CULs	39	60	49.5	53	UPDATED FOR SW CUL = 0.3 µg/L (AS GW CUL)	2070

Notes:
µg/L = micrograms per liter
CUL = cleanup level
GW = groundwater
SW = surface water

GW CUL = 4 µg/L Drinking water
SW CUL = 0.3 µg/L Drinking water & Consumption of organisms

*Total timeframe for Alt 4 assumes 3 years of bio beginning in 2017 to get to 100 ug/L (starting point of model degredation)
**Revised 9/1/17 based on July 2017 groundwater data

Attachment 1D

Revised Disproportionate Cost Analysis

Powder Mill Gulch

TABLE D-24a
Comparison of Alternative Costs
Exposure pathway Model: EPM K
Esperance Sand, North Complex, PMG SWMU

ALTERNATIVE 1 — **CONTINUED OPERATION OF EXISTING GET SYSTEM AND INSTITUTIONAL CONTROLS**

Client	Boeing	**EPM Group**	K
Location	BCA Everett Plant	**Site Name**	Esperance Sand/Powder Mill Gulch
Project	Upland Area Feasibility Study	**Building**	N/A
Estimator	Piper Roelen	**Media**	Groundwater
Report Date	10/30/15	**Plume Length**	2,800 FT
Last Updated *	9/1/17	**Max Plume Width**	700 FT
QA Reviewer	Jerry Ninteman	**Saturated Thickness**	10 to 60 FT
QA Review Date	9/1/17		

* highlighted cells indicate inputs modified from original FS estimates

Site/Problem Description Chlorinated solvents in groundwater within the Esperance Sand Aquifer beneath Powder Mill Gulch and chlorinated solvents in surface water in Powder Mill Creek at concentrations exceeding MTCA cleanup standards.

Proposed Remedial Action Continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.

Alternative Specific Assumptions

1. Costs presented have an accuracy of +50% to -30% and are suitable for comparing alternatives
2. Washington State Sales Tax is applied to Direct Costs only
3. Discount Rate is 1.5% per Office of Management and Budget, Circular A-94 Appendix C, Revised Dec 2015
4. Operation of existing GET system with 12 extraction wells.
5. Assumes GET system operation for 59 yrs from 2017 to reach TCE CUL of 0.3 μg/L.
6. Assumes major equipment replacement at 20 year intervals.
7. Annual groundwater and surface water monitoring
8. Six quarters of confirmation groundwater and surface water sampling.

DETAILED COST ESTIMATE

Cost Type	Category	Item #	Description	Quantity	Unit	Unit Cost	Total
IMPLEMENTATION	**REMEDIAL DESIGN, PLANNING, AND GENERAL (Indirect Costs)**						
		1	Engineering/Proj Mgmt/Const Mgmt/Reporting				
		2	Cleanup action plan	1	LS	$ 30,000	$ 30,000
		3	Permits	1	LS	$ 10,000	$ 10,000
		4	Negotiate and implement institutional controls	1	LS	$ 10,000	$ 10,000
		5	Cleanup action construction report	0	LS	$ 20,000	$ -
		6	Engineering/Remedial Design	8%	pct	$ 50,000	$ 4,000
		7	Construction Management/Oversight	6%	pct	$ 50,000	$ 3,000
		8	Project Management	5%	pct	$ 12,976,000	$ 648,800
		9	Ecology oversight	5%	pct	$ 12,976,000	$ 648,800
	Subtotal Remedial Design, Planning, and General Costs						*$ 1,354,600*
	Indirect Contingency and Unlisted Engineering Services (%)			**15%**	pct	$1,354,600	$ 203,200
	TOTAL INDIRECT COST						**$1,558,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	REMEDIAL ACTION CONSTRUCTION - NOT APPLICABLE (Direct Costs)						
		1	No New Construction Required				
		2	Construction	0	LS	$ -	$ -
	Subtotal Remedial Action Construction Costs						$ -
	Direct Cost Contingency and Unlisted Engineering Services (%)			**25%**	pct	$0	$ -
	Contractor Bond Fee, Overhead, and Profit (%)			**20%**	pct	$0	$ -
	Washington State Sales Tax (%)			**9.2%**	pct	$0	$0
	TOTAL DIRECT COST						**$0**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
OM&M	**ANNUAL OPERATION, MAINTENANCE, MONITORING, AND REPORTING**						
		1	Electrical Usage	1	yr	$ 36,500	$ 36,500
		2	Cell phone/GET system remote access charges	12	mo	$ 369	$ 4,428
		3	Carbon Usage	1	ea	$ 9,600	$ 9,600
		4	System monitoring/NPDES reporting	1	yr	$ 20,000	$ 20,000
		5	O&M Labor and Cost	1	yr	$ 80,000	$ 80,000
		6	NPDES annual renewal fee	1	yr	$ 18,265	$ 18,265
		7	Groundwater sampling	1	yrs	$ 65,000	$ 65,000
		8	Groundwater elevation monitoring	1	yrs	$ 8,000	$ 8,000
		9	Surface water sampling	1	yrs	$ 8,000	$ 8,000
		10	Reporting	1	yr	$ 15,000	$ 15,000
	Subtotal Annual OM&M and Reporting Cost						$ 264,800
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$264,800	$ 53,000
			Years of Annual Monitoring	*59*	yrs	$317,800	$ 18,750,200
	TOTAL ANNUAL OM&M AND REPORTING COST						***$18,750,000***
	Present-Worth Annual OM&M and Reporting Cost		Presumed Discount Rate	*1.5%*	pct		**$12,385,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	NON-ROUTINE OPERATION, MAINTENANCE, MONITORING, AND REPORTING						
		1	Baseline groundwater/surface water sampling	1	event	$ 73,000	$ 73,000
		2	GET System Replacement Cost	2	event	$ 150,000	$ 300,000
		3	1.5 years qtly confirmation sampling	6	event	$ 73,000	$ 438,000
		4	Cleanup completion report	1	LS	$ 20,000	$ 20,000
	Subtotal Non-Routine OM&M and Reporting Cost						$ 831,000
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$831,000	$ 166,200
	TOTAL NON-ROUTINE OM&M AND REPORTING COST						***$997,000***
	Present-Worth Non-Routine OM&M and Reporting Cost		Presumed Discount Rate	*1.5%*	pct		**$534,000**
TOTAL	**ALTERNATIVE COST SUMMARY**						
	TOTAL PRESENT-WORTH REMEDIAL DESIGN, PLANNING, AND GENERAL COST (INDIRECT)						**$1,558,000**
	TOTAL PRESENT-WORTH REMEDIATION IMPLEMENTATION COST (DIRECT)						**$0**
	TOTAL PRESENT-WORTH OM&M COST (ANNUAL & NON-ROUTINE)						**$12,919,000**
	TOTAL PRESENT-WORTH COST						**$14,480,000**
			Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 10,140,000**	**$ 21,720,000**

TABLE D-24b
Comparison of Alternative Costs
Exposure pathway Model: EPM K
Esperance Sand, North Complex, PMG SWMU

ALTERNATIVE 2 **SOURCE AREA EISB CONTINUED OPERATION OF GET SYSTEM, AND INSTITUTIONAL CONTROL**

Client	Boeing	**EPM Group**	K
Location	BCA Everett Plant	**Site Name**	Esperance Sand/Powder Mill Gulch
Project	Upland Area Feasibility Study	**Building**	N/A
Estimator	Piper Roelen	**Media**	Groundwater
Report Date	10/30/15	**Plume Length**	2,800 FT
Last Updated *	9/1/17	**Max Plume Width**	700 FT
QA Reviewer	Jerry Ninteman	**Saturated Thickness**	10 to 60 FT
QA Review Date	9/1/17		

* highlighted cells indicate inputs modified from original FS estimates

Site/Problem Description Chlorinated solvents in groundwater within the Esperance Sand Aquifer beneath Powder Mill Gulch and chlorinated solvents in surface water in Powder Mill Creek at concentrations exceeding MTCA cleanup standards.

Proposed Remedial Action Injection of electron donor for enhanced bioremediation of groundwater in detention basin source area (TCE > 500 µg/L) in combination with continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.

Alternative Specific Assumptions

1. Costs presented have an accuracy of +50% to -30% and are suitable for comparing alternatives
2. Washington State Sales Tax is applied to Direct Costs only
3. Discount Rate is 1.5% per Office of Management and Budget, Circular A-94 Appendix C, Revised Dec 2015
4. Installation of injection wells at 8 locations (3 depth interval wells each location)
5. Assume all wells installed to a depths of 30, 50, and 70 ft bgs (20 ft screen each)
6. Well spacing at 15 ft OC crossgradient and 100 ft downgradient
7. Assume 3 injection events of electron donor over 3 year period
8. Operation of existing GET system with 12 extraction wells.
9. Assumes GET system operation for 57 yrs from 2017 (including 2-3 yrs for injection events) to reach TCE CUL of 0.3 ug/L.
10. Assumes major equipment replacement at 20 year intervals.
11. Annual groundwater and surface water monitoring
12. Six quarters of confirmation groundwater and surface water sampling.

DETAILED COST ESTIMATE

Cost Type	Category	Item #	Description	Quantity	Unit	Unit Cost	Total
IMPLEMENTATION	**REMEDIAL DESIGN, PLANNING, AND GENERAL (Indirect Costs)**						
		1	Engineering/Proj Mgmt/Const Mgmt/Reporting				
		2	Cleanup action plan	1	LS	$ 30,000	$ 30,000
		3	Permits	1	LS	$ 15,000	$ 15,000
		4	Negotiate and implement institutional controls	1	LS	$ 10,000	$ 10,000
		5	Contract documents and contractor bidding/procurement	1	LS	$ 20,000	$ 20,000
		6	Cleanup action construction report	1	LS	$ 20,000	$ 20,000
		7	Engineering/Remedial Design	8%	pct	$ 797,000	$ 63,760
		8	Construction Management/Oversight	6%	pct	$ 797,000	$ 47,820
		9	Project Management	5%	pct	$ 14,415,580	$ 720,779
		10	Ecology oversight	5%	pct	$ 14,415,580	$ 720,779
	Subtotal Remedial Design, Planning, and General Costs						*$ 1,648,100*
	Indirect Contingency and Unlisted Engineering Services (%)			**15%**	pct	$1,648,100	$ 247,200
	TOTAL INDIRECT COST						**$1,895,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	REMEDIAL ACTION CONSTRUCTION - ELECTRON DONOR INJECTIONS (Direct Costs)						
		1	Install injection wells wells/distribution				
		2	Utility locate/clearing	1	LS	$ 2,500	$ 2,500
		3	Driller mobilization/demobilization	1	LS	$ 20,000	$ 20,000
		6	Drilling - injection wells (detention basin hotspot)	24	wells	$ 4,000	$ 96,000
		7	Well development	24	wells	$ 500	$ 12,000
		8	IDW Disposal	70	Drums	$ 200	$ 14,000
		9	Injection of Electron Donor				
		10	Injection crew/labor	75	days	$ 3,000	$ 225,000
		11	Purchase equipment/supplies for injection system setup	1	LS	$ 25,000	$ 25,000
		12	Materials and rentals for injection events	3	event	$ 20,000	$ 60,000
		13	Water for injection events	285,000	gal	$ 0.03	$ 8,550
		14	Donor for injection events	36,000	lbs	$ 1.50	$ 54,000
	Subtotal Remedial Action Construction Costs						*$ 517,100*
	Direct Cost Contingency and Unlisted Engineering Services (%)			**25%**	pct	$ 517,100	$ 129,300
	Contractor Bond Fee, Overhead, and Profit (%)			**20%**	pct	$ 180,625	$ 36,100
	Washington State Sales Tax (%)			**9.2%**	pct	$ 216,725	$ 19,900
	TOTAL DIRECT COST						**$702,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
OM&M	**ANNUAL OPERATION, MAINTENANCE, MONITORING, AND REPORTING**						
		1	Electrical Usage	1	yr	$ 36,500	$ 36,500
		2	Cell phone/GET system remote access charges	12	mo	$ 369	$ 4,428
		3	Carbon Usage	1	ea	$ 9,600	$ 9,600
		4	System monitoring/NPDES reporting	1	yr	$ 20,000	$ 20,000
		5	O&M Labor and Cost	1	yr	$ 80,000	$ 80,000
		6	NPDES annual renewal fee	1	yr	$ 18,265	$ 18,265
		7	Groundwater sampling	1	yrs	$ 65,000	$ 65,000
		8	Groundwater elevation monitoring	1	yrs	$ 8,000	$ 8,000
		9	Surface water sampling	1	yrs	$ 8,000	$ 8,000
		10	Reporting	1	yr	$ 15,000	$ 15,000
	Subtotal Annual OM&M and Reporting Cost						$ 264,800
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$264,800	$ 53,000
			Years of Annual Monitoring	***57***	yrs	$317,800	$ 18,114,600
	TOTAL ANNUAL OM&M AND REPORTING COST						***$18,115,000***
	Present-Worth Annual OM&M and Reporting Cost		Presumed Discount Rate	***1.5%***	pct		**$12,119,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	NON-ROUTINE OPERATION, MAINTENANCE, MONITORING, AND REPORTING						
		1	Baseline groundwater/surface water sampling	1	event	$ 73,000	$ 73,000
		2	Quarterly groundwater sampling	9	event	$ 65,000	$ 585,000
		3	Quarterly groundwater elevation monitoring	9	event	$ 8,000	$ 72,000
		4	Quarterly surface water sampling	9	event	$ 8,000	$ 72,000
		5	GET System Replacement Cost	2	event	$ 150,000	$ 300,000
		6	1.5 years qtly confirmation sampling	6	event	$ 73,000	$ 438,000
		7	Cleanup completion report	1	LS	$ 20,000	$ 20,000
	Subtotal Non-Routine OM&M and Reporting Cost						$ 1,560,000
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$1,560,000	$ 312,000
	TOTAL NON-ROUTINE OM&M AND REPORTING COST						***$1,872,000***
	Present-Worth Non-Routine OM&M and Reporting Cost		Presumed Discount Rate	***1.5%***	pct		**$1,388,000**
TOTAL	**ALTERNATIVE COST SUMMARY**						
	TOTAL PRESENT-WORTH REMEDIAL DESIGN, PLANNING, AND GENERAL COST (INDIRECT						**$1,895,000**
	TOTAL PRESENT-WORTH REMEDIATION IMPLEMENTATION COST (DIRECT						**$702,000**
	TOTAL PRESENT-WORTH OM&M COST (ANNUAL & NON-ROUTINE						**$13,507,000**
	TOTAL PRESENT-WORTH COST						**$16,100,000**
			Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 11,270,000**	**$ 24,150,000**

TABLE D-24c
Comparison of Alternative Costs
Exposure pathway Model: EPM K
Esperance Sand, North Complex, PMG SWMU

ALTERNATIVE 3 **FOCUSED ISCO, CONTINUED OPERATION OF GET SYSTEM, AND INSTITUTIONAL CONTROLS**

Client	Boeing	**EPM Group**	K
Location	BCA Everett Plant	**Site Name**	Esperance Sand/Powder Mill Gulch
Project	Upland Area Feasibility Study	**Building**	N/A
Estimator	Piper Roelen	**Media**	Groundwater
Report Date	10/30/15	**Plume Length**	2,800 FT
Last Updated *	9/1/17	**Max Plume Width**	700 FT
QA Reviewer	Jerry Ninteman	**Saturated Thickness**	10 to 60 FT
QA Review Date	9/1/17		

* highlighted cells indicate inputs modified from original FS estimate

Site/Problem Description Chlorinated solvents in groundwater within the Esperance Sand Aquifer beneath Powder Mill Gulch and chlorinated solvents in surface water in Powder Mill Creek at concentrations exceeding MTCA cleanup standards.

Proposed Remedial Action Injection of chemical oxidant (sodium persulfate) for contaminant oxidation in groundwater in TCE focus areas (TCE > 250 µg/L) in in combination with continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.

Alternative Specific Assumptions

1. Costs presented have an accuracy of +50% to -30% and are suitable for comparing alternatives
2. Washington State Sales Tax is applied to Direct Costs only
3. Discount Rate is 1.5% per Office of Management and Budget, Circular A-94 Appendix C, Revised Dec 2015
4. Installation of injection wells at 27 locations in detention basin (3 depth interval wells each location)
5. Installation of injection wells at 53 locations in S. of Seaway (2 depth interval wells each location)
6. Installation of injection wells at 70 locations in N. of Seaway (2 depth interval wells each location)
7. Assume wells installed to a depths of 30, 50, and 70 ft bgs in detention basin (20 ft screen each)
8. Assume wells installed to a depths of 40 and 60 ft bgs S. of Seaway (20 ft screen each)
9. Assume wells installed to a depths of 45 and 60 ft bgs N. of Seaway (15 ft screen each)
10. Well spacing at 15 ft OC crossgradient and 30 ft downgradient
11. Assume 6 injection events of sodium persulfate and activating agent over 3 - 5 year period
12. Assume construction of iron/iron bacteria pretreatment system for extracted groundwater with iron from ISCO.
13. Quarterly groundwater and surface water monitoring during injection period
14. Operation of existing GET system with 12 extraction wells.
15. Assumes GET system operation for 50 yrs after injection events (5 yrs beginning 2017, or 55 yrs from 2017) to reach TCE CUL of 0.3 ug/L.
16. Assume O&M of iron/iron bacteria pretreatment facility and biofouling maintenance of wells for 7 years
17. Annual groundwater and surface water monitoring
18. Six quarters of confirmation groundwater and surface water sampling.

DETAILED COST ESTIMATE

Cost Type	Category	Item #	Description	Quantity	Unit	Unit Cost	Total
IMPLEMENTATION	**REMEDIAL DESIGN, PLANNING, AND GENERAL (Indirect Costs)**						
		1	Engineering/Proj Mgmt/Const Mgmt/Reporting				
		2	Cleanup action plan	1	LS	$ 30,000	$ 30,000
		3	Permits	1	LS	$ 20,000	$ 20,000
		4	Negotiate and implement institutional controls	1	LS	$ 10,000	$ 10,000
		5	Contract documents and contractor bidding/procurement	1	LS	$ 20,000	$ 20,000
		6	Cleanup action construction report	1	LS	$ 20,000	$ 20,000
		7	Engineering/Remedial Design	6%	pct	$ 6,600,000	$ 396,000
		8	Construction Management/Oversight	6%	pct	$ 6,600,000	$ 396,000
		9	Project Management	5%	pct	$ 22,078,000	$ 1,103,900
		10	Ecology oversight	5%	pct	$ 22,078,000	$ 1,103,900
	Subtotal Remedial Design, Planning, and General Costs						*$ 3,099,800*
	Indirect Contingency and Unlisted Engineering Services (%)			**15%**	pct	$3,099,800	$ 465,000
	TOTAL INDIRECT COST						**$3,565,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	REMEDIAL ACTION CONSTRUCTION - OXIDANT INJECTIONS (Direct Costs)						
		1	ISCO treatability study/pilot test	1	LS	$ 150,000	$ 150,000
		2	Install injection wells wells/distribution				
		3	Utility locates	1	LS	$ 7,500	$ 7,500
		4	Site prep/clearing/grubbing	1	LS	$ 350,000	$ 350,000
		5	Driller mobilization/demobilization	1	LS	$ 20,000	$ 20,000
		6	Drilling - injection wells (Lot 9 TCE focus area)	140	wells	$ 3,500	$ 490,000
		7	Drilling - injection wells (Boeing Seaway TCE focus area)	106	wells	$ 3,750	$ 397,500
		8	Drilling - injection wells (detention basin TCE focus area)	81	wells	$ 4,000	$ 324,000
		9	Well development	327	wells	$ 500	$ 163,500
		10	IDW Disposal	660	Drums	$ 200	$ 132,000
		11	ISCO materials/Injection of oxidants				
		12	Injection crew/labor	480	days	$ 3,000	$ 1,440,000
		13	Purchase equipment/supplies for injection system setup	1	LS	$ 25,000	$ 25,000
		14	Materials and rentals for injection events	6	event	$ 20,000	$ 120,000
		15	Water for injection events	3120000	gal	$ 0.03	$ 93,600
		16	Oxidant for injection events	312000	lbs	$ 2.05	$ 639,600
		17	Construct Iron/Iron Bacteria Pre-treatment Facility	1	LS	$ 200,000	$ 200,000
	Subtotal Remedial Action Construction Costs						*$ 4,552,700*
	Direct Cost Contingency and Unlisted Engineering Services (%)			**25%**	pct	$4,552,700	$ 1,138,200
	Contractor Bond Fee, Overhead, and Profit (%)			**20%**	pct	$2,605,625	$ 521,100
	Washington State Sales Tax (%)			**9.2%**	pct	$ 3,126,725	$287,700
	TOTAL DIRECT COST						**$6,500,000**
OM&M	**Category**	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	ANNUAL OPERATION, MAINTENANCE, MONITORING, AND REPORTING						
		1	Electrical Usage	1	yr	$ 36,500	$ 36,500
		2	Cell phone/GET system remote access charges	12	mo	$ 369	$ 4,428
		3	Carbon Usage	1	ea	$ 9,600	$ 9,600
		4	System monitoring/NPDES reporting	1	yr	$ 20,000	$ 20,000
		5	O&M Labor and Cost	1	yr	$ 80,000	$ 80,000
		6	NPDES annual renewal fee	1	yr	$ 18,265	$ 18,265
		7	Groundwater sampling	1	yrs	$ 65,000	$ 65,000
		8	Groundwater elevation monitoring	1	yrs	$ 8,000	$ 8,000
		9	Surface water sampling	1	yrs	$ 8,000	$ 8,000
		10	Reporting	1	yr	$ 15,000	$ 15,000
	Subtotal Annual OM&M and Reporting Cost						$ 264,800
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$264,800	$ 53,000
			Years of Annual Monitoring	***55***	yrs	$317,800	$ 17,479,000
	TOTAL ANNUAL OM&M AND REPORTING COST						***$17,479,000***
	Present-Worth Annual OM&M and Reporting Cost		Presumed Discount Rate	*1.5%*	pct		**$11,845,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	NON-ROUTINE OPERATION, MAINTENANCE, MONITORING, AND REPORTING						
		1	Baseline groundwater/surface water sampling	1	event	$ 73,000	$ 73,000
		2	GET System Replacement Cost	2	event	$ 150,000	$ 300,000
		3	Iron/Biofouling Maintenance/Equipment Replacement	7	yr	$ 60,000	$ 420,000
		4	Iron Pretreatment System O&M	7	yr	$ 40,000	$ 280,000
		2	Quarterly groundwater sampling	9	event	$ 65,000	$ 585,000
		3	Quarterly groundwater elevation monitoring	9	event	$ 8,000	$ 72,000
		4	Quarterly surface water sampling	9	event	$ 8,000	$ 72,000
		5	1.5 years qtly confirmation sampling	6	event	$ 73,000	$ 438,000
		6	Cleanup completion report	1	LS	$ 20,000	$ 20,000
	Subtotal Non-Routine OM&M and Reporting Cost						$ 2,260,000
	Annual Monitoring Cost Contingency and Unlisted Items (%)			**20%**	pct	$2,260,000	$ 452,000
	TOTAL NON-ROUTINE OM&M AND REPORTING COST						***$2,712,000***
	Present-Worth Non-Routine OM&M and Reporting Cost		Presumed Discount Rate	*1.5%*	pct		**$2,841,000**
TOTAL	**ALTERNATIVE COST SUMMARY**						
	TOTAL PRESENT-WORTH REMEDIAL DESIGN, PLANNING, AND GENERAL COST (INDIRECT)						**$3,565,000**
	TOTAL PRESENT-WORTH REMEDIATION IMPLEMENTATION COST (DIRECT)						**$6,500,000**
	TOTAL PRESENT-WORTH OM&M COST (ANNUAL & NON-ROUTINE)						**$14,686,000**
	TOTAL PRESENT-WORTH COST						**$24,750,000**
			Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 17,330,000**	**$ 37,130,000**

TABLE D-24d
Comparison of Alternative Costs
Exposure pathway Model: EPM K
Esperance Sand, North Complex, PMG SWMU

ALTERNATIVE 4 (Ecology Modific FOCUSED EISB, CONTINUED OPERATION OF GET SYSTEM, AND INSTITUTIONAL CONTROLS

Client	Boeing	**EPM Group**	K
Location	BCA Everett Plant	**Site Name**	Esperance Sand/Powder Mill Gulch
Project	Upland Area Feasibility Study	**Building**	N/A
Estimator	Piper Roelen	**Media**	Groundwater
Report Date	10/30/15	**Plume Length**	2,800 FT
Last Updated *	9/1/17	**Max Plume Width**	700 FT
QA Reviewer	Jerry Ninteman	**Saturated Thickness**	10 to 60 FT
QA Review Date	9/1/17		

* highlighted cells indicate inputs modified from original FS estimate

Site/Problem Description Chlorinated solvents in groundwater within the Esperance Sand Aquifer beneath Powder Mill Gulch and chlorinated solvents in surface water in Powder Mill Creek at concentrations exceeding MTCA cleanup standards.

Proposed Remedial Action Injection of electron donor for enhanced bioremediation of groundwater in TCE focus areas (TCE > 250μg/L) in combination with continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.

Alternative Specific Assumptions

1. Costs presented have an accuracy of +50% to -30% and are suitable for comparing alternatives
2. Washington State Sales Tax is applied to Direct Costs only
3. Discount Rate is 1.5% per Office of Management and Budget, Circular A-94 Appendix C, Revised Dec 2015
4. Installation of injection wells at 14 locations in detention basin (3 depth interval wells each location)
5. Installation of injection wells at 11 locations in S. of Seaway (2 depth interval wells each location)
6. Installation of injection wells at 22 locations in S. of Seaway (2 depth interval wells each location)
7. Assume wells installed to a depths of 30, 50, and 70 ft bgs in detention basin (20 ft screen each)
8. Assume wells installed to a depths of 40 and 60 ft bgs S. of Seaway (20 ft screen each)
9. Assume wells installed to a depths of 45 and 60 ft bgs N. of Seaway (15 ft screen each)
10. Well spacing at 15 ft OC crossgradient and 100 ft downgradient
11. Assume 3 injection events of electron donor over 3 year period
12. Assume construction of TOC and metals pretreatment system for extracted groundwater with TOC from EISB
13. Operation of existing GET system with 12 extraction wells.
14. Assumes GET system operation for 50 yrs after injection events (3 yrs beginning 2017, or 53 yrs from 2017) to reach TCE CUL of 0.3 ug/L.
15. Assume O&M of TOC pretreatment facility and biofouling maintenance of wells for 13 years
16. Assumes major equipment replacement at 20 year intervals.
17. Annual groundwater and surface water monitoring
18. Six quarters of confirmation groundwater and surface water sampling.

DETAILED COST ESTIMATE

Cost Type	Category	Item #	Description	Quantity	Unit	Unit Cost	Total
IMPLEMENTATION	**REMEDIAL DESIGN, PLANNING, AND GENERAL (Indirect Costs)**						
		1	Engineering/Proj Mgmt/Const Mgmt/Reporting				
		2	Cleanup action plan	1	LS	$ 30,000	$ 30,000
		3	Permits	1	LS	$ 30,000	$ 30,000
		4	Negotiate and implement institutional controls	1	LS	$ 10,000	$ 10,000
		5	Contract documents and contractor bidding/procurement	1	LS	$ 20,000	$ 20,000
		6	Cleanup action construction report	1	LS	$ 20,000	$ 20,000
		7	Engineering/Remedial Design	6%	pct	$ 6,018,000	$ 361,080
		8	Construction Management/Oversight	6%	pct	$ 6,018,000	$ 361,080
		9	Project Management	5%	pct	$ 22,538,160	$ 1,126,908
		10	Ecology oversight	5%	pct	$ 22,538,160	$ 1,126,908
	Subtotal Remedial Design, Planning, and General Costs						*$ 3,086,000*
	Indirect Contingency and Unlisted Engineering Services (%)			**15%**	pct	$3,086,000	$ 462,900
	TOTAL INDIRECT COST						**$3,549,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	REMEDIAL ACTION CONSTRUCTION - ELECTRON DONOR INJECTIONS (Direct Costs)						
		1	EISB tracer study/pilot test	1	LS	$ 150,000	$ 150,000
		2	Install injection wells wells/distribution				
		3	Utility locate	1	LS	$ 2,500	$ 2,500
		4	Site prep/clearing/grubbing	1	LS	$ 150,000	$ 150,000
		5	Driller mobilization/demobilization	1	LS	$ 20,000	$ 20,000
		6	Drilling - injection wells (Lot 9 TCE focus area	44	wells	$ 3,500	$ 154,000
		7	Drilling - injection wells (Boeing Seaway TCE focus area	22	wells	$ 3,750	$ 82,500
		8	Drilling - injection wells (detention basin TCE focus area)	42	wells	$ 4,000	$ 168,000
		9	Well development	108	wells	$ 500	$ 54,000
		10	IDW Disposal	240	Drums	$ 200	$ 48,000
		11	Injection of Electron Donor				
		12	Injection crew/labor	150	days	$ 3,000	$ 450,000
		13	Purchase equipment/supplies for injection system setup	1	LS	$ 25,000	$ 25,000
		14	Materials and rentals for injection events	3	event	$ 20,000	$ 60,000
		15	Water for injection events	#######	gal	$ 0.03	$ 36,000
		16	Donor for injection events	330,000	lbs	$ 1.50	$ 495,000
		17	Construct TOC and Metals Pre-treatment Facility	1	LS	$ 2,000,000	$ 2,000,000
	Subtotal Remedial Action Construction Costs						*$ 3,895,000*
	Direct Cost Contingency and Unlisted Engineering Services (%			**25%**	pct	$3,895,000	$ 973,800
	Contractor Bond Fee, Overhead, and Profit (%)			**20%**	pct	$3,348,750	$ 669,800
	Washington State Sales Tax (%)			**9.2%**	pct	$ 4,018,550	$369,700
	TOTAL DIRECT COST						**$5,908,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
OM&M	**ANNUAL OPERATION, MAINTENANCE, MONITORING, AND REPORTING**						
		1	Electrical Usage	1	yr	$ 36,500	$ 36,500
		2	Cell phone/GET system remote access charges	12	mo	$ 369	$ 4,428
		3	Carbon Usage	1	ea	$ 9,600	$ 9,600
		4	System monitoring/NPDES reporting	1	yr	$ 20,000	$ 20,000
		5	GET System O&M Labor and Cost	1	yr	$ 85,000	$ 85,000
		6	NPDES annual renewal fee	1	yr	$ 18,265	$ 18,265
		7	Groundwater sampling	1	yrs	$ 65,000	$ 65,000
		8	Groundwater elevation monitoring	1	yrs	$ 8,000	$ 8,000
		9	Surface water sampling	1	yrs	$ 8,000	$ 8,000
		10	Reporting	1	yr	$ 15,000	$ 15,000
	Subtotal Annual OM&M and Reporting Cost						$ 269,800
	Annual Monitoring Cost Contingency and Unlisted Items (%			**20%**	pct	$269,800	$ 54,000
			Years of Annual Monitoring	***53***	yrs	$323,800	$ 17,161,400
	TOTAL ANNUAL OM&M AND REPORTING COST						***$17,161,000***
	Present-Worth Annual OM&M and Reporting Cost		Presumed Discount Rate	***1.5%***	pct		**$11,781,000**
	Category	**Item #**	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
	NON-ROUTINE OPERATION, MAINTENANCE, MONITORING, AND REPORTING						
		1	Baseline groundwater/surface water sampling	1	event	$ 73,000	$ 73,000
		2	GET System Replacement Cost	2	event	$ 150,000	$ 300,000
		3	Biofouling Maintenance/Equipment Replacement	13	yr	$ 60,000	$ 780,000
		4	TOC/Metals Pretreatment System O&M	13	yr	$ 100,000	$ 1,300,000
		5	Quarterly groundwater sampling (EISB parameters)	13	yr	$ 95,000	$ 1,235,000
		6	Quarterly groundwater sampling	9	event	$ 65,000	$ 585,000
		7	Quarterly groundwater elevation monitoring	9	event	$ 8,000	$ 72,000
		8	Quarterly surface water sampling	9	event	$ 8,000	$ 72,000
		9	1.5 years qtly confirmation sampling	6	event	$ 73,000	$ 438,000
		10	Cleanup completion report	1	LS	$ 20,000	$ 20,000
	Subtotal Non-Routine OM&M and Reporting Cost						$ 4,875,000
	Annual Monitoring Cost Contingency and Unlisted Items (%			**20%**	pct	$4,875,000	$ 975,000
	TOTAL NON-ROUTINE OM&M AND REPORTING COST						***$5,850,000***
	Present-Worth Non-Routine OM&M and Reporting Cost		Presumed Discount Rate	***1.5%***	pct		**$4,017,000**
TOTAL	**ALTERNATIVE COST SUMMARY**						
	TOTAL PRESENT-WORTH REMEDIAL DESIGN, PLANNING, AND GENERAL COST (INDIRECT						**$3,549,000**
	TOTAL PRESENT-WORTH REMEDIATION IMPLEMENTATION COST (DIRECT)						**$5,908,000**
	TOTAL PRESENT-WORTH OM&M COST (ANNUAL & NON-ROUTINE)						**$15,798,000**
	TOTAL PRESENT-WORTH COST						**$25,260,000**
			Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 17,680,000**	**$ 37,890,000**

Table 8-24a (Revised 9/1/17)
Summary of MTCA Alternatives Evaluation and Disproportionate Cost Alternatives Ranking
Exposure Pathway Model K
Powder Mill Gulch SWMU

Alternative Number	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4 (Ecology Modified)**
Alternative Name	**Continued GET System Operation and Institutional Controls**	**EISB Source Area Treatment w/GET System and Institutional Controls**	**Focused ISCO Treatment w/GET System and Institutional Controls**	**Focused EISB Treatment w/GET System and Institutional Controls**
Alternative Description	Continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.	Injection of electron donor for enhanced bioremediation of groundwater in detention basin source area (TCE > 250 µg/L) in combination with operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.	Injection of chemical oxidant (sodium persulfate) for contaminant oxidation in groundwater in TCE focus areas (TCE > 250 µg/L) in combination with continued operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors.	Injection of electron donor for enhanced bioremediation of groundwater in TCE focus areas (TCE > 250 µg/L) in combination with continuous operation of GET system for hydraulic control of chlorinated solvents in groundwater, minimizing migration of chlorinated solvents in groundwater to surface water, groundwater flushing and restoration, and protection of human and ecological receptors. Construction and operation of TOC and arsenic pretreatment system.
Individual Ranking Criteria				
1 Meets Remedial Action Objectives	Yes	Yes	Yes	Yes
2 Compliance With MTCA Threshold Criteria [WAC 173-340-360(2)(a)]				
- Protect human health and the environment	Yes	Yes	Yes	Yes
- Comply with cleanup standards	Yes	Yes	Yes	Yes
- Comply with applicable state/federal laws	Yes	Yes	Yes	Yes
- Provide for compliance monitoring	Yes	Yes	Yes	Yes
3 Relative Benefits Ranking for DCA [WAC 173-340-360(2)(b)(i) and WAC 173-340-36093)(f)]				
- Overall Weighted Benefit Score (from Table 8-24b)	6.9	7.5	7.7	7.3
4 Restoration Timeframe [WAC 173-340-360(2)(b)(ii) and WAC 173-340-360(4)]	Approximately 59 years from 2017	Approximately 57 years from 2017	Approximately 55 years from 2017	Approximately 53 years from 2017
- Potential risk to human health and environment [a]	Low	Low	Low	Low
- Practicability of achieving shorter restoration time	See DCA below	See DCA below	See DCA below	See DCA below
- Current use of site, surrounding area, and resources	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park
- Future use of site, surrounding area, and resources	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park	Onsite: Industrial Offsite: Open Space, Recreational Purposes, Office and Industrial Park
- Availability of alternative water supplies	Yes	Yes	Yes	Yes
- Likely effectiveness/reliability of institutional controls [a]	High	High	High	High
- Ability to monitor migration of hazardous substances [a]	High	High	High	High
- Toxicity of hazardous substances at the site [a]	Moderate to High	Moderate to High	Moderate to High	Moderate to High
- Natural processes that reduce concentrations	Yes	Yes	Yes	Yes
- Overall Reasonable Restoration Timeframe	Yes	Yes	Yes	Yes
5 Disproportionate Cost Analysis				
Overall Weighted Benefit Score	6.9	7.5	7.7	7.3
Estimated Remedy Cost (including interim action)	$14,480,000	$16,100,000	$24,750,000	$25,260,000
Most Permanent Solution	No	No	No	**Yes**
Lowest Cost Alternative	**Yes**	No	No	No
Relative Benefit/Cost Ratio [b]	6.9	6.7	4.5	4.2
Incremental Increase/Decrease in Relative Benefit to Most Permanent Alternative	-5%	3%	5%	0%
Incremental Increase/Decrease in Relative Benefit to Next Most Expensive Alternative	-8%	-3%	5%	-5%
Incremental Increase/Decrease in Cost Compared to Most Permanent Alternative	-43%	-36%	-2%	0%
Incremental Increase/Decrease in Cost Compared to Next Most Expensive Alternative	-10%	-35%	-2%	0%
Costs Disproportionate to Incremental Benefits	No	Yes, but Boeing willing to perform to address ECY concerns	Yes	Yes
Remedy Permanent to the Maximum Extent Practicable?	**Yes**	No	No	No
Preferred Alternative	**Yes**	**No - However, permanent to the maximum extent practicable when compared only to Alternatives 3 and Ecology-modified Alternative 4**	**No**	**No**

Notes:
: highlighted cells are values modified from November 2015 DCA
[a] Ratings used: Low, Moderate, or High.
[b] Benefit/Cost Ratio scaled (divided) by lowest cost alternative in order to compare ranges similar in scale to comparative overall benefit, as presented on Figure 8-24

Lowest Cost Alternative	**$14,480,000**
Highest Ranked Alternative	7.7
Cost of Highest Ranked Alternative	**$24,750,000**

MTCA = Model Toxics Control Act
DCA = Disproportionate Cost Alternative
GET = groundwater extraction and treatment
µg/L = micrograms per liter
TCE = trichloroethene
ISCO = *in situ* chemical oxidation
EISB = enhanced *in situ* bioremediation

Table 8-24b (Revised 11/2/16)
Summary of MTCA Alternatives Relative Benefits Ranking
Exposure Pathway Model K
Powder Mill Gulch SWMU

Alternative Number and Name	Alternative 1 Continued GET System Operations and Institutional Controls				Alternative 2 EISB Source Area Treatment w/GET System and Institutional Controls				Alternative 3 Focused ISCO Treatment w/GET System and Institutional Controls				Alternative 4 (Ecology Modified) Focused EISB Treatment w/GET System and Institutional Controls				
Relative Benefits Ranking for DCA [WAC 173-340-360(2)(b)(i) and WAC 173-340-36093)(f)]																	
Comparative Overall Benefit [a]		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score	**Notes on changes to rankings**
- Overall Protectiveness	Excellent	6	0.3	1.8	Excellent	7	0.3	2.1	Excellent	8	0.3	2.4	Excellent	7	0.3	2.1	Restoration timeframe extended to 50+ yrs w/new SW CULs for all Alternatives (impacts protectiveness of all remedies equally) Alt 1. Reduce protectiveness score per Ecology comments. Alt. 4. Generation of VC and arsenic near creek that could discharge to surface water not previously considered and increases onsite and offsite risk, score lowered accordingly.
- Permanence	Good	5	0.2	1	Excellent	7	0.2	1.4	Superior	8	0.2	1.6	Excellent	7	0.2	1.4	Alt 1. Reduce permanence score per Ecology comments. Alt. 4. Capture and treatment of arsenic and VC generated by EISB increases toxic residuals generated, score reduced accordingly.
- Long-Term Effectiveness	Good	6	0.2	1.2	Excellent	7	0.2	1.4	Excellent	8	0.2	1.6	Excellent	8	0.2	1.6	Although Ecology indicates significant difference in long-term effectiveness, 50+ yr restoration timeframe for all alternatives suggests none of the alternatives demonstrate significant long-term results. Therefore, scores not altered.
- Manageability of Short-Term Risk	Superior	10	0.1	1	Superior	9	0.1	0.9	Good	6	0.1	0.6	Excellent	7	0.1	0.7	Ecology's comments do not take into consideration risk to environment from implementation o EISB (i.e., potential to discharge TOC, oil, and/or arsenic and VC to surface water). Therefore, scores not altered.
- Implementability	Superior	9	0.1	0.9	Excellent	7	0.1	0.7	Good	5	0.1	0.5	Good	5	0.1	0.5	Alt. 4. Addition of TOC and metals treatment system increases technical challenges; major modification of NPDES permit increases administrative challenges, score reduced accordingly.
- Consideration of Public Concerns	Superior	10	0.1	1	Superior	10	0.1	1	Excellent	10	0.1	1	Superior	10	0.1	1	Per Ecology comments, since actual public concerns are not know, assume all public concerns managed equally (Alt. 3 and 4 scores increased accordingly).
Overall Weighted Benefit Score				6.9				7.5				7.7				7.3	

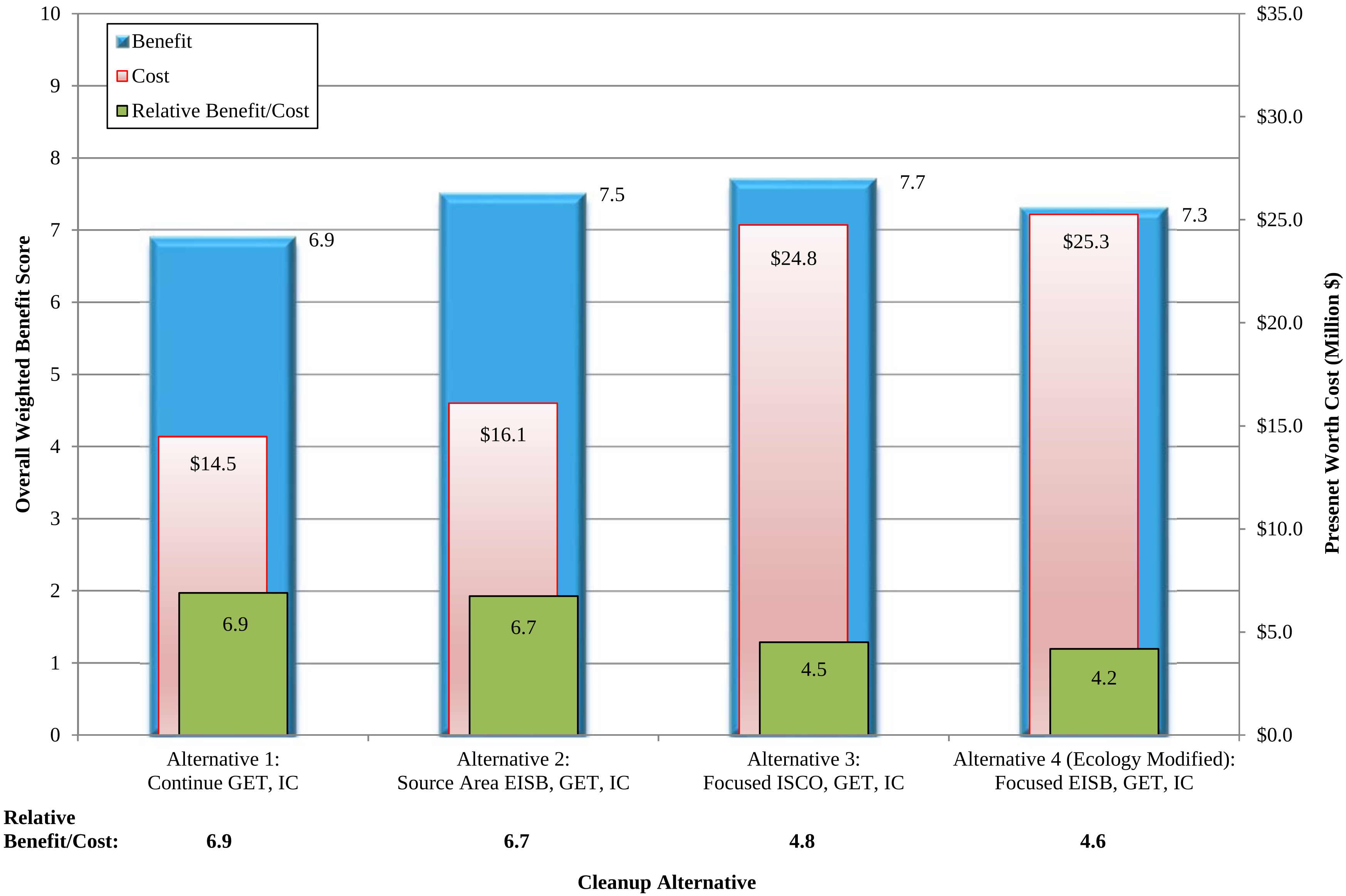
Notes:

: highlighted cells are values modified from November 2015 FS DCA

[a] Ratings used: Poor (1-2), Fair (3-4), Good (5-6), Excellent (7-8), and Superior (9-10).

µg/L = micrograms per liter
CUL = cleanup level
DCA = Disproportionate Cost Alternative
Ecology = Washington State Department of Ecology
EISB = enhanced *in situ* bioremediation
GET = groundwater extraction and treatment
ISCO = *in situ* chemical oxidation
MTCA = Model Toxics Control Act
NPDES = National Pollutant Discharge Elimination System
TCE = trichloroethene
TOC = total organic carbon
VC = vinyl chloride

Figure 8-24 (Revised 9/1/17)
Present Worth Cost vs. Overall Weighted Benefit
Powder Mill Gulch SWMU



Attachment 1E

Technical Memorandum

Proposed Cleanup Levels and Use of Remediation Levels for Groundwater and Surface Water

Powder Mill Gulch

Technical Memorandum

TO: Debbie Taege, The Boeing Company

FROM: Piper Roelen, PE

DATE: September 8, 2017

RE: **Proposed Cleanup Levels and Use of Remediation Levels for Groundwater and Surface Water at Powder Mill Gulch**
Boeing Everett Plant, Everett, Washington
Project No. 0025175.017.012

Introduction

The Boeing Company (Boeing) and the Washington State Department of Ecology (Ecology) have engaged in formal dispute resolution negotiations related to the Boeing Everett Feasibility Study (FS; AECOM/LAI 2015) and Ecology's FS final decision letter (Ecology 2017a). Based on changes to surface water quality standards (SWQS) promulgated since submittal of the FS and Ecology's stated position related to the application of surface water cleanup levels (CULs) to groundwater and proposed use of remediation levels (RLs), it has become apparent that clarification is needed related to Boeing's proposed approach to CULs and RLs for cleanup of groundwater and surface water at the Powder Mill Gulch site (PMG; and the rest of the Boeing Everett facility to the extent applicable). This technical memorandum was prepared to provide Ecology with such clarification.

Proposed Cleanup Standards

In November 2017, new human health criteria were promulgated for surface water, including for chlorinated volatile organic compounds (cVOCs), in Washington Administrative Code (WAC) 173-201A (SWQS) as approved and revised by the US Environmental Protection Agency (EPA), which is an applicable, relevant, and appropriate requirement (ARAR) for development of cleanup standards for surface water under the Model Toxics Control Act (MTCA). Therefore, it has become necessary to revisit and revise, as necessary, the proposed cleanup standards originally presented in the FS. The following summarizes Boeing's proposed development and use of cVOC surface water and groundwater cleanup standards (consisting of the point of compliance and the CULs for a given media and contaminant of concern) for PMG.

Surface Water Cleanup Standards

The proposed cleanup standards for cVOCs in surface water at PMG are as follows:

Point of Compliance (Surface Water) - WAC 173-340-730(6)(a) states that "The point of compliance for the surface water cleanup levels shall be the point or points at which hazardous substances are released to surface waters of the state . . ." Consistent with this requirement, compliance samples should be collected in the surface water of Powder Mill Creek, as close to the bottom of the creek bed as possible (i.e., the point at which groundwater is released to surface water). During Boeing's discussion with Ecology on October 5, 2016, Ecology emphasized that surface water compliance samples need to be collected in the pore water (i.e., the transitional zone) beneath the creek. However, Ecology's surface water point of compliance implementation guidance (Ecology 2017b) clearly states that "MTCA defines groundwater as within a saturated zone beneath surface water or the land surface. This definition encompasses the transitional zone. Therefore, water in this zone is considered groundwater under MTCA." Therefore, sampling groundwater is not consistent with the MTCA requirement for surface water compliance sampling, and Boeing will demonstrate compliance with the surface water CULs via samples collected within the creek and immediately above the creek bed at various locations along Powder Mill Creek both on and off Boeing property. Specific locations for the surface water sampling locations will be determined in conjunction with development of the Cleanup Action Plan (CAP) or Engineering Design Report (EDR).

Cleanup Levels (Surface Water) - WAC 173-340-730(3)(b) states:

> "Standard Method B cleanup levels for surface waters shall be at least as stringent as the following: (i) Concentrations established under applicable state and federal laws, including the following requirements:
>
> (A) All water quality criteria published in the water quality standards for surface waters of the state of Washington, Chapter 173-201A WAC
>
> (B) Water quality criteria based on the protection of aquatic organisms (acute and chronic criteria) and human health published under section 304 of the Clean Water Act unless it can be demonstrated that such criteria are not relevant and appropriate for a specific surface water body or hazardous substance
>
> (C) National toxics rule (40 C.F.R. Part 131)."

Per these requirements, Boeing proposes the following CULs for contaminants of concern in surface water in PMG:

Summary of Surface Water Cleanup Levels

Contaminant of Concern	CUL (µg/L)	Surface Water ARAR 1)
TCE	0.3	WAC 173-201A-240 (Human Health Criteria for Consumption of Water & Organisms1))
VC	0.02	WAC 173-201A-240 (Human Health Criteria for Consumption of Water & Organisms1))
cis-1,2-DCE	NE3)	NE3)
trans-1,2-DCE	200	WAC 173-201A-240 (Human Health Criteria for Consumption of Water & Organisms2))
1,1-DCE	300	National Recommended Water Quality Criteria – Clean Water Act 304(a) (Human Health Criteria for Consumption of Water & Organisms2))

cis-1,2-DCE = cis-1,2-dichloroethene
1,1-DCE = 1,1-dichloroethene
µg/L = micrograms per liter
TCE = trichloroethene
VC = vinyl chloride

Notes:
1) Most conservative available regulatory surface water criteria.
2) As indicated in FS report, no consumption of organisms or water from Powder Mill Creek is currently occurring or likely to occur in the future; therefore, CUL based on consumption of Water and Organisms is very conservative.
3) NE = no surface water criteria established under applicable ARARs.

Table 1a, attached, provides a more detailed summary of ARARs and the development of surface water CULs.

Groundwater Cleanup Standards

The proposed cleanup standards for cVOCs in groundwater at PMG are as follows:

Point of Compliance (Groundwater) - WAC 173-340-720(8)(b) states that "The standard point of compliance [for groundwater] shall be established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site." Consistent with this requirement, Boeing proposes to demonstrate compliance with the groundwater CULs via samples from existing monitoring wells in the plume (specific wells to be determined in conjunction with development of the CAP or EDR).

Cleanup Levels (Groundwater) - WAC 173-340-720(4)(b) states:

> "Where the groundwater cleanup level is based on a drinking water beneficial use, standard Method B cleanup levels shall be at least as stringent as all of the following:
>
> (i) Applicable state and federal laws. Concentrations established under applicable state and federal laws . . .
>
> (ii) Protection of surface water beneficial uses. Concentrations established in accordance with the methods specified in WAC 173-340-730 for protecting surface water beneficial uses . . .
>
> (iii) Human health protection. For hazardous substances for which sufficiently protective, health-based standards or criteria have not been established under applicable state and federal laws . . ."

Applicable state and federal laws for groundwater include the Federal/State Maximum Contaminant Levels (MCL) for protection of groundwater as drinking water.

Based on the MCLs and the MTCA adjustments for site risk for development of protection of drinking water [i.e., WAC 173-340-720(7)(a), a hazard quotient no greater than 1 for acute or chronic toxic effects and total excess cancer risk no greater than 1 x 10^{-5}], Boeing proposes the following CULs for groundwater:

Summary of Groundwater Cleanup Levels

Contaminant of Concern	CUL (µg/L)	Groundwater ARAR
TCE	4	Federal/State MCL (5 µg/L) adjusted down so hazard quotient is less than 1 (1) (MTCA Method B Non-carcinogen Standard Formula Value)
VC	0.07	Federal/State MCL (2 µg/L) adjusted down so total excess cancer risk is less than 1 x 10^{-5} (2)
cis-1,2-DCE	16	Federal/State MCL (5 µg/L) adjusted down so hazard quotient is less than 1 (3) (MTCA Method B Non-**carcinogen** Standard Formula Value)
trans-1,2-DCE	100	Federal/State MCL
1,1-DCE	7	Federal/State MCL

Trans-1,2-DCE = trans-1,2-dichloroethene

1) TCE MCL (5 µg/L) adjusted down to 4 µg/L so hazard quotient is less than 1 per WAC 173-340-720(7)(b) and as described in May 2015 CLARC Guidance "Trichloroethylene (TCE) - Deriving Cleanup Levels Under the Model Toxics Control Act (MTCA)"
2) Adjustments to the CULs for carcinogens (such as TCE and vinyl chloride) may be made as allowable under WAC 173-340-720(7)(a) and WAC 173-340-708(5)(d), which states that "for carcinogens . . . the cancer risks resulting from exposure to multiple hazardous substances may be apportioned between hazardous substances in any combination as long as the total excess cancer risk does not exceed one in one hundred thousand (1 x 10-5)".
3) Federal/State MCL (70 µg/L) adjusted down so hazard quotient is less than 1. (1)

Table 1b, attached, provides a more detailed summary of ARARs and the development of groundwater CULs. Table 2 summarizes the total excess cancer risk for the site based on the groundwater and surface water CULs presented in the tables above.

Although the numerical values for TCE, trans-1,2-DCE, and VC under WAC 173-201A are lower than the ARARs identified above, they are applicable only at the point of discharge into surface water, not for the standard point of compliance for groundwater. This is based on the following regulatory justification:

1. Per WAC 173-340-710(6)(a), "applicable state and federal laws may also impose certain technical and procedural requirements for performing cleanup actions". These technical and procedural requirements are identified in WAC 173-340-710(4) which states "Relevant and appropriate requirements include those cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law", the criteria of which must be evaluated to determine whether they are relevant to a cleanup including "(e) Whether the actions or activities regulated by the requirement are similar to the cleanup action contemplated at the site." In other words, the procedural elements of the ARAR and the intent of what the ARAR is regulating (not just the numerical values) are applicable and relevant when developing cleanup standards under a MTCA cleanup action.

2. For the SWQS under WAC 173-201A, the toxic substances criteria for human health protection, found in Table 240 in WAC 173-201A-240(5)(b), are subject to the following technical and procedural requirement: "All waters shall maintain a level of water quality **when entering downstream waters** [emphasis added] that provides for the attainment and maintenance of the water quality standards of those downstream waters . . ." This requirement means that the quality of groundwater **entering** the surface water of Powder Mill Creek, not all groundwater, must have sufficiently low contaminant concentrations to be protective of surface water (i.e., does not result in an exceedance of surface water criteria/cleanup levels). Therefore, the values under WAC 173-201A are specific only to demonstrating compliance of water quality at the point of discharge into the surface water body, as discussed in the Surface Water Cleanup Standards section above, not to groundwater at the groundwater standard point of compliance (i.e., groundwater throughout the site).

Compliance with Cleanup Standards for Groundwater and Surface Water

As stated in Ecology's final decision letter "this site will have established (1) groundwater cleanup levels; and (2) surface water cleanup levels. Both must be met in their respective media." Boeing understands and agrees with this statement, and recognizes that these cleanup levels do not need to be equal in order to achieve a MTCA-compliant cleanup at the site. More specifically, Boeing understands that, even if the groundwater CULs proposed above are met at the groundwater standard point of compliance, if the cVOC concentrations in the surface water compliance samples exceed the surface water CULs, the remedial actions would continue to be implemented until such time as both the groundwater and surface water CULs are met at their respective standard points of compliance.

Proposed Remediation Levels

Per WAC 173-340-355(1) "Remediation levels are used to identify the concentrations (or other methods of identification) of hazardous substances at which different cleanup action components will be used."

Per WAC 173-340-705(7), -708(3)(d) & -708(10)(b), alternate reasonable maximum exposure (RME) scenarios (to those used for development of CLULs) may be used to help assess the protectiveness to human health of a cleanup action alternative that incorporates RLs.

It is well established that pump and treat systems reach a point of diminishing return in their effectiveness to remove contaminant mass or reduce contaminant concentrations beyond a certain level. In order that the groundwater extraction and treatment (GET) system at PMG is not operated/used unnecessarily or in an inefficient or non-cost effective application when it reaches the point of diminishing return (e.g., when concentrations of cVOCs in groundwater reach a point of asymptotic decline), RLs are proposed to provide a logical endpoint for operation of the GET system (or individual extraction wells in portions of the plume).

Under current and likely future site conditions, the complete and potentially chronic exposure pathways of concern at the site are possible ecological exposure and human recreational exposure to contaminated surface water[1]. Therefore, ecological and human recreational exposures are considered the alternate RME for determining RLs, consistent with WAC 173-340-355(1). Based on this alternate RME, the following freshwater concentration values for TCE and other cVOCs, based on the most stringent of ecological benchmarks/screening levels and Ecology-approved human direct exposure screening levels[2] are proposed for groundwater and surface water[3] as the RLs for operation of the GET system:

Proposed RLs for Groundwater and Surface Water GET System Operations

Contaminant of Concern	Remediation Level (µg/L) [(a)]
TCE	21 [(b1)]
cis-1,2-DCE	590 [(b1, c)]
trans-1,2-DCE	970 [(b1, b3)]
1,1-DCE	25 [(b1)]
VC	15 [(d)]

(a) Compliance with RLs would be demonstrated through sampling at approved groundwater monitoring wells and surface water sampling locations.

(b) Most conservative value indicated from the following resources (and most conservative value for aquatic life and/or terrestrial/freshwater wildlife):

(b1) EPA Region 3 BTAG Freshwater Screening Benchmarks, July 2006

(b2) EPA Region 4 Waste Management Division Freshwater Surface Water Screening Values for Hazardous Waste Sites, Supplement to RAGS, 1995 updated Aug. 1999

(b3) EPA Region 5 Ecological Screening Levels, Aug. 22, 2003.

(c) Value indicated for "1,2-dichloroethene" in reference.

(d) Ecology-approved calculated direct exposure screening level for Boeing Auburn site protective of children and (LAI 2013, Ecology 2013).

[1] Human direct contact with surface water is a potential exposure scenario; however, direct contact should be minimized with institutional controls as proposed in each alternative.

[2] Ecology-approved calculated direct exposure screening level for Boeing Auburn site protective of children and workers (LAI 2013, Ecology 2013).

[3] Note that surface water concentrations are already below the RLs; therefore, using these RLs for groundwater is very conservative and protective of potential ecological and human exposures. Also note that surface water concentrations have historically been considerably lower than groundwater concentrations and are anticipated to decline to values near or below the CULs by the time groundwater concentrations decline to the RLs.

In addition to being a value based on the current RME, the proposed RL value for TCE also corresponds to the approximate point where modeling (BIOCHLOR and batch flushing) indicates that asymptotic declines in TCE levels with time will likely be reached in groundwater. In other words, this indicates that it is likely that operation of the GET system will no longer effectively reduce groundwater concentrations at the site at around the time when the RLs have been achieved in groundwater.

However, Boeing recognizes that:

1) The GET system may still be effectively helping with cVOC concentration reduction even after RLs have been achieved (i.e., RLs have been met, but concentration declines are not yet asymptotic).
2) The GET system may still be effectively helping protect surface water beneficial uses even after RLs have been achieved (i.e., surface water cleanup levels are only being met when the GET system is still in operation).

Therefore, Boeing proposes the following conditional requirements for operation and shutdown of the GET system related to the use of RLs:

1. **Conditional Requirement 1** – If the RLs have been met throughout the groundwater plume and in surface water, but there is sufficient evidence that groundwater concentrations are continuing to appreciably decline toward the CUL (e.g., in a non-asymptotic manner) as a direct result of GET system operations, the GET system **WILL NOT BE SHUT DOWN**.
2. **Conditional Requirement 2** – If the RLs have been met in groundwater and surface water and asymptotic[4] declines in cVOC concentration in groundwater and surface water have been observed, the GET system **WILL BE SHUT DOWN**. However, the GET system **WILL BE RESTARTED** if cVOC concentrations in surface water or groundwater return to levels above the RLs **OR** rebound is observed in surface water cVOC concentrations that would indicate that the GET system was still effectively preventing discharge of cVOCs to surface water.

Upon achieving conditions that allow for the GET system to be shut down, monitored natural attenuation (MNA) will be implemented (along with continued adherence to institutional controls) for further contaminant reduction until the cleanup standards for groundwater and surface water are met. Ongoing evaluation of monitoring results and/or the 5-year post-cleanup review process will be used to determine whether additional actions may be required or if MNA can be discontinued.

Note that if it becomes evident that GET system operation will not achieve the RLs and groundwater cVOC data indicates that declining concentrations have become asymptotic, Boeing will consult with Ecology and operation of the GET system will be evaluated for potential optimization, the need for supplemental remedial actions, and/or appropriateness of shutting the GET system down and implementing alternate remedial actions.

* * * * *

[4] Evaluation of asymptotic behavior will be performed per EPA guidance (EPA 1994 and 2009) or another statistically valid method acceptable to Ecology and Boeing.

We appreciate Ecology's consideration of Boeing's proposals related to the Boeing Everett FS and the approach to the application of cleanup standards and RLs as described herein.

LANDAU ASSOCIATES, INC.

Piper M. Roelen, PE, CHMM
Senior Associate

PMR/JRN/tam
P:\025\175\FileRm\R\Feasibility Study\2015 FS\Formal Dispute\ECY Final Letter Response - Sept2017\Letter Attachments\Boeing_Everett_Landau_090817_CUL-REL_TM.docx

Attachments

Table 1a Surface Water Cleanup Levels
Table 1b Groundwater Cleanup Levels
Table 2 Total Site Risk at Cleanup Levels

References

AECOM/LAI. 2015. Feasibility Study for Upland Areas and Powder Mill Gulch, BCA Everett Plant. AECOM and Landau Associates, Inc. November 16.

Ecology. 2013. Letter 7012 3460 0000 3272 2959, Robin Harrover (Ecology) to James Bet (Boeing), Ecology review and approval of site-specific surface water screening levels for evaluation of the Yard and Ditch SW sampling in residential north Algona; FISD #2018, CSID #5049, and WAD041337130. Washington State Department of Ecology. November 22.

Ecology. 2017a. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Final Decision Under Informal Dispute Resolution Regarding the Upland Feasibility Study (FS) Report and Ecology Selected Remedies for the Boeing Everett Site. Washington State Department of Ecology. July 20.

Ecology. 2017b. Implementation Memorandum No. 16 - Developing Conditional Points of Compliance at MTCA Sites Where Groundwater Discharges to Surface Water. Publication No. 16-09-053. July 25.

EPA. 1994. *Methods for Monitoring Pump-and-Treat Performance*. EPA/600/R-94/123, NTIS Order Number PB95-125456. Office of Research and Development Publication. June 1994.

EPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*. EPA/530/R-09-007. Office of Resource Conversation and Recovery. March 1996.

LAI. 2013. Draft Technical Memorandum: Screening Levels for Yard and Ditch Surface Water, Boeing Auburn Plant, Auburn, Washington. Landau Associates, Inc. October 21.

Table 1a
Surface Water Cleanup Levels
Powder Mill Gulch
Boeing Everett Plant
Everett, Washington

Contaminant of Concern	Surface Water ARARs: Water Quality Criteria - WAC 173-201A-240 (µg/L) (a)		Human Health – Fresh Water – Clean Water Act §304 (µg/L) (b)		Human Health – Fresh Water – National Toxics Rule, 40 CFR 131.45 (applicable to Washington) (µg/L)		MTCA Method B Standard Formula Value (µg/L)		Proposed Surface Water Cleanup Level (µg/L)
	(drinking water + organism consumption)	(organism consumption only)	(drinking water + organism consumption)	(organism consumption only)	(drinking water + organism consumption)	(organism consumption only)	(carcinogen)	(non-carcinogen)	
Trichloroethene	0.3	0.7	0.6	7	0.3	0.7	13	118	0.3
cis-1,2-dichloroethene	NE	NE	NE	NE	NE	NE	N/A	NE	N/A
trans-1,2-dichloroethene	200	1,000	200	4,000	200	1,000	N/A	32,400	200
1,1-dichloroethene	700	4,000	300	20,000	700	4,000	N/A	23,100	300
Vinyl Chloride	0.02	0.18	0.022	1.6	NE	0.18	3.7	6,480	0.02

Contaminant of Concern	Excess Cancer Risk: Concentration (µg/L) at Carcinogenic Risk = $1x10^{-6}$ (c)	*Excess Cancer Risk for Surface Water at Cleanup Level (d)*
Trichloroethene	13	*2.3E-08*
cis-1,2-dichloroethene	N/A	*N/A*
trans-1,2-dichloroethene	N/A	*N/A*
1,1-dichloroethene	N/A	*N/A*
Vinyl Chloride	3.7	*5.4E-09*
TOTAL EXCESS CANCER RISK		***2.8E-08***

NE = not established
N/A = not applicable
µg/L = micrograms per liter

ARAR = Applicable, Relevant, and Appropriate Requirements
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
MTCA = Model Toxics Control Act
WAC = Washington Administrative Code
RAGS = Risk Assessment Guidance for Superfund
BTAG = Biological Technical Assistance Group

Notes:
highlighted cells = most conservative cleanup level for applicable ARARs and exposure pathway(s)/receptors
(a) Per August 1, 2016 rulemaking for 201A-240; revised per EPA November 15, 2016 response.
(b) EPA June 2015 published final national recommended ambient water quality criteria for protection of human health for 94 chemical pollutants. Updated recommendations reflect the latest scientific drinking water consumption rate, fish consumption rate, bioaccumulation factors, health toxicity values, and relative source contributions.
(c) Concentration at carcinogenic risk = 1E-06 is equal to the Method B formula value for surface water.
(d) Carcinogenic risk at preliminary cleanup level = (preliminary screening level divided by the concentration at which the risk is 1E-06) x 1E-06.

Table 1b
Groundwater Cleanup Levels
Powder Mill Gulch
Boeing Everett Plant
Everett, Washington

Contaminant of Concern	Groundwater ARARs (a): Federal/State Primary Maximum Contaminant Level (MCL) (µg/L)	Groundwater ARARs (a): MTCA Method B Carcinogen Standard Formula Value (µg/L)	Groundwater ARARs (a): MTCA Method B Non-carcinogen Standard Formula Value (µg/L)	Groundwater Cleanup Level (µg/L) (b)	Excess Cancer Risk: Concentration (µg/L) at Carcinogenic Risk = $1x10^{-6}$ (c)	Excess Cancer Risk: *Excess Cancer Risk for Groundwater at Cleanup Level (d)*
Trichloroethene	5	0.54	4 (e)	4	0.54	*7.4E-06*
cis-1,2-dichloroethene	70	N/A	16 (e)	16	N/A	*N/A*
trans-1,2-dichloroethene	100	N/A	160	100	N/A	*N/A*
1,1-dichloroethene	7	N/A	400	7	N/A	*N/A*
Vinyl Chloride	2	0.029	24	0.07 (f)	0.029	*2.4E-06*
						TOTAL EXCESS CANCER RISK
						9.8E-06

N/A = not applicable
µg/L = micgrograms per liter
ARAR = Applicable, Relevant, and Appropriate Requirements
MTCA = Model Toxics Control Act

Notes:
highlighted cells = most conservative cleanup level for applicable ARARs and exposure pathway(s)/receptors
(a) Based on protection of groundwater as drinking water.
(b) Cleanup level established through MTCA Method B protective of human health for drinking water.
(c) Concentration at carcinogenic risk = 1E-06 is equal to the Method B formula value for groundwater.
(d) Carcinogenic risk at cleanup level = (cleanup level divided by the concentration at which the risk is 1E-06) x 1E-06.
(e) For cis-1,2-DCE (non-carcinogen), cleanup level based on MCL (70 µg/L) must be adjusted down to 16 ug/L so hazard quotient is less than 1 per WAC 173-340-720(7)(b). For TCE (carcinogen) cleanup level must not exceed and excess cancer risk of 1x10-5, and if based on an MCL (5 µg/L) must be adjusted down to 4 µg/L so hazard quotient is less than 1 as described in May 2015 CLARC Guidance "Trichloroethylene (TCE) - Deriving Cleanup Levels Under the Model Toxics Control Act (MTCA)"
(f) Adjustments to the CULs for carcinogens (such as TCE and vinyl chloride) may be made as allowable under WAC 173-340-720(7)(a) and WAC 173-340-708(5)(d) which states that "for carcinogens . . . the cancer risks resulting from exposure to multiple hazardous substances may be apportioned between hazardous substances in any combination as long as the total excess cancer risk does not exceed one in one hundred thousand (1 x 10-5)". Vinyl chloride value adjusted down from Federal MCL to 0.07 µg/L such that total site risk is less than 1 x 10-5.

Table 2
Total Site Risk at Cleanup Levels
Powder Mill Gulch
Boeing Everett Plant
Everett, Washington

Contaminant of Concern	*Carcinogenic Risk for Surface Water (consumption of water and organisms) at Cleanup Level*	*Carcinogenic Risk for Groundwater (as drinking water) at Cleanup Level*	*Carcinogenic Risk for Contaminant*
	Pathway		
	Consumption of Water & Organisms	*Groundwater Protective of Drinking Water*	
Trichloroethene	*2.3E-08*	*7.4E-06*	*7.4E-06*
cis-1,2-dichloroethene	*N/A*	*N/A*	*N/A*
trans-1,2-dichloroethene	*N/A*	*N/A*	*N/A*
1,1-dichloroethene	*N/A*	*N/A*	*N/A*
Vinyl Chloride	*5.4E-09*	*2.4E-06*	*2.4E-06*
	Pathway Risk	***Pathway Risk***	***TOTAL SITE EXCESS CANCER RISK***
	2.8E-08	***9.8E-06***	***9.8E-06***

Attachment 2

Uplands Attachment

Attachment #2 – Upland Areas

This attachment addresses Feasibility Study (FS)-related items specific to the upland areas.

I. Areas of Agreement

Boeing concurs with or agrees to the following statements and stipulations provided in the Washington State Department of Ecology's (Ecology's) final decision letter:

- Boeing agrees to conduct indoor air monitoring at solid waste management units (SWMUs)/areas of concern (/AOCs) 171, 098, 170, 169, Former Paint Crib (Building 40-02), 054, and Footing Excavation (Building 40-32) as requested in Section 5a of Ecology's final decision letter.
- Boeing agrees that a downgradient deep groundwater monitoring well at SWMU 083 is not required as stated in Footnote 35 of Ecology's final decision letter.
- Boeing agrees that EGW177 and EGW178 satisfy the deep downgradient groundwater monitoring well requirement for SWMUs/AOCs 169 and 170 at Building 40-02 as stated in Footnote 36 of Ecology's final decision letter.
- Boeing agrees that SWMUs/AOCs can be combined for monitoring by the same downgradient deep monitoring well as stated in the third bullet point on Page 22 of Ecology's final decision letter.
- Boeing agrees that remedial action contingency evaluation is not required in the CAP and agrees to modify the cleanup order if remedy failure occurs as stated in Section 7 of Ecology's final decision letter.
- Boeing agrees that the FS report should not be revised as stated in the first bullet on Page 24 of Ecology's final decision letter.
- Boeing agrees to investigate the presence of contaminated perched groundwater near ESB1290 (SWMUs/AOCs 055/168) as stated in the second bullet point on Page 17 and Footnote 28 of Ecology's final decision letter.

II. Areas of Disagreement

A. Remedy Selection

1. Future Excavation

Boeing selected "Maintain Containment" as the final cleanup remedy in the FS for four SWMUs/AOCs (054, 093, 165, and 067/071) because it meets Model Toxics Control Act (MTCA) requirements for the selection of cleanup remedies in Washington Administrative Code (WAC) 173-340-360, there is no risk to human health and the environment under this scenario, and the remedy is permanent to the maximum extent practicable (as determined following the MTCA Disproportionate Cost Analysis [DCA] process in WAC 173-340-360(3)(e)). Boeing commits to voluntarily excavate or otherwise remediate these areas (and others) in the future when there is an opportunity for access without putting undue burden on facility operations. Ecology is presently seeking an additional commitment to future excavation as the final remedy

Attachment #2 – Upland Areas

within a specific timeframe at these areas plus three additional SWMUs/AOCs at Building 40-22, Building 40-23, and Building 40-25. As discussed during the informal dispute resolution process and in an attempt to move negotiations forward, Boeing is willing to conduct future excavation as the selected remedy if mutually agreeable language can be negotiated. We are unaware of any MTCA sites where Ecology has required operationally burdensome excavation where there is no immediate risk to human health and the environment, a situation not presented at this site.

Ecology's rationale for requiring future excavation within a specific timeframe that is unrelated to operational access at these SWMUs/AOCs is unclear and inconsistent with "Maintain Containment" requirements for other SWMUs/AOCs. In paragraph 1 of Section 2b on Page 15 in its final decision letter, Ecology states that it *"explained its preferred remedies (and rationale) at these SWMUs in its response letter dated August 18, 2016, and summarizes that explanation below.*" Boeing has carefully reviewed those letters and is unable to find a rationale or summary describing the reasons for requiring future excavation instead of maintaining containment for these SWMUs/AOCs in either Ecology's letter dated August 18, 2016, or the final decision letter.

During the second informal dispute resolution meeting held on October 27, 2016, Ecology explained that it used a *"mixed set of criteria"* to include a requirement for future excavation within a specified timeframe and these four original SWMUs/AOCs were selected by Ecology because they had higher contaminant concentrations and would be easier to access at some point than the other SWMUs/AOCs where only containment was selected. Ecology has not explained how these areas were considered to be easier to access. Nor has Ecology articulated what *"mixed set of criteria"* it used to make its decision that these areas must be excavated subject to a set timeframe. Additionally, Boeing has pointed out that complete removal of contamination at these four areas is not attainable at any point while the facility is actively operating or without the complete demolition of a building. Boeing anticipates that its Everett facility will be actively operating for the foreseeable future. Complete removal of all the contamination is unlikely due to the presence of operationally necessary utilities at SWMU/AOC 054, and because the contamination is below active work spaces (SWMU/AOC 093) and an operationally critical one-of-a-kind shop (SWMUs/AOCs 067/071). The minimal amount of contamination remaining after the limited excavation proposed for SWMU/AOC 165 does not warrant an additional, future excavation requirement pursuant to a mandatory timetable, especially in operationally critical areas of the facility (i.e., fuel farm).

Ecology asserted during informal dispute meetings that contaminant mass reduction is important even if cleanup levels (CULs) are not met because, according to Ecology, permanence is evaluated for each cleanup action alternative as part of the DCA based on the degree to which the alternative permanently reduces or eliminates the contamination. Boeing acknowledges that permanence is one of the evaluation criteria under the DCA, per WAC 173-340-360(3)(e). However, adjusting the numerical value of permanence for the DCA would not significantly change the weighting of the DCA factors and selection of containment as the preferred remedy for these SWMUs/AOCs. Therefore, Boeing disputes that the mass reduction criteria, on its own, warrants the requirement for future excavation at a specified point in time for these SWMUs/AOCs.

However, Boeing's position is that it will conduct future excavation as the selected remedy for these seven SWMUs/AOCs, contingent on Ecology removing the requirement for a schedule and inclusion of mutually agreeable language in the CAP regarding the conditions under which the remedies are to be implemented. Boeing submitted this suggested language to Ecology in an email dated March 6, 2017, which was rejected by Ecology:

> Boeing shall implement Alternative 1 (maintenance of containment) in SWMU 054, SWMU 165, SWMU 093 and SWMU 067/071. If, in the future, (1) operations change, (2) conditions at that time warrant further cleanup beyond containment, (3) Boeing determines that implementation of SVE or an alternative source removal technology compliant with MTCA (e.g., excavation) will not put an undue burden on operations, and (4) implementation of such alternative will result in either: (a) significant reduction in post-remedy groundwater monitoring for that SWMU or (b) a NFA finding from Ecology, Boeing will submit a work plan to Ecology to implement SVE or an alternative source removal technology.

While Ecology has stated that it is willing to work with Boeing to prevent impacts to plant operations, it now seeks to require Boeing to commit to a 15-year removal schedule, regardless of Boeing's operational needs. And, Ecology's criteria for extensions of this removal schedule are burdensome, costly, and fail to acknowledge Boeing's operational needs. Ecology's extension criteria regarding the additional excavation work would only permit 5-year schedule extensions upon Boeing's written request and justification provided within a 6-month window that starts only 18 months ahead of the deadline for performing excavation. Further, Ecology's criteria requires annual status reports to Ecology indicating if a change of operations has occurred that would allow excavation. Boeing reiterates that commitment to an excavation schedule for these SWMUs/AOCs is not practical and not required by MTCA. The 6-month window for extension requests does not provide Boeing sufficient time to plan for whether construction will be completed, particularly if there is no guarantee that Ecology will grant extensions as promised.

Boeing proposes that the remedy should remain as "Maintain Containment" with future excavation as a contingent remedy if the containment remedy fails or if the opportunity arises for Boeing to conduct the excavation without undue burden on Boeing's operations. Boeing has provided clear, workable language to that effect. Boeing is also willing to consider future excavation if mutually agreeable language can be negotiated that allows operations to continue until a suitable time.

2. SWMU/AOC 171, Building 40-31, Former Bluestreak Vapor Degreaser

Boeing proposed a containment remedy for SWMU/AOC 171, Building 40-31, Former Bluestreak Vapor Degreaser, while Ecology is seeking for Boeing to implement soil vapor extraction (SVE). Conducting SVE in the short term would cause undue burden on Boeing's operations, and Ecology agreed that SVE could be completed at a future date. However, as described above for future excavation, a schedule fixed today for implementing SVE does not reflect Boeing's operational needs. Boeing proposes that the remedy should remain "Maintain Containment" with future SVE as a contingent remedy if the containment remedy fails or if the opportunity arises for Boeing to conduct SVE without undue burden on Boeing's plant operations.

Ecology stated on page 28 of its original comment letter dated August 18, 2016, that the containment remedy selected for SWMU/AOC 171 does not meet MTCA threshold criteria and other minimum requirements for a cleanup action; specifically, Ecology contends that containment is not permanent to the maximum extent practicable. Boeing does not entirely understand Ecology's basis for its statement; we assume Ecology does not agree with the DCA that Boeing performed that showed containment was in fact permanent to the maximum extent practicable and that containment provides for a reasonable restoration timeframe. Based on this understanding of Ecology's rationale, Boeing maintains that Ecology is misinterpreting MTCA for containment remedies. As Ecology is aware, the agency often approves containment remedies under MTCA and has done so for years. MTCA allows for containment alternatives as long as they meet the specific requirements listed in WAC 173-340-740(6)(f), including that "the selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360." This is precisely the analysis that Boeing conducted. The criteria for determining whether a cleanup action is permanent to the maximum extent practicable are defined solely under WAC 173-340-360(3)(e),(f). Additionally, disallowing containment on the basis that such a remedy does not meet a reasonable restoration timeframe disregards the accepted propriety of containment remedies at MTCA-regulated sites because an active remedy would always achieve CULs in a shorter timeframe than containment. As discussed above, containment remedies are routinely approved under MTCA. Under MTCA, the criteria for determining a reasonable restoration time frame are found at WAC 173-340-360(4)(b). These criteria include current and future site uses (WAC 173-340-360(4)(b)(iii), (iv)). Thus, containment as part of the remedy is fully consistent with MTCA's permanence and restoration timeframe criteria and is consistent with many years of Ecology's MTCA decisions.

B. SWMUs/AOCs 055/168, Building 40-24, Utility Trenches and Sumps

In Ecology's original comments to the FS, Ecology required continuous removal of perched groundwater from within the Building 40-24 utility trench and installation of extraction wells near ESB1290 and the North Sump if this area contains contaminated perched water. In Response A22 of its response letter to Ecology's original comments, dated September 19, 2016, Boeing noted that the selected remedy it proposed in the FS includes periodic pumping of perched groundwater from the trench. On page 17 of the final decision letter, Ecology allows for intermittent pumping depending on the amount of contaminated groundwater present and goes on to say that *"the objective of the groundwater pumping [at Building 40-24] should be to remove at least 15-20 gallons of contaminated groundwater while operational as Boeing proposed in its March 6, 2017, email attachment."*

This statement does not accurately capture what Boeing proposed in the March 6, 2017, email attachment. Boeing wrote "Boeing will monitor the need for continuous pumping during quarterly removal at EGW037 and increase the frequency if a significant volume (example: more than 15-

20 gallons) of water is removed during quarterly pumping." Thus, Boeing's March 6, 2017, proposal included the understandable limitation that if sufficient water is not present for pumping, the water cannot and will not be pumped. The objective of pumping is to remove as much water as is practicable, not to achieve a specific volume.

Boeing agrees to investigate the presence of contaminated perched groundwater near ESB1290 and, if contaminated perched groundwater is present, will propose a remedy to Ecology that considers the plant operations in the area. Boeing will not be able to investigate perched water near the location of the North Sump because a new 5-foot-thick concrete pad was recently installed in Building 40-24 that covers a large area, including Slants 1, 2, and 3.

C. Soil Cleanup Levels

On pages 8 and 17 of Ecology's comment letter on the Upland and PMG FS, dated August 18, 2016, Ecology required that soil CULs be protective groundwater CULs equal to surface water quality standards, which Ecology has determined are Applicable or Relevant and Appropriate Requirements (ARARs) for the SWMUs/AOCs associated with Building 40-56 (i.e., SWMUs/AOCs 067/071 and 086/089/094), and included revised soil CULs in the table on pages 8 and 9 that are approximately 10 times lower than the soil CULs in the Upland FS. Boeing's proposed soil CULs were based on MTCA Method B protection of groundwater as presented in Ecology's Cleanup Levels and Risk Calculation (CLARC) tables dated July 2015.

As discussed in the PMG section and the Memorandum of Law provided with its written submittal, Ecology's interpretation of MTCA on this is incorrect and not authorized by MTCA. Requiring surface water quality standards to serve as cleanup site CULs in upland groundwater and soil is contrary to Washington and applicable federal law. In addition, Ecology indicates that the groundwater CULs for standard points of compliance must be the same for the entire aquifer (even at different SWMUs/AOCs separated by large distances). Ecology states that at Boeing Everett, *"all contaminated groundwater at the site must meet a single cleanup level at the SPOC (per WAC 173-340-720(8)(b))"* (page 6, last paragraph). Ecology's statement does not accurately reflect this MTCA citation. WAC 173-340-720(8)(b) states *"The standard point of compliance* [emphasis added] *shall be established throughout the site"* (i.e., for a standard point of compliance, CULs must be met throughout the saturated zone at the site). It does not say that the established CULs must be the same throughout the site. Boeing is aware of sites where different CULs for the same contaminant in the same media have been established and approved by Ecology under MTCA at cleanup sites. Therefore, it is not necessary to apply the same CUL to groundwater at PMG and for groundwater at the upland SWMUs/AOC.

Furthermore, Boeing has conducted modeling to demonstrate that the soil CULs proposed in the FS are protective of surface water criteria (see Attachment 2A).

As stated during comment resolution meetings with Ecology, Boeing is committed to monitoring the Building 40-56 deep groundwater well EGW040 to ensure contaminants of concern (COCs) do not leach to the Esperance Sand aquifer; if results indicate that contamination is leaching to the aquifer, Boeing will reevaluate the remedy in conjunction with Ecology and in accordance with MTCA requirements.

Boeing notes that while Ecology included the requirement for lower soil CULs at Building 40-56, Ecology specifically excluded this requirement for the SWMU/AOCs in exposure pathway model (EPM) A and EPM E in Ecology's August 18, 2016, comments. Specifically for EPM A, Ecology stated on page 7 of its original comment letter, dated August 18, 2016, *"Based on the low concentrations of contaminants and low volumes of perched groundwater at these SWMUs, Ecology believes the likelihood of contaminated perched groundwater migrating to the Esperance Sand Aquifer is unlikely under WAC 173-340-720(2)(c). Therefore, based on current information, Ecology is not requiring Boeing meet soil cleanup levels protective of the more stringent potable groundwater cleanup levels based on water quality ARARs."*

For EPM E, Ecology stated on page 12 of its original comment letter, dated August 18, 2016, *"Based on the absence of perched groundwater at these SWMUs, Ecology believes the likelihood of contaminated vadose zone soils migrating to the Esperance Sand Aquifer is unlikely under WAC 173-340-720(2)(c). Therefore, based on current information, Ecology is not requiring Boeing meet soil cleanup levels protective of the more stringent potable groundwater cleanup levels based on water quality ARARs."* Ecology's letter was silent on the soil CULs for EPMs F through K, and Boeing concluded that the soil CULs presented in the FS are acceptable.

In Footnote 4[1] of Ecology's final decision letter, dated July 20, 2017, it appears that Ecology is now, for the first time, requiring lower soil CULs protective of surface water, using the surface water quality criteria as the CULs, at SWMUs/AOCs 171, 054, 165, 093, 151, 097, 098, 169, 170, 068, EV 48-1, Former Paint Crib, and Footing Excavation. Boeing requests Ecology to clarify if the lower soil CULs presented in Ecology's comments for Building 40-56 are now being sought at SWMU/AOCs 171, 054, 165, 093, 151, 097, 098, 169, 170, 068, Former Paint Crib, Footing Excavation, and EV-48-1. If the requirement is in fact new for these areas to meet soil CULs that are protective of groundwater CULs equal to surface water quality criteria, that decision would represent a significant change from Boeing's previous understanding of Ecology's requirements and would require us to reevaluate the technical implications and cost impacts. If this is a new requirement that was not included in the original comment letter or raised in the five subsequent meetings held between Boeing and Ecology where this issue was discussed, Boeing requests that this new topic be addressed through informal dispute resolution rather than as part of formal dispute to comply with the process laid out in the Agreed Order.

If Ecology intends to require soil CULs protective of groundwater equal to the most conservative surface water quality standard CULs at the SWMUs/AOCs previously noted, Boeing additionally requests establishing conditional points of compliance (CPOCs) in the groundwater, in accordance with WAC 173-340-720(8)(c), and the use of modeling to determine appropriate

[1] Footnote 4 of the final decision letter states, *"Groundwater cleanup levels based on the more stringent of the new water quality criteria (WQCs), MTCA Method B cleanup levels and other ARARs. For TCE, the WQCs are the most stringent ARAR for setting the groundwater cleanup level (0.3 ug/L)."*

CULs for those CPOCs for upland soils that are protective of surface water ARARs.

D. Additional Monitoring

1. Vapor Intrusion Monitoring

In Ecology's comments dated August 18, 2016, Ecology requires indoor air and sub-slab vapor or soil gas monitoring at 11 SWMUs/AOCs. In responses A28, A29, A30, A31, A33, A34 of the Boeing response letter dated September 19, 2016, Boeing has agreed to conduct indoor air sampling for compliance monitoring at six SWMUs/AOCs where sub-slab vapor concentrations exceeded sub-slab vapor screening levels.

It is not necessary to conduct indoor air monitoring where sub-slab vapor results are below the screening levels (SWMUs/AOCs 067/071), where active SVE is proposed (SWMUs/AOCs 086/089/094), or where contamination is outside the building (SWMUs/AOCs 090 and 112). Indoor air, not sub-slab vapor or soil gas, is the point of compliance as described in WAC 173-340-740(3)(c)(iv).

Sub-slab vapor and soil gas sampling is the appropriate tool to demonstrate whether a soil vapor pathway is present when conducted during the investigation phase, when indoor air exceedances are observed, or during closeout activities. However, Boeing does not agree to conduct sub-slab vapor sampling so that subsequent indoor air sampling events can be reduced to annual sampling, as indicated in the second bullet point on Page 20 of Ecology's final decision letter. Initially sampling indoor air twice a year will demonstrate which season results in the highest sub-slab vapor concentrations, and future indoor air sampling can occur annually during the season with the highest concentrations.

Boeing proposes to conduct sub-slab vapor sampling at SWMUs/AOCs 090 and 112 for two seasonal events to determine whether a complete pathway for vapor intrusion exists. If sub-slab vapor concentrations are below MTCA Method C sub-slab soil gas screening levels at either SWMU/AOC, Boeing will request to remove future soil vapor intrusion (soil vapor and indoor air) sampling at that SWMU/AOC from the monitoring program. If a complete pathway is demonstrated by sub-slab vapor results, Boeing will conduct indoor air monitoring for these SWMUs/AOCs. Boeing agrees to conduct indoor air monitoring at the Former Paint Crib in Building 40-02.

However, Boeing maintains that sub-slab vapor and soil gas sampling as part of routine monitoring are not warranted nor required under MTCA. Concentrations in sub-slab vapor or soil gas are not expected to change meaningfully over short time periods, and the data show no exceedances of indoor air CULs at SWMUs/AOCs have been documented at the site. This data strongly suggest that current soil concentrations and building conditions result in a negligible risk for the vapor intrusion pathway. If indoor air exceedances are detected or Boeing intends to close out a soil vapor/soil gas SWMU/AOC, Boeing will submit a work plan to Ecology to conduct appropriate investigations of sub-slab vapor and/or soil gas at that time.

Boeing does not agree to indoor air and soil gas monitoring for SWMU/AOC 165 and UST EV-48-1 because no vapor intrusion pathway has been established here and requests Ecology to clarify if indoor air and sub-slab vapor sampling are now intended for these two additional SWMUs/AOCs. These areas were not included in previous communications on this topic.

2. Deep Groundwater Monitoring Wells

Ecology is requiring downgradient deep groundwater monitoring wells as close as possible to (but not within) the soil contamination and routine deep groundwater monitoring at 13 locations. While Boeing remains concerned that installing deep wells near contamination can serve as a transport conduit to the aquifer, Boeing worked in good faith with Ecology to identify appropriate monitoring locations during negotiations. In Ecology's final decision letter, Ecology agreed that a deep well was not required for SWMU/AOC 083 (Footnote 35), that the deep wells existing near Building 40-02 can be used for SWMU/AOCs 169 and 170 (Footnote 36), and that a deep well can be used to monitor multiple SWMUs/AOCs (third bullet on page 22). However, it is unclear which SWMUs/AOCs can be grouped together as this could not be agreed upon during negotiations.

For Building 40-56, Ecology states the following in Footnote 36 of the July 20, 2017, letter:

> *EGW040 does not adequately serve as a downgradient deep groundwater monitoring well. Ecology requires an additional deep groundwater monitoring well on the east side of building 40-56, if it cannot be located inside the building. This additional monitoring well will serve to monitor these five SWMUs.*

Boeing maintains that EGW040 is sufficient to monitor the SWMUs/AOCs associated with Building 40-56 because it is downgradient of the contamination and because the original purpose of installing this well was to evaluate the groundwater quality downgradient of these SWMUs/AOCs in Building 40-56 (as documented in Section 14.7 of the Final Remedial Investigation Report [URS and Landau 2011] and Section 4.2.6 of the 1997 interim action work plan [Dames and Moore 1997]). In addition, Boeing does not agree to the need or value of a well east of Building 40-56, as requested in Footnote 36 of Ecology's final decision letter, as the Esperance Sand groundwater flows to the northwest in this area, and Ecology's proposed location would not be downgradient of the SWMUs/AOCs.

Ecology states in the third bullet on Page 21 of the final decision letter that *"many of the SWMU areas listed above [SWMUs/AOCs where deep wells are required by Ecology] are located outdoors and have documented perched groundwater contamination near and below the contaminated soils,"* suggesting that perched water is a basis for requiring deep wells. However, Boeing notes that only three of the 13 SWMUs/AOCs where wells are being required have perched water near the soil contamination and only two are outside (combined SWMUs/AOCs 086/089/094 and 055/168, where active remedies have been selected and are anticipated to remove both a significant amount of the source contamination and perched water). Therefore, Boeing concludes that the presence of perched water elsewhere at the site does not justify Ecology's requirement for deep wells for the 10 SWMUs/AOCs where perched water is not present. The requirement is not supported by the justification. Boeing agrees to install deep wells where perched water is present and deep wells do not already exist (i.e., SWMUs/AOCs 055/168 and the Footing Excavation at Building 40-32).

Ecology states in Footnote 18 of the comments on the FS and Footnote 38 of the final decision letter that groundwater was not accounted for in the vadose zone modeling, which is not accurate. The vadose zone modeling considered perched groundwater, as stated in Appendix B of the FS. The total mass associated with the perched groundwater was not significant relative to the soil concentrations and, therefore, was not added as an input to the model. Furthermore, the model scenarios assume limited recharge conditions and, therefore, are comparable to the conditions found at SWMUs/AOCs with perched water.

In the list of SWMUs/AOCs where a deep well is being requested by Ecology, Ecology includes Footing Excavation Area, Building 45-32. Boeing notes that the Footing Excavation is located in Building 40-32, not 45-32.

III. Outstanding Issues

The following clarifications were requested by Boeing in their response letter to Ecology's comments dated September 19, 2016, and have not been clarified by Ecology during the informal dispute process:

- In Response A4, Boeing requested that Ecology clarify how Ecology would apply a "reasonable timeframe" to the cleanup actions and how a "reasonable timeframe" is defined.
- In Response A18, Boeing requested that Ecology clarify if it is in concurrence with the groundwater extraction at five existing wells for SWMUs/AOCs 086/089/094 proposed by Boeing as part of the remedy.
- In Response A20, Boeing requested clarification from Ecology regarding their requirement for SWMU/AOC 166 that the groundwater CULs are met at the time the CAP is finalized. Boeing requested that Ecology clarify what they would require if this condition is not met. Boeing proposes that the SWMU/AOC be closed if CULs are met.
- In Response C35, Boeing requested that Ecology clarify why long-term groundwater monitoring would be required when CULs are met for SWMU/AOC 151.

IV. References

AECOM/LAI (AECOM and Landau Associates, Inc.). 2015. Feasibility Study for Upland Areas and Powder Mill Gulch, BCA Everett Plant. AECOM and Landau Associates, Inc. November 16.

Boeing. 2016. Letter from Deborah Taege (Boeing) to Dean Yasuda (Ecology), Informal Dispute Resolution – Boeing Responses to Ecology's Comments on Draft Uplands and Powder Mill Gulch Feasibility Study Report, dated August 18, 2016. September 19.

Dames & Moore. 1997. Draft Interim Action Work Plan, BCAG Everett Plant. March 28.

Ecology (Washington State Department of Ecology). 2016. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Contingent Approval and Modifications to the Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 13, 2015. Washington State Department of Ecology. August 18.

Ecology. 2017. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Final Decision Under Informal Dispute Resolution Regarding the Upland Feasibility Study (FS) Report and Ecology Selected Remedies for the Boeing Everett Site. Washington State Department of Ecology. July 20.

URS/LAI (URS and Landau Associates, Inc.). 2011. Final Remedial Investigation Report, BCA Everett Plant. URS and Landau Associates, Inc. November 4.

Attachment 2A

Technical Memorandum

Demonstration that Proposed Soil Cleanup Levels are Protective of Surface Water Quality Criteria

Building 40-56

AECOM
1111 3rd Ave
Suite 1600
Seattle, WA 98101
www.aecom.com

206 438 2700 tel
866 495 5288 fax

Memorandum

To	Debbie Taege, The Boeing Company	Info	FINAL
Subject	Summary of Bioscreen Model Results Demonstration that Proposed Soil Cleanup Levels are Protective of Surface Water Quality Criteria		
From	Michael DeSmet, Hydrogeologist Amy L. Dahl, Project Manager		
Date	September 7, 2017		

Introduction

The purpose of this memorandum is to demonstrate that the soil cleanup levels (CULs) proposed in the *Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 16, 2015* are protective of surface water quality criteria. In Ecology's letters dated August 18, 2016, regarding *Ecology Contingent Approval and Modifications to the FS* (Ecology 2016) and July 20, 2017, regarding *Final Decision under Informal Dispute Resolution Regarding the Upland Feasibility Study Report* (Ecology 2017), Ecology requires that soil CULs be calculated using current Water Quality Criteria for human health in surface water as the target groundwater CULs. This requirement effectively reduces the soil CULs proposed in the *Feasibility Study for Upland Areas and Powder Mill Gulch* (AECOM/LAI 2015) for several chemicals of concern (COCs) by approximately ten times.

The soil CULs in the FS were taken from Ecology's Cleanup Levels and Risk Calculations (CLARC) tables dated July 2015, which are calculated to be protective of groundwater under unsaturated conditions at a temperature of 13 degrees Celsius. These soil CULs are back-calculated such that the migration of soil contamination to groundwater would not exceed the target groundwater CULs. The target groundwater CULs used to calculate the soil CULs presented in the CLARC tables are based on standard Method B concentrations, also presented in the CLARC tables dated July 2015, and described in an Ecology guidance document (Ecology 2015). Therefore, if the soil CULs are protective of the target groundwater CULs and if groundwater contamination at the target groundwater CULs will never reach surface water, the soil CULs are protective of surface water. The modeling performed as described below demonstrates that the target groundwater CULs are protective of surface water; therefore, the soil CULs proposed in the FS are also protective of surface water.

Methodology

Bioscreen is a screening model that was used to simulate the fate and transport of the COCs for the SWMUs/AOCs at Building 40-56 (i.e., ethylbenzene, toluene, and xylene) in groundwater as it flows through the Esperance Sand aquifer from directly beneath SWMUs/AOCs 086/089/094 to where the aquifer daylights in Powder Mill Creek (PMC) (Figure 1). Bioscreen is a screening model developed from a collaborative effort between EPA, AFCEE, and Groundwater Services, Inc. that simulates remediation through natural attenuation of dissolved hydrocarbons and is designed to simulate biodegradation by both aerobic and anaerobic reactions (Newell et al. 1996).

Bioscreen predicts the maximum extent of contaminant travel and dissolved contaminant concentration along the centerline of a plume, which can then be compared to potential points of exposure (e.g. PMC). Programmed in the Microsoft Excel environment, Bioscreen has the ability to simulate advection, dispersion, and adsorption. Aerobic decay, as well as anaerobic conditions, which contribute to the degradation of released petroleum COCs, can also be simulated. These processes can significantly enhance the rate of COC attenuation and removal from a contaminated aquifer.

Bioscreen model input parameters include hydrogeological data, chemical specific data, and biodegradation data. A simulation distance of 3,000 feet was assumed, approximately representing the distance from Building 40-56 to PMC. Biodegradation of COCs was simulated as an biodegradation reaction using multiple electron acceptors including site-specific concentrations of dissolved oxygen, nitrate, and sulfate measured in the Esperance Sand aquifer. Ferrous iron and methane were not detected in the Esperance Sand aquifer upgradient of the source area and input as zero. The transport porosity and hydraulic conductivity previously published for Powder Mill Gulch (PMG) were also used as inputs. Bioscreen modeled input parameters are presented in Table 1.

Two simulations were performed for each COC:

- Initial simulations were completed to predict the maximum distance each COC would travel using target groundwater concentrations (Table 1) used to calculate the soil CULs presented in the FS. These groundwater concentrations are theoretical sources in the Esperance sand.

- As a second line of reasoning, additional simulations were then completed for each COC to determine a theoretical groundwater concentration threshold that would facilitate the migration of simulated COCs within the Esperance sand to PMC (approximately 3,000 feet). An unsaturated zone soil concentration was then determined from the simulated groundwater threshold concentration for each COC and compared to the soil CULs presented in the FS. Unsaturated zone soil concentrations were derived from the three-phase partitioning model (as described by equation 747-1) presented in Washington Administrative Code (WAC) 173-340-747. Equation 747-1 is presented below:

$$Cs = Cw(UCF)DF[Kd + ((\theta w + \theta aHcc))/\rho b]$$

Where:

Cs = Soil concentration (mg/kg)
Cw = Groundwater concentration (µg/L)
UCF = Unit conversion factor (1 mg/1,000 µg)
DF = Dilution factor (dimensionless: 20 for unsaturated zone soil)
Kd = Distribution coefficient [L/kg: toluene (0.252), ethylbenzene (0.367), xylene (average) (0.432)]
θw = water-filled porosity (ml water/ml soil: 0.092 for unsaturated zone)
θa = (ml air/ml soil: 0.295 for unsaturated zone)
Hcc = Henry's law constant [dimensionless: toluene (0.272), ethylbenzene (0.323), xylene (0.279)]
ρb = Dry bulk density (1.64 kg/L)

Results

The Bioscreen model results are presented in the following figures:

- Maximum distance simulations using toluene, ethylbenzene, and xylene target groundwater concentrations derived from FS soil CULs are presented in Figures 2, 3, and 4, respectively.

- Predicted threshold groundwater concentration simulations for each COC are presented in Figures 5, 6, and 7, respectively.

The model indicates that soil CUL derived groundwater COC concentrations will decrease to zero within 300 feet of entering the Esperance Sand aquifer and will not reach PMC, 3,000 feet away, within 1,000 years under simulated anaerobic conditions (Figures 2, 3, and 4). Based on contaminant threshold predictive scenarios, it would take COC groundwater concentrations beneath SWMUs/AOCs 086/089/094 greater than 58 mg/L to reach PMC within 1,000 years, which is approximately one order of magnitude, or greater, above the target groundwater CULs used to calculate the soil CULs presented in the FS (Figures 5, 6, and 7).

The soil concentrations derived from the three-phase partitioning equation (equation 747-1) using a threshold groundwater concentration of 58 mg/L for toluene, ethylbenzene, and xylene are 414 mg/kg, 558 mg/kg, and 624 mg/kg, respectively. These concentrations are significantly higher than the soil CULs proposed in Table 5-2 of the FS for toluene, ethylbenzene, and xylenes (4.5 mg/kg, 6 mg/kg, and 15 mg/kg, respectively) which indicates that the proposed soil CULs are very protective of PMC and groundwater within the Esperance Sand. It should be noted that the model assumes a constant, infinite source mass for the entire 1,000 year period simulated in each scenario. This assumption is extremely conservative and further indicates that even in the presence of a long-term contributing source proposed soil CULs will be protective of PMC.

Boeing provides this new information for Ecology's consideration and requests that Ecology approve the soil CULs presented in the FS.

References

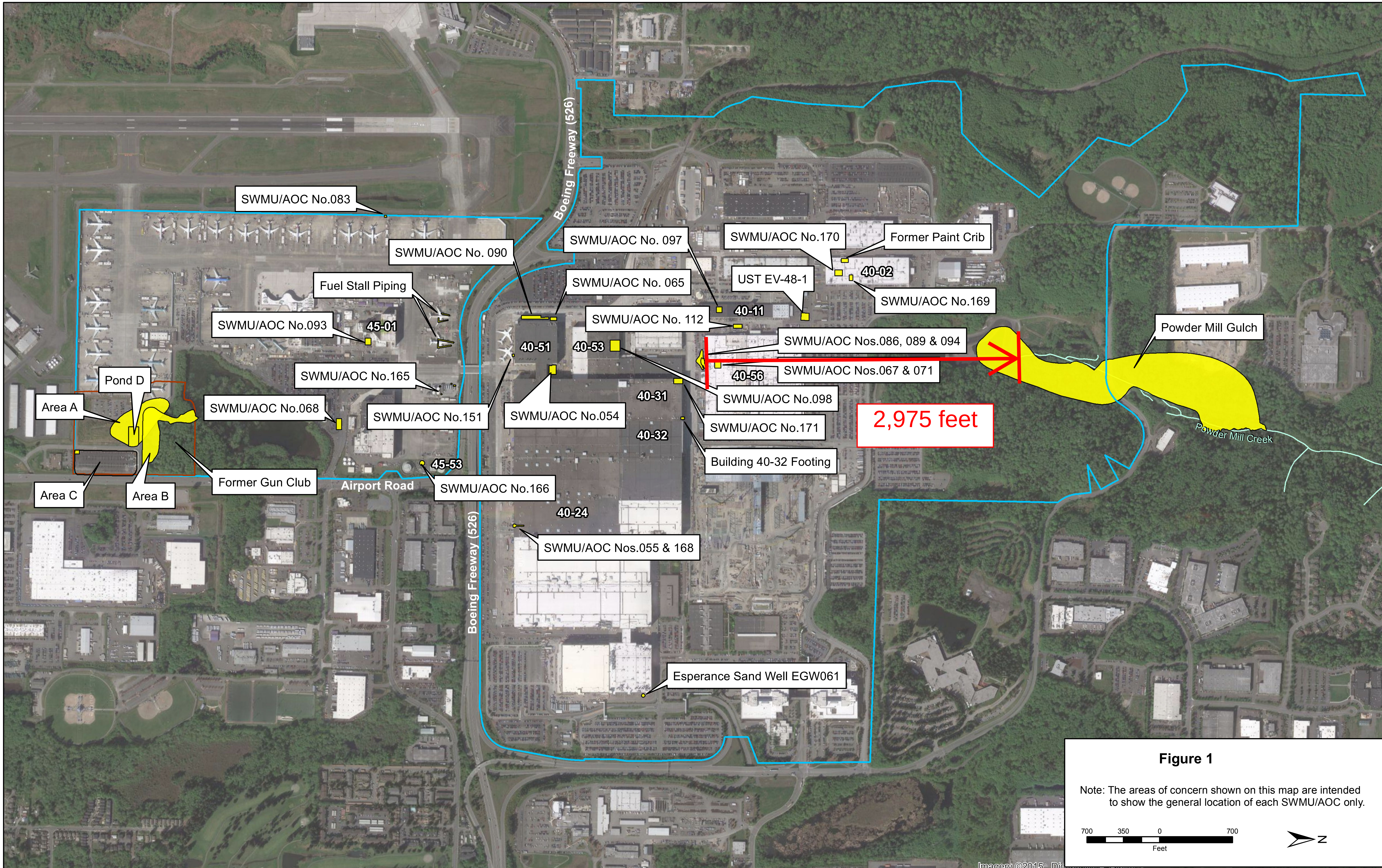
Ecology (Washington State Department of Ecology). 2015. Soil Cleanup Levels to Protect Groundwater. https://fortress.wa.gov/ecy/clarc/FocusSheets/Soil%20Protective%20of%20Groundwater%20-%20CLARC%20Guidance.pdf

Ecology. 2016. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Contingent Approval and Modifications to the Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 13, 2015. Washington State Department of Ecology. August 18.

Ecology. 2017. Letter from Dean Yasuda (Ecology) to Debbie Taege (Boeing), Ecology Final Decision Under Informal Dispute Resolution Regarding the Upland Feasibility Study (FS) Report and Ecology Selected Remedies for the Boeing Everett Site. Washington State Department of Ecology. July 20.

AECOM/LAI (AECOM and Landau Associates, Inc.). 2015. Feasibility Study for Upland Areas and Powder Mill Gulch, BCA Everett Plant. AECOM and Landau Associates, Inc. November 16.

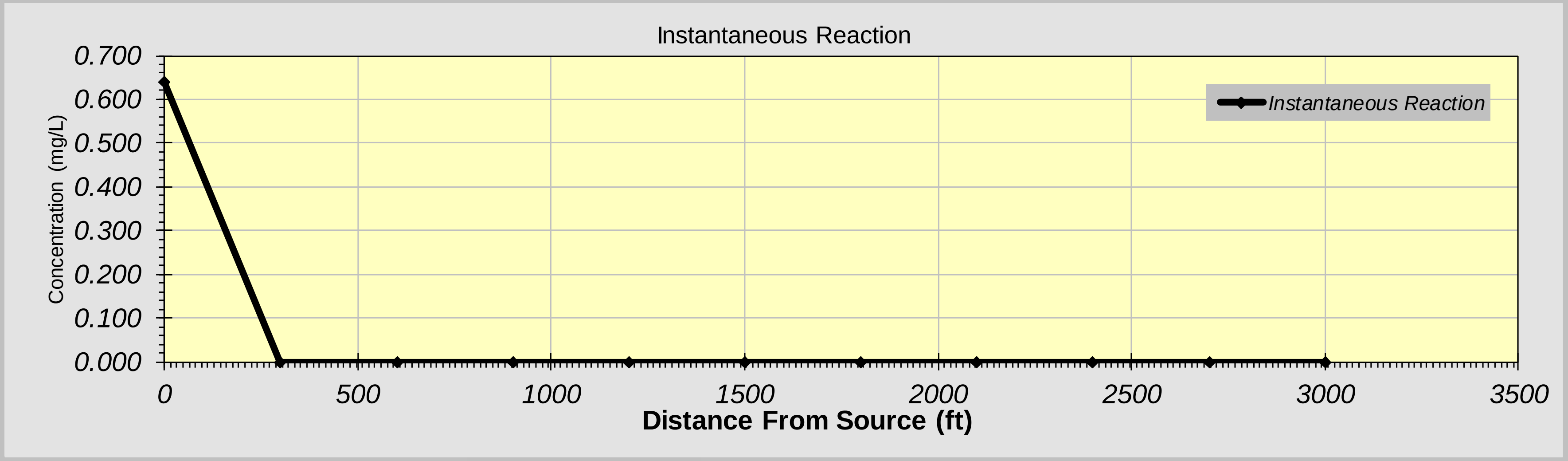
Newell, C.J., McCleod, R.K., and Gonzales, J.. 1996. BIOSCREEN Natural Attenuation Decision Support System, EPA/600/R-96/087. August. https://www.epa.gov/water-research/bioscreen-natural-attenuation-decision-support-system



Path: J:\Projects\B\Boeing\Everett CA 2015\09 General Support and Admin\H - GIS\maps\Presentation - Powder Mill Gulch Groundwater Plume Soil Sediment Surface Water _North South Complex_20150908.mxd Date: 9/14/2015

FIGURE 2. DISSOLVED TOLUENE CONCENTRATION ALONG PLUME CENTERLINE (0.64 mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	0.640	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

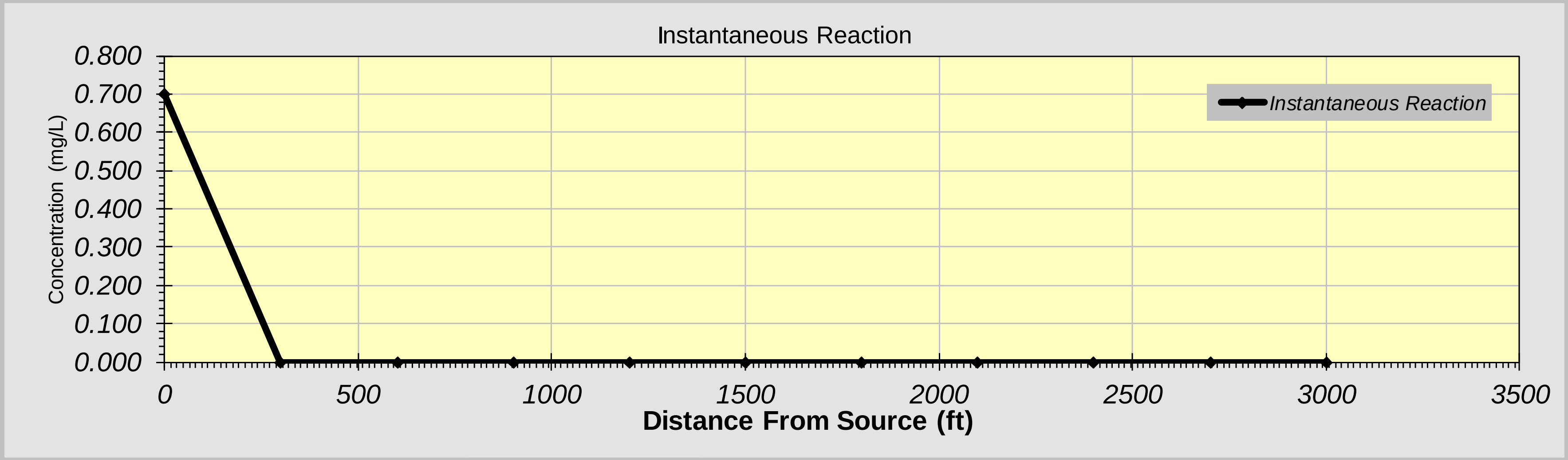


SimulationTime:

1000 Years

FIGURE 3. DISSOLVED ETHYLBENZNE CONCENTRATION ALONG PLUME CENTERLINE (0.7 mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	0.700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

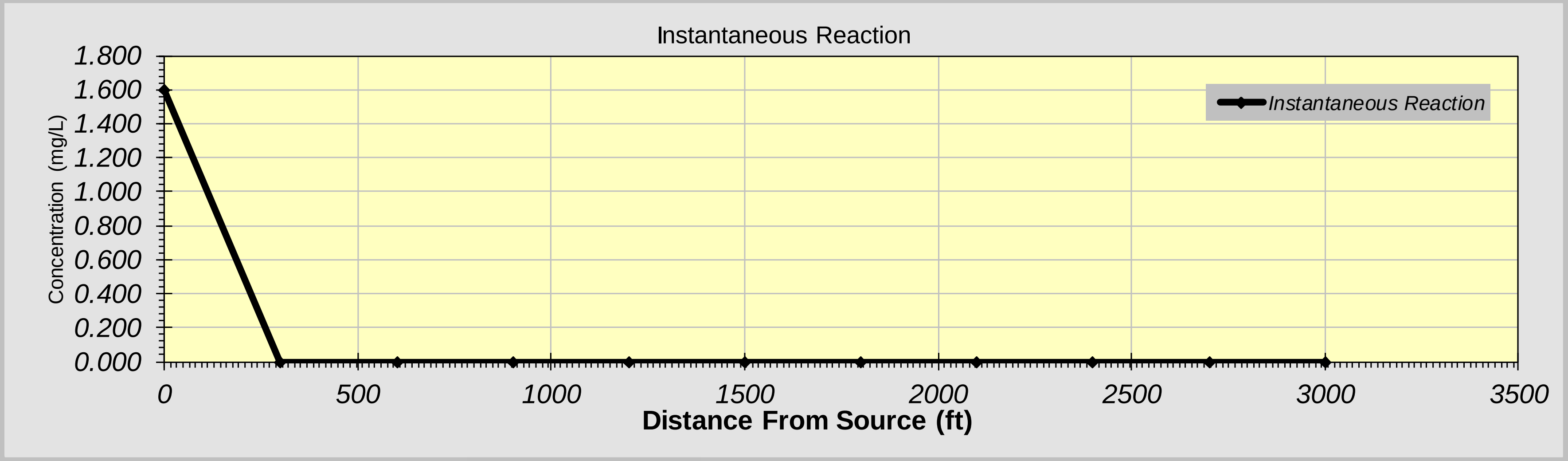


SimulationTime:

1000 Years

FIGURE 4. DISSOLVED XYLENE CONCENTRATION ALONG PLUME CENTERLINE (1.6 mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	1.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

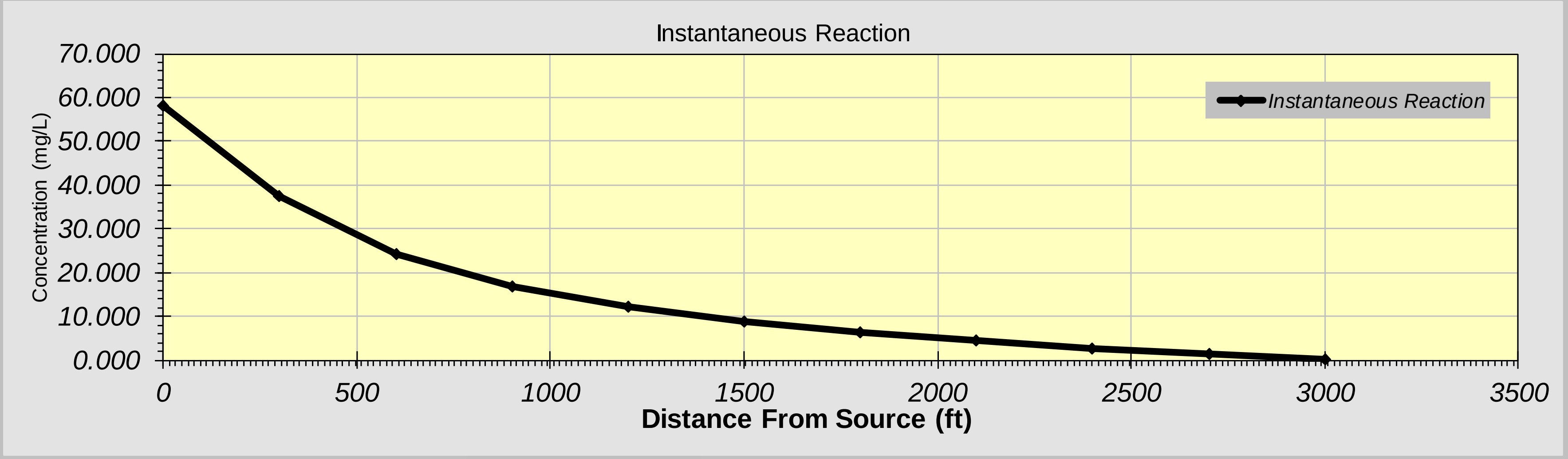


SimulationTime:

1000 Years

FIGURE 5. DISSOLVED TOLUENE MAXIMUM CONCENTRATION NOT LIKELY TO REACH PMC (58 mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	58.000	37.449	24.127	16.890	12.220	8.895	6.374	4.378	2.748	1.383	0.220

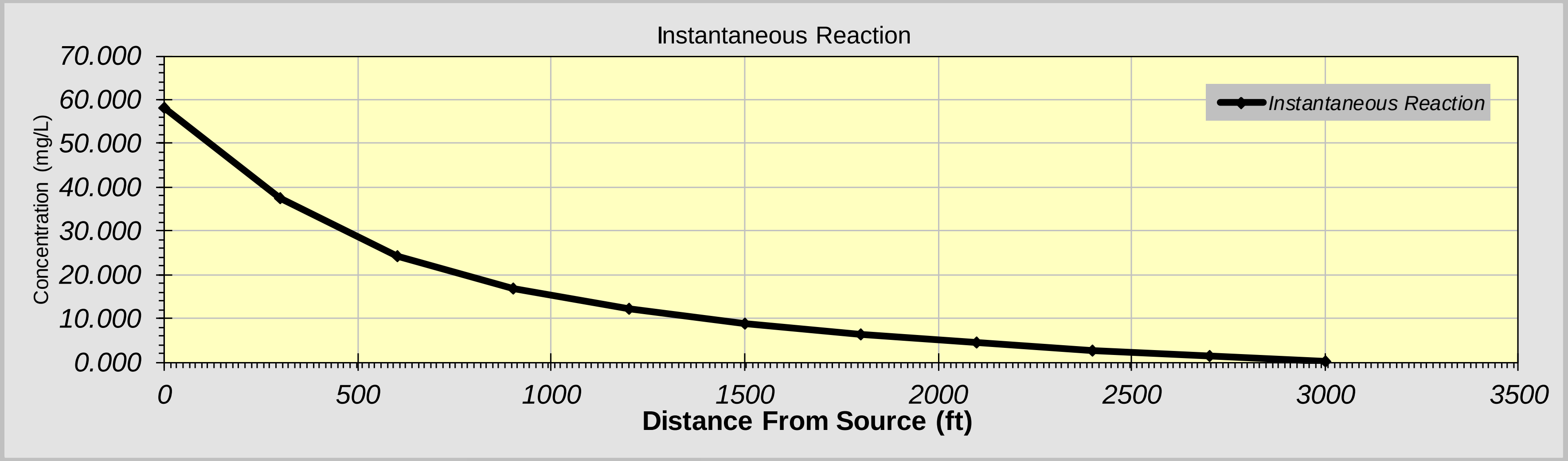


SimulationTime:

1000 Years

FIGURE 6. DISSOLVED ETHYLBEZENE MAXIMUM CONCENTRATION NOT LIKELY TO REACH PMC (58 mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	58.000	37.449	24.127	16.890	12.220	8.895	6.374	4.378	2.748	1.383	0.220



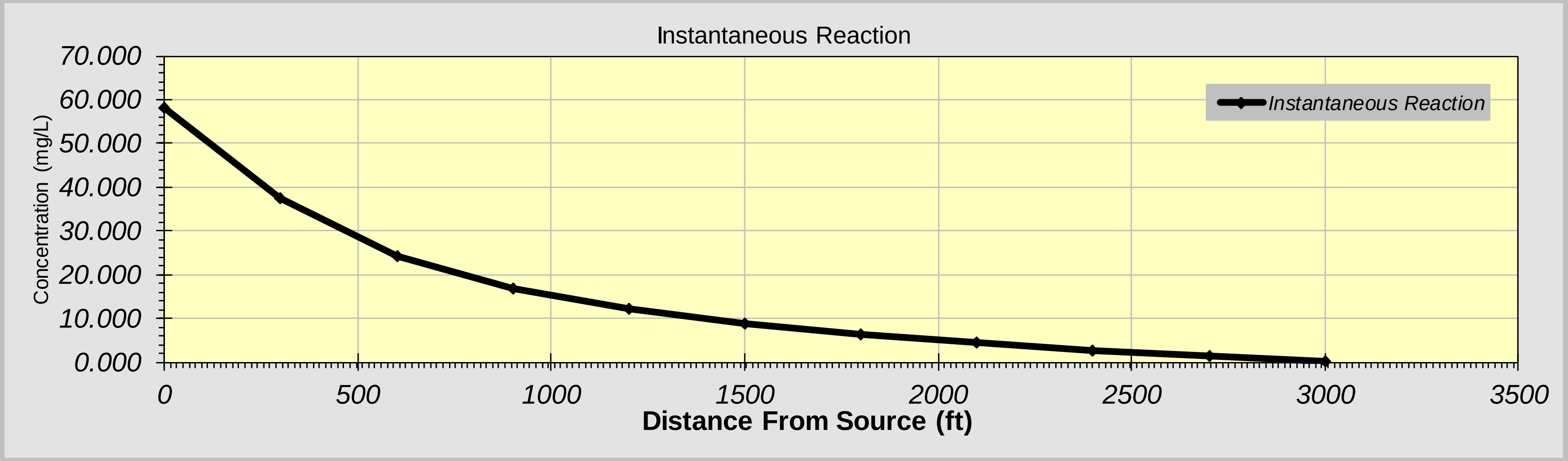
SimulationTime:

1000 Years

FIGURE 7. DISSOLVED XYLENE MAXIMUM CONCENTRATION NOT LIKELY TO REACH PMC (58 mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
Inst. Reaction	58.000	37.449	24.127	16.890	12.220	8.895	6.374	4.378	2.748	1.383	0.220



SimulationTime:

1000 Years

Attachment 3

Memorandum of Law

ATTACHMENT 3

FORMAL DISPUTE RESOLUTION SUBMISSION
BY BOEING TO ECOLOGY DATED SEPTEMBER 8, 2017

Boeing Memorandum of Law

Ecology's Application of Surface Water Quality
Standards to Groundwater and Soil at Everett is Unlawful

At the Boeing Everett industrial site, the Department of Ecology has determined that the adjusted drinking water level to be achieved for TCE in groundwater is 4 parts per billion. Ecology also has determined that in the adjacent Powder Mill Creek, surface water quality standards which protect fish and humans who might consume those fish require a level of TCE in the flowing stream that is three tenths of a part per billion, more than an order of magnitude lower. Boeing is a responsible company and takes no issue at this time with cleaning groundwater to the drinking water standard and surface water to a fish consumption standard. *But then the agency takes a step too far*. It seeks to take the entirely separate standards for regulation of groundwater and the regulation of surface water and combine them in a manner that no law or reasonable scientific concept ever intended them to be combined. The Ecology team seeks to take the legal level it is requiring in the stream and shift it upland a distance of two to ten football fields into two media – groundwater and soil – as to which surface water standards do not apply and which, in fact, have their own regulatory standards. The position is wrong and should be reversed.

Ecology's attempt to assign the 0.3 micrograms per liter surface water quality standard as the cleanup level for groundwater and to develop the level for soil at Everett is wrong on just about every level. It violates Washington State regulations under MTCA. It upends Washington State groundwater standards. It violates Washington State surface water quality and Clean Water Act standards. It violates federal surface water quality and Clean Water Act standards. It is contrary to the requirements of the federal promulgation of a new Washington surface WQS for TCE of 0.3 parts per billion. It violates public positions that this very Department of Ecology has taken in support of the recent Clean Water Rule which demonstrate that the Department knows and insists that groundwater and surface water are very different. It violates scientific principles showing clear differences between groundwater and surface water. And it violates clear pronouncements from Ecology that no surface water standard would be applied throughout a groundwater plume hundreds of yards away from the surface stream, but that instead it is the stream itself where compliance is mandatory. The illegalities sought here are severe, rendering the present course arbitrary, capricious, and contrary to law.

If Ecology were to unlawfully apply the surface water quality standards as cleanup levels for Site soil and groundwater, it would need to set the point of compliance in the surface water. This is not "conditional" or discretionary. It is mandatory under surface water quality law. Moreover, even if it were a "conditional" point of compliance in the surface water where the groundwater meets it, Boeing has met those MTCA requirements also. Requiring Boeing to achieve surface water standards at points of compliance in different media two to ten football fields from Powder Mill Creek is something Ecology may not lawfully require.

I. Ecology Rationally Rejected SWQS as Cleanup Levels in Upland Groundwater or Soil Under MTCA

When it promulgated MTCA rules, Ecology was presented with the comment that surface water quality standards ("SWQS") should apply in surface water and not in upland[1] groundwater or soil. "To require meeting surface water criteria *within the groundwater* would result in needlessly expensive cleanup actions with no overall benefit to human health or the aquatic environment."[2] Ecology concluded that "the above arguments [are] *very persuasive*" and based upon the persuasive arguments, even the very concept of monitoring upland throughout a groundwater plume for surface water standards was rejected by the agency:

> [W]here [groundwater] cleanup levels are based on protecting nearby surface water, compliance with [the surface water quality criteria,] will generally be based on surface water monitoring performed as close as possible to the groundwater/surface water interface . . . ," and *not in the groundwater*.[3]

Below we will show that surface water quality standards are a joint federal-state enterprise defined by the federal Clean Water Act and that CERCLA standards also guide MTCA standards. For now, we simply note that EPA agrees on the above point with Ecology: "where the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards (such as State WQSs . . .) that may be [the cleanup level] *for the surface water*."[4]

Consistent with the Clean Water Act ("CWA"), which will be discussed in detail below, MTCA's standards create plain definitions and distinctions as between surface water and groundwater. *See* WAC 173-340-200 (defining surface water and groundwater separately as well as pursuant to separate programs under WAC 173-201A-020 (surface water) and WAC 173-200-020(12) (groundwater)).

The reason MTCA creates the clear distinction between surface and ground waters is found, naturally, in the regulations on surface and ground waters themselves. Washington's state surface WQS is founded upon chapter 173-201A WAC. Ecology and EPA limit the application of the Washington SWQS *to surface water*. By contrast, applying the SWQS to groundwater at Everett would result in *de facto* rulemaking and an unlawful application of state law. Chapter 173-201A WAC, which sets forth the "water quality standards for surface waters of the state," limits its application to "surface waters," defined as "lakes, rivers, ponds, streams, inland waters, saltwaters … and all other surface waters and water courses within the jurisdiction of the state of Washington." WAC 173-201A-020. It distinguishes between groundwater and surface water, making clear that the definition of surface water, and thus the SWQS, do not extend to groundwater. *See* WAC 173-201A-020 (defining "ground water exchange" as the "discharge and recharge of ground water [*i.e.*, an aquifer, seeps or springs] to surface water."). Chapter 173-200 WAC, which sets forth

---

[1] We use "upland" herein for its dictionary meaning, and not as the specific "Upland" area used in this proceeding.
[2] Ecology, Responsiveness Summary for the Amendments to MTCA Cleanup Regulation Chapter 173-340 WAC, ("Responsiveness Summary") at 202 (1991) (emphasis added).
[3] *Id*. (Emphasis added).
[4] *See* ARARs Q's & A's: Compliance With Federal Water Quality Criteria (June 1990).

Washington's "water quality standards for groundwaters of the state of Washington" confirms that groundwater is distinct from surface water, and outside the scope of the SWQS. WAC 173-200-020 (defining groundwater as "water in a saturated zone or stratum beneath the surface of land or below a surface water body.") These distinct and separate water quality standards impose different requirements, as described below. By applying the SWQS in groundwater, Ecology's actions are unlawful under state law.

If Washington's SWQS had been written to apply to groundwater, there would have been no reason for Washington to promulgate separate groundwater water quality standards. But consistent with EPA's recommendation,[5] Ecology determined that the two media warranted separate regulatory regimes and requirements. As examples:

- Washington's water quality standards for surface waters protect the waters for designated uses including the propagation of fish and wildlife, recreation, aesthetic values and water supply uses. WAC 173-201A-200. In contrast, Washington's water quality standards for groundwater are designed to protect groundwater largely for drinking water. WAC 173-200-040(1).

- Washington's water quality standards for surface waters must ensure that the surface waters do not exceed the federally-approved surface water quality criteria for toxic substances, *see* WAC 173-201A-240 (*e.g.*, 0.3 µg/L for TCE), whereas Washington's groundwater quality standards for groundwater ensure that the groundwater does not exceed the non-zero maximum contaminant levels for the protection of drinking water (an adjusted 4.0 µg/l for TCE). WAC 173-200-040(2).

- The point of compliance under Washington's surface water quality standards is described as a "continuing surveillance program" in which Ecology inspects the discharge treatment and control facilities, monitors the discharge characteristics, and monitors the receiving water, WAC 173-201A-520, while the point of compliance under Washington's groundwater water quality standards is "throughout the site from the uppermost level of the saturated zone extending vertically to the lowest depth that could potentially be affected by [site, area, facility, structure, vehicle, installation, or discharge which may produce pollution]." WAC 173-200-020(1), 060(1)(b).

Yet perhaps the most pertinent distinction is that Washington law enforces the surface water and groundwater quality standards under separate permitting regimes. This is also the most obvious distinction between Washington law and the CWA in that Washington law requires a non-CWA permit for discharges into underground waters, whereas the CWA is confined to discharges that affect surface waters. Ecology divides its water quality permitting programs largely on the basis of whether the discharge of pollutants is to surface water or to underground waters. *Compare* WAC 173-220-020 (NPDES permits for discharges to surface water) *with* WAC 173-221A-010 (Waste

[5] Although not permitted pursuant to the CWA, EPA recommended that States use separate authority to adopt water quality standards to protect underground waters of the State. *WQS and Underground Waters Guidance* at 2 (citing *EPA Guidelines for State and Areawide Water Quality Management Program Development: Chapter 5, Water Quality Standards,* November, 1976).

Discharge permits under state law for other waters of the state, including groundwater).

Given these differences, it is improper for Ecology to upend its own regulatory landscape by choosing not to apply its own groundwater quality standards to groundwater cleanups, *see* WAC 173-200-010, and instead to import separate water quality standards expressly designed for surface water. *See* WAC 173-340-720(3)(b)iv), - 720(4)(b)(iv). To the extent any water quality standards are applied under MTCA to groundwater, it should be those which Washington specifically promulgated for the protection of groundwater, and the attendant non-zero maximum contaminant level for the protection of drinking water (an adjusted 4.0 µg/l for TCE), WAC 173-200-040(2), consistent with Boeing's groundwater cleanup level proposal here.

II. SWQS are not ARARs with Respect to Groundwater or Soil at Everett.

For groundwater at Everett, there is a legally promulgated MCL for TCE in drinking water (adjusted under Ecology rules) and where such MCL is applied, under MTCA, surface water standards may not be substituted for the applicable regulation. MTCA requires that cleanup actions comply with legally applicable state and federal laws and regulations, as well as other requirements determined to be relevant *and* appropriate ("ARAR"). RCW 70.105D.030(2(e); WAC 173-340-710(1). Washington's ARAR regulations and those under CERCLA are virtually identical;[6] therefore, CERCLA guidance assists in interpreting Washington's ARAR requirements. *See Bird-Johnson Corp. v. Dana Corp.*, 119 Wn.2d 423, 427 (1992). CERCLA section 121(d)(2)(A) specifically states that the CWA is a source of requirements that can be ARARs (provided, of course, that they are either applicable or relevant and appropriate). It states that remedial actions should at least achieve "water quality criteria established under . . . the Clean Water Act, *where such … criteria are relevant and appropriate* under the circumstances of the release or threatened release." 42 U.S.C. § 9621(d)(2)(A) (emphasis added).

Legally applicable requirements under MTCA are "those cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations adopted under state or federal law that specifically address a hazardous substance, cleanup action, location or other circumstances at the site" WAC 173-340-200; 173-340-710(3). "A requirement is applicable if the specific terms (or "jurisdictional prerequisites") of the law or regulation directly address the circumstances at a site."[7] We establish above and below that the SWQS are not legally applicable in groundwater or soil; they are legally applicable in surface water bodies only. Therefore, the SWQS mightonly have been ARARs if "relevant and appropriate" at the Everett site as applied to upland groundwater and soil. They are not.

"Relevant and appropriate" requirements are "those cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that, while not legally applicable to the hazardous substance, cleanup action, location, or other circumstances at a site, *address problems or situations sufficiently similar to those encountered at*

[6] Responsiveness Summary at 177.

[7] CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006 at 1-5 (Aug. 1988) ("Manual"). In 1988 EPA marked this manual as "interim," and "draft," but it was and remains authoritative and is listed by EPA as a "significant guidance document." *See* EPA's current model for Remedial Design/Remedial Action Statement of Work, https://www.epa.gov/sites/production/files/2015-10/rdra-cd-sow-093015.docx; and, http://www.epaarchive.cc/node/11209.html.

the site that their use is well suited to the particular site." WAC 173-340-200; 173-340-710(4). Among the criteria used in determining whether a requirement is "relevant and appropriate" are, in relevant part:

- "Whether the purpose for which the statute or regulations under which the requirement was created is similar to the purpose of the cleanup action;"
- "Whether the media regulated or affected by the requirement is similar to the media contaminated or affected at the site;"

WAC 173-340-710(4) (a), (b), (d).

The SWQS are plainly not "relevant and appropriate" as the groundwater or soil cleanup levels at the Everett site. In analyzing whether the use of the requirement in the remedial action context is consistent with its purpose, Ecology must construe the purpose of a program narrowly.[8] EPA guidance emphasizes that requirements that are not applicable must be both relevant *and* appropriate, stating that "a requirement may be relevant but not appropriate for [a] site-specific situation."[9] "A requirement may also be found relevant but not appropriate *when another requirement is available that has been designed to apply to that specific situation, reflecting an explicit decision about the requirements appropriate to that situation.*"[10] The specific requirement here for groundwater is the adjusted groundwater MCL with its aspirational intended drinking water use[11], meaning MTCA cannot import the SWQS.

Next, the purpose of the SWQS "is to establish water quality standards for surface waters of the state of Washington," WAC 173-201A-010(1)(a), and the media to be regulated is surface water, not ground water. As explained previously, "[b]ased on [the surface waterbody's] use designations, numeric and narrative criteria are assigned to a water body to protect the existing and designated uses." *Id*. 010(1)(1)(b). Surface waters of the state include lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands, and all other surface waters and water courses within the jurisdiction of the state of Washington"; surface water is not groundwater or soil, and the SWQS are only relevant as to whether the surface water meets the SWQS. Indeed,

> [w]here groundwater flows naturally into surface water, the ground-water remediation should be <u>*designed so that the receiving surface water body will be able to meet any ambient water-quality standards*</u> (such as State WQS…) that may be ARARs for the surface water. This means that the [SWQS] should be considered when establishing cleanup levels for the ground water at those sites, but they are not necessarily ARARs for the cleanup of ground water.[12]

The Supreme Court of the State of Washington has made clear that surface water standards are not designed to create standards for other media but instead are designed to ensure that contaminants in

---

[8] Manual at 1-65.
[9] Manual at 1-10.
[10] *See also* Manual at 1-68 (emphasis added).
[11] Manual at 1-16 ("In determining the applicability or relevance and appropriateness of water quality criteria, the most important factors to consider are the designated uses of the water and the purposes for which the potential requirements are intended."). S*ee also* CERCLA §121(d)(2)(B)(i).
[12] EPA, ARARs Q's and A's: Compliance with Federal Water Quality Criteria (1990) (emphasis added).

other media that might leach into surface waters do not "lead to water quality violations." *Port of Seattle v. Pollution Control Hearings Board*, 151 Wn.2d 568, 622 (2004). In *Port of Seattle*, the Supreme Court reviewed whether Ecology had properly used MTCA cleanup standards when it determined that a surface water fill project should receive a certificate of compliance under the Clean Water Act showing that the fill would not degrade water quality standards. *Id.* at 579. The question was whether the fill would *lead to* water quality standard violations, not whether the fill itself met those surface water criteria. *Id.* at 622. In addition, where the Pollution Control Hearings Board determined to apply a natural background level for waters as a way to determine what level of soil contamination (in the fill) was to be allowed, the Court reversed, making clear that the medium matters under the law: "*that rule* applies to natural levels in waters of the state, not in soil." *Id.* at 621 (emphasis added). By analogy, here, Ecology may not transfer an SWQS to groundwater or soil, and the highest court in the state would not hesitate to reverse such determination.

Finally, where, as here, the groundwater's designated use is as an aspirational future source of drinking water,

> *[w]ater quality criteria without modification are not relevant and appropriate in selecting cleanup levels in ground water*, since consumption of contaminated fish is not a concern. . . .
>
> MCLs represent the level of quality EPA has determined to be safe for drinking and are generally relevant and appropriate for ground water that is or may be used for drinking and for surface water designated as a current or potential drinking water supply. Therefore, *when a promulgated MCL exists, the water quality criteria for that pollutant would not be relevant and appropriate.*[13]

Accordingly, the SWQS are not applicable, relevant or appropriate in the groundwater or soil at the Everett Site.

III. The Clean Water Act is, by Design, a Surface Water Statute.

a. <u>The federal statute created the program and defines it</u>.

The entire preceding discussion showing that Washington State regulates groundwater and surface water through separate rubrics and that MTCA and CERCLA apply these ARARs similarly for waste cleanups is founded upon fundamental legislative and scientific concepts that emerge beginning with the federal Clean Water Act of 1972. The Act "determined the basic structure . . . for regulating pollutant discharges *into waters of the United States*," including the promulgation of the surface water quality standards ("SWQS" or "standards").[14] Congress limited the objective of

---

[13] Manual at 3-10 (emphasis added); *see also* EPA, Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action at 5.4, & n. 10. (cleanup level should generally be based on drinking water use if the aquifer is considered by EPA or the State to be a reasonably expected future source of drinking water, using the federal non-zero maximum contaminant level (MCL) established under the Safe Drinking Water Act or potentially a more stringent state MCL, if applicable).

[14] See Water Quality Standards Regulatory Revisions, Final Rule, 80 Fed. Reg. 51019, 51021 (Aug. 1, 2015) (emphasis added).

the CWA ‘‘to restor[ing] and maintain[ing] the chemical, physical, and biological integrity *of the Nation's waters.*'' 33 U.S.C. § 1301 (emphasis added).[15]

The CWA establishes the basis and application for the SWQS.[16] "CWA section 303(c) (33 U.S.C. 1313(c)) directs states to adopt [water quality standards] *for their waters subject to the CWA.*" [17] CWA section 303 alsoembodies the Act's cooperative federalism approach. Sections 303(a) through (c) of the Act direct the States, with EPA's oversight and approval or disapproval, to adopt and maintain SWQS for the state's surface waters. *See* 33 U.S.C. §§ 1313(a)-(c). States must designate the use or uses for which each surface water body is to be protected (*e.g*., fishing, swimming) and adopt criteria that represent surface water quality sufficient to support the designated use. *Id.* § 1313(c)(2)(A). In setting SWQS, States are to consider their surface waters' "use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and . . . their use and value for navigation." *Id.*

EPA oversees the States' implementation of the statutory scheme, and approves or disapproves the States' proposed water quality standards and promulgates SWQS for a State where necessary. *Id.* § 1313(c)(3), (4). "The state water quality standards—promulgated by the States with substantial guidance from EPA and approved by the Agency—are part of the *federal law of pollution control*." *Arizona v. Oklahoma*, 503 U.S. 91, 110 (1992) (emphasis in original); *Umatilla Waterquality Prot. Ass'n v. Smith Frozen Foods*, 962 F. Supp. 1312, 1320 (D. Or. 1997) ("The U.S. Supreme Court has noted that state standards implementing the CWA 'are part of the federal law of water pollution control' and 'have a federal character.'") Although states can apply stricter standards or limitations on their surface waters, CWA section 510, 33 U.S.C. § 1310, they cannot apply CWA surface water quality standards in non-jurisdictional media, such as groundwater and soil, and EPA therefore permits these to be regulated under separately developed standards if they are to be regulated by the states.[18] *See Northern Plains Resource Council v. Fidelity Exploration and Development Company,* 325 F.3d 1155, 1164 (9th Cir. 2003) ("the EPA cannot delegate to a state more authority than the EPA has under the CWA"). By contrast, in this instance the federal EPA required a more stringent SWQS under federal CWA principles than Washington itself sought. Because Ecology operated under the federal CWA and its implementing state law in adopting its SWQS, Ecology cannot apply its CWA SWQS as MTCA cleanup levels in groundwater, much less throughout a groundwater plume or soil.

b. Groundwater is inherently different than surface water.

As an initial matter, groundwater and surface water are fundamentally different. First, as EPA notes, because of its unique geologic and geochemical factors that influence its movement and characteristics, groundwater is a very complex resource to understand and address. Once contaminated, groundwater is difficult to monitor and expensive to clean. Next, groundwater generally moves very slowly in comparison with surface water. Formations containing layers of consolidated clays with little fracturing allow groundwater to move as slowly as a few inches a year.

---

[15] *See als*o 80 Fed. Reg at 51019, 51021.
[16] *Id*.
[17] Revision of Certain Federal Water Quality Criteria Applicable to Washington, Final Rule, 81 Fed. Reg. 85417, 85419 (Nov. 28, 2016) (emphasis added).
[18] *See* Technical Support Document for the Clean Water Rule: Waters of the United States at 13 (May 27, 2015) ("Technical Support Document").

But in strata containing unconsolidated sand and gravel, groundwater moves up to 800 feet or more a year. These slow rates do not allow contaminants to spread or mix quickly. [19]

The contaminants in groundwater—unlike those in surface water—generally move in a plume with relatively little mixing or dispersion. These plumes move slowly and are typically present for many years—sometimes for decades or longer. Some pollutants dissolve into and essentially become part of the groundwater; other pollutants are simply carried along in suspension with the groundwater.[20] During their journey through an aquifer, the processes of "natural attenuation" attack dissolved or suspended pollutants and may alter their chemical character, biologically destroy them, physically remove them, or dilute them.[21] Surface water standards cannot rationally be imported hundreds of yards upland into a groundwater plume that is subject to immutable physical and biological forces. These forces deliver water of a different quality to the surface water than that present underground at the points of contamination upland.

Due in part to the inherent differences between surface water and groundwater, Congress did not stretch federal jurisdiction under the CWA so far as to encompass underground waters. This is irrefutable under the language, structure and legislative history of the Act.

c. Congress specifically did not intend the CWA and associated <u>surface water quality standards to apply to groundwater</u>.

Both the plain language of the CWA and the legislative history provide that Congress did not intend for groundwater to fall within the purview of the CWA water quality standards. First, the CWA shows that when Congress intended for certain provisions of the statute to apply to groundwater, it stated so explicitly. For example, the CWA identifies groundwater as distinct and separate from "navigable waters," in those portions of the Act dealing with EPA program development as well as the study of water pollution. *See, e.g.*, 33 U.S.C. §§ 1252(a) (water pollution plan development and funding "for preventing, reducing, or eliminating the pollution of the *navigable waters* and *ground waters* and improving the sanitary condition of *surface* and *underground waters*") and 1254(a) (requirement for "water quality surveillance system for the purpose of monitoring the quality of the *navigable waters and ground waters*") (emphases added).

But in the provisions for SWQS and discharge permitting, only the phrase "navigable waters" is used, and the term groundwater is noticeably absent. *See* 33 U.S.C. §§ 1312(a) (water quality effluent limitations for "navigable waters"), 1313(a)(c)(2)(A) ("water quality standard shall consist of the designated uses of the navigable waters . . . and the water quality criteria for such waters based upon such uses."), and 1342(a)(4) (discussing "permits for discharges into the navigable waters") "[W]here Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion." *Russello v. U.S.*, 464 U.S. 16, 23 (1983) (citation omitted). Thus, "[i]f the terms were synonymous," or subject to the same requirements,

[19] EPA, Overview of State Ground-Water Program Summaries at 1, 3-4 (1988).
[20] *See generally* C. W. Fetter, Contaminant Hydrogeology 2-10 (Prentice Hall 1993) (discussing the types of contaminants typically introduced into groundwater).
[21] *See generally* EPA, Use of Monitored Natural Attenuation at superfund, RCRA Corrective Action, and Underground Storage Tank Sites, Office of Solid Waste and Emergency Response Directive 9200.4-17P (April 21, 1999).

"it would not have been necessary for Congress to make distinct references to groundwater and navigable water." *Wash. Wilderness Coal. v. Hecla Min. Co*, 870 F. Supp. 983, 989 (E.D.Wa. 1994).

That Congress did not intend to subject groundwater to the SWQS is also supported by the legislative history. While the CWA was being drafted, there were numerous attempts by members of Congress to include groundwater within the permitting and water quality protection requirements of the CWA. Those attempts failed:

> Several bills pending before the Committee provided authority to establish Federally approved standards for groundwaters which permeate rock, soil and other surface formations. *Because the jurisdiction regarding groundwaters is so complex and varied from State to State, the Committee did not adopt the recommendation.*[22]

Similarly, the House overwhelmingly rejected an amendment that would have regulated groundwater within the permitting and enforcement sections of the bill.[23] The rejection of this proposed amendment "strongly militates against a judgment that Congress intended a result that it expressly declined to enact." *See, e.g., Kelley v. Mich.*, 618 F. Supp. 1103, 1107 (S.D. Mich. 1985) ("the unmistakably clear legislative history . . . demonstrates that Congress did not intend the Clean Water Act to extend federal regulatory and enforcement authority over groundwater contamination").

In opposing the House amendment, Rep. Clausen, a sponsor of the House bill, highlighted the difference between surface water and groundwater, and the absence of information necessary to regulate groundwater under the CWA, and, in turn, under the federally-mandated SWQS:

> [I]t was determined by the committee that *there was not sufficient information on ground waters to justify the types of controls that are required for navigable waters.*[24]

Accordingly, Congress limited EPA's—and in turn, Ecology's—jurisdiction to apply the Washington SWQS, which are adopted pursuant to the CWA, to the state's surface waters. *See* Section 502(7), 33 U.S.C. § 1362(7) (jurisdiction limited to "navigable waters," defined as "the waters of the United States.").

---

[22] S. Rep. No. 92-414, 1st Sess. 73 (1971), 1971 WL 11307, at *3739 (emphasis added).
[23] *See* 118 Cong. Rec. 10666-67 (1972) (statement of Rep. Aspin).
[24] 118 Cong. Rec. 10,667 (1972) (remarks of Rep. Clausen) (emphasis added).

d. Adhering to Congress's limits on regulatory jurisdiction under the CWA, EPA has consistently emphasized that SWQS promulgated under the CWA apply only in surface water bodies, and not in groundwater.

EPA has itself repeatedly emphasized that it "has never interpreted [groundwater] to be a 'water of the United States' under the CWA,"[25] and that the SWQS, promulgated under the CWA, do not extend to groundwater.

First, in its Notice of Proposed Rulemaking on the SWQS, EPA provided an explanation of a water quality standard, confirming that the standards apply only to bodies of surface water:

> *A numerical concentration limit is in effect an ambient standard; it sets a maximum pollutant concentration level which is not to be exceeded in a particular water body.* An example of a water quality standard under the act might be: in the A river, which is designated for fishing and swimming (use), there shall be no more than X micrograms of lead per liter of water (criterion) . . . .[26]

Consistent with this description, EPA has reiterated its view in guidance, grounded in the CWA's legislative history, that "[surface] water quality standards [do not apply] to an underground aquifer merely because the aquifer has a clear connection to a surface water body."[27] It is only "where a surface stream has some underground segments,"[28] *plus*, for the SWQS to apply, "*the subterranean component must be sufficiently stream-like so as to possibly allow the passage of fish and other aquatic organisms from a surface segment of the stream into the underground segment*."[29] No fish are swimming in the upland groundwater at Everett.

Similarly, in the 2015 Clean Water Rule ("Rule"), its Preamble, and in EPA's response to Comments on the Rule, EPA confirmed its longstanding and consistent interpretation that groundwater is not covered by SWQS.[30] For example, the final rule provides an explicit exclusion for groundwater, including groundwater "drained through subsurface drainage systems,"[31] and the Rule's Preamble explicitly states that "neither shallow subsurface connections nor any type of groundwater, shallow or deep, are ever jurisdictional."[32]

Most relevant to Ecology's attempt here to apply SWQS to groundwater, EPA pronounced that groundwater "is not jurisdictional even when the [groundwater] connects directly or through another

[25] 80 Fed. Reg. 13453, 37073.
[26] Water Quality Standards, Statement of Current Policy and Advance Notice of Proposed Rulemaking, 43 Fed. Reg. 29588, 29589 (July 10, 1978) (footnote excluded) (emphasis added).
[27] Memo. from J. Bernstein, General Counsel, EPA, to Conrad Simon, Director, Water Division, Region II, re Water Quality Standards and Underground Waters, at 3 (May 29, 1979) ("WQS and Underground Waters Guidance").
[28] *Id.* at 3 (emphasis added); *see also* Clean Water Rule Response to Comments – Topic 7: Features and Waters Not Jurisdictional at 224.
[29] Amendments to the Water Quality Standards Regulations that Pertain to Standards on Indian Reservations, Final Rule, 56 Fed. Reg. 64876, 64892 (Dec. 12, 1991), 1991 WL 260534, at * 64892 (emphasis added).
[30] *See* Final Clean Water Rule: Definition of "Waters of the United States,", 80 Fed. Reg. 13435, 37054, 37055, 37060, 37073, 37096, 37099- 37100 (June 29, 2015) ("Clean Water Rule").
[31] Clean Water Rule, 80 Fed. Reg. at 37054, 37104.
[32] Clean Water Rule Response to Comments – Topic 7: Features and Waters Not Jurisdictional at 226; *see also* Clean Water Rule, 80 Fed. Reg. at 37090.

water to a traditional navigable water, interstate water, or the territorial seas." In addition to stream-like underground segments of streams, described above, CWA jurisdiction, and the associated SWQS, may apply to "surface expressions of groundwater , . . . where groundwater emerges on the surface and becomes baseflow in streams or spring fed ponds."[33] At that point, "*when groundwater emerges on the surface, it is surface water, and the resulting water feature is potentially regulated under the Clean Water Act.*"[34]

Under EPA's clear policy, SWQS (and associated criteria) do not apply in groundwater, and to the extent they apply to groundwater at all, that application is limited to the point (1) where groundwater surfaces and becomes part of a connected surface waterbody; or (2) to "sufficiently-stream-like" underground segments of surface waters. What Ecology attempts to do here—apply SWQS in groundwater and in soil for the protection of groundwater—denies this clear policy.

e. EPA's clarifications in defense of the 2015 Clean Water Rule underscore the requirement of groundwater exclusion.

Soon after EPA promulgated the Clean Water Rule, eighteen states and other parties challenged the Rule in the court of appeals largely on the basis that the rule improperly expanded EPA's regulatory jurisdiction over waters under the CWA. *See In re EPA*, 803 F.3d 804, 806 (6th Cir. 2015).[35] In its documents and briefs in defense of the Rule, EPA underscored the validity of the Rule, its commitment to the longstanding policy against regulating groundwater under the CWA, and the propriety of the groundwater exclusion:

- "Each of the Rule's exclusions is well-supported. . . . The *groundwater exclusion* reflects the Agencies' permissible and long-established interpretation of the Act and its legislative history."[36]

---

[33] Clean Water Rule, 80 Fed. Reg. at 37096, 37100.

[34] Clean Water Rule Response to Comments – Topic 7: Features and Waters Not Jurisdictional at 224; *see also id.* at 231 ("While groundwater is exempted from this rule, once it is pumped into surface drainage ditches or into a pond/reservoir, the surface feature itself could be subject to jurisdiction.").

[35] The cases were consolidated in the Sixth Circuit, which issued a stay of the Clean Water Rule. *See In re EPA*, 803 F.3d 804, 2015 WL 5893814 (6th Cir. 2015); *see also* Exec. Order No. 13778, 82 FR 12497, 2017 WL 819672 (Feb. 28, 2017) (requiring the agencies to review the Rule to "consider interpreting the term 'navigable waters' . . . in a manner consistent with the opinion of Justice Scalia in *Rapanos v. United States*, 547 U.S. 715[, 126 S.Ct. 2208, 165 L.Ed.2d 159] (2006)," which limited EPA's jurisdiction over "navigable waters.") In response, EPA published a proposed rule on July 27, 2017, to (1) rescind the Rule, (2) recodify the regulations that existed before the Rule, and (3) pursue rulemaking in which the agencies would evaluate the definition of "waters of the United States," further narrowing that term. Definition of "Waters of the United States"—Recodification of Pre-Existing Rules, 82 Fed. Reg. 34899, 34899 (July 27, 2017). Because the Rule's groundwater exclusion merely codified an exclusion implemented by the agencies, and mandated by Congress, prior to the Clean Water Rule consistent with "Supreme Court decisions and longstanding practice," reverting to the pre-Rule definition and any subsequent narrowing of the definition will just reinforce the breadth of the groundwater exclusion. *See Rapanos*, 547 U.S. at 739 ("In sum, on its only plausible interpretation, the phrase 'the waters of the United States' includes only those relatively permanent, standing or continuously flowing bodies of water 'forming geographic features' that are described in ordinary parlance as 'streams[,] . . . oceans, rivers, [and] lakes.).

[36] Br. for Resp. EPA at 38, *Murray Energy Corp., v. EPA*, 803 F.3d 804, 2017 WL 372073 (2017) (No. 15-3751 and consolidated cases).

- "Consistent with the CWA's limited and isolated references to groundwater, its legislative history, and EPA's longstanding interpretation, numerous courts have concluded that Congress did not intend the term "waters of the United States" to include groundwater."[37]

f. Washington State Supported EPA's Clean Water Rule, including its Groundwater Exclusion, in Litigation Challenging the Clean Water Rule.

Washington was not one of the states that challenged the Rule. To the contrary, Washington intervened in support of the Rule. In its Motion to Intervene, Washington explained the significance of the Clean Water Rule: "The Rule defines the term 'waters of the United States' as used in the federal Clean Water Act, 33 U.S.C. § 1251 *et seq.,* thereby *establishing the scope of protection under the Act*."[38] In emphasizing the validity of the Rule, Washington recognized that the Rule "*allows [Washington] to avoid having to impose costly, disproportionate, and economically harmful limits on instate pollution sources to waters within [its] borders . . . .*"[39] Washington also recognized that "the Act's pollution prohibition and NPDES program apply only to discharges into the "waters of the United States.'"[40] Fundamental to the issue at hand, Washington acknowledged:

> *The Act requires states to set water quality standards for [surface] waters within their borders . . . . But states can only protect their waters by performing these functions when the involved waters are deemed "waters of the United States."*[41]

In supporting the Rule and in its response to comments on its own cleanup rules, Washington accepted the groundwater exclusion and the prohibition against applying water quality criteria in "groundwater" unless and until there are "surface expressions of groundwater, . . . such as where groundwater emerges on the surface and becomes baseflow in streams or spring fed ponds."[42] It is wholly arbitrary and unlawful for Washington to now take the opposite position and attempt to apply SWQS as the cleanup levels for upland groundwater and soil at Everett.

g. SWQS do not apply to groundwater even in limited instances where groundwaters have a "direct hydrological connection with surface water."

Although EPA has long maintained that the CWA does not generally apply to groundwater, EPA has recognized a limited exception where groundwater has certain direct hydrological connections to surface water, the CWA could be applicable to discharges to surface water via groundwater *in the context of NPDES permitting* but not in the SWQS context.

---

[37] *Id.* at 144 (citing and giving as just a few examples: *Vill. of Oconomowoc Lake v. Dayton Hudson, Corp.*, 24 F.3d 962, 965 (7th Cir. 1994); *Chevron U.S.A. Inc. v. Apex Oil Co., Inc.*, 113 F. Supp. 3d 807, 816 (D. Md. 2015)).
[38] Mot. by States of New York, Connecticut, Hawaii, Massachusetts, Oregon, Vermont, and Washington and the District of Columbia, to Intervene in Support of Resp. in Dkt. No. 15-3751 and in Each of the Related Cases ("Motion to Intervene") at 1 & 14-16, *In re EPA*, 803 F.3d 804, 806 (6th Cir. Aug. 28, 2015) (No. 15-3751 and consolidated cases), ECF No. 19-1; *see also id*. at 2-3 (The CWA's "sole 'objective [is] . . . to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.").
[39] *Id*. at 14-16 (emphasis added).
[40] *Id*. at 6.
[41] *Id*. (emphasis added)
[42] Clean Water Rule, 80 Fed. Reg. at 37099, 37100.

As acknowledged by EPA in its comments on the Clean Water Rule, "the Clean Water Act may cover discharges of pollutants *from point sources to surface water* that occur via groundwater that has a direct hydrologic connection to surface water[; however, nothing in the Rule] changes or affects that longstanding interpretation, including the exclusion of groundwater from the definition of 'waters of the United States,'" and thus the *prohibition against applying SWQS in groundwater*.[43]

The vast majority of courts interpreting this exception have done so in the context of the NPDES permitting scheme and are split on whether groundwater discharges can be covered under the NPDES program if that groundwater has a direct hydrological connection to surface water. *Compare, e.g., Exxon Corp. v. Train*, 554 F.2d 1310, 1317-31 (5th Cir. 1977) (discharges to groundwater not covered), *with, e.g., Quivira Mining Co. v. EPA*, 765 F.2d 126, 129 (10th Cir. 1985) (discharge to groundwater may be covered).

As cogently explained by one district court, summarizing Supreme Court jurisprudence in finding groundwater outside the scope of the CWA regardless of any hydrological connection:

> The plurality holding in *Rapanos [v. United States]* repeatedly admonishes the lower courts and the Corps for attempting to expand the definition of navigable waters to encompass virtually all water, regardless of its actual navigability, location, or consistency of flow. The Supreme Court also reiterates that, in [*United States v. Riverside Bayview Homes*, 474 U.S. 121, 106 S.Ct. 455 (1985)], it held that the phrase "waters of the United States" "referred primarily to 'rivers, streams, and other hydrographic features more conventionally identifiable as waters' than the wetlands adjacent to such features." "Likewise, in both *Riverside Bayview* and [*Solid Waste Agency of Northern Cook County v. United States Army Corps of Engineers*, 531 U.S. 159, 121 S.Ct. 675 (2001)], [the Supreme Court] repeatedly described the 'navigable waters' covered by the [CWA] as 'open water' and 'open waters.'"
>
> After close review of the competing analyses, this court . . . holds that Congress did not intend for the CWA to extend federal regulatory authority over groundwater, regardless of whether that groundwater is eventually or somehow "hydrologically connected" to navigable surface waters. There is support for this holding in both the language and legislative history of the CWA and in the Supreme Court's ruling in *Rapanos*. In *Rapanos,* the Court does not endorse a broad interpretation of the term navigable waters, and sets forth tests that will exclude some wetlands from the scope of the CWA. Thus, this court is satisfied that groundwater (which is even less fairly described as "open water" or a conventionally understood hydrographic or geographic "feature" than any wetland) does not fall within the meaning of the [CWA].

Cape Fear River Watch v. Duke Energy Prog., Inc., 25 F. Supp. 3d 798, 809-810 (E.D.N.C. 2014) (dismissing all claims) (internal citations omitted), *clarified by* No. 7:13-CV-200-FL, 2014 WL 10991530, at *1 (E.D.N.C. 2014) (CWA claims dismissed for lack of jurisdiction but state claims based on separate state groundwater permitting statute preserved).

[43] Clean Water Rule Response to Comments – Topic 10: Legal Analysis at 383 (emphasis added); *see also generally id*; EPA, Technical Support Document at 16-17.

Even courts that have found that discharges of pollutants to surface water via groundwater warrant a NPDES permit have emphasized that "applying effluent limitations to tributary groundwater does not change the nature of CWA monitoring." *Wash. Wilderness Coal.*, 870 F. Supp. at 990. In other words, because it must be demonstrated that pollutants from a point source affect the surface waters of the United States, the monitoring to confirm compliance with the SWQS would occur in the surface water, *not in the groundwater*. *See id*.

The lone court that addressed the question in the context of SWQS a long time ago determined only that "underground segments" of a stream were subject to the SWQS. *See Kentucky v. Train*, 9 Env't Rep. Cas. (BNA) 1280, 1282, 1976 WL 23622, at * 2 (E.D. Ky. 1976). Since that time, EPA has explained the limited import of the over 40-year old, unpublished *Kentucky v. Train* decision, reiterating EPA's view "that the CWA [SWQS] generally [do] not apply to groundwater" and instructing that the "clear hydrological nexus" required for the SWQS to apply to groundwater "must be construed as narrowly as possible" such that the "nexus" is "applicable only where a surface stream has some underground segments,"[44] that are "sufficiently stream-like so as to possibly allow the passage of fish and other aquatic organisms from a surface segment of the stream into the underground segment."[45] Here, the Everett groundwater is not an "underground segment of a stream" nor is "sufficiently-stream like" in that "fish and other aquatic organisms" can pass into the groundwater. Therefore, consistent with EPA's view, Ecology cannot apply the SQWS to the Everett groundwater.

IV. If SWQS Applied Here Under MTCA to Upland Groundwater and Soils, Which They do not, the Point of Compliance Would Need to be in the Surface Water.

First, as established previously, the SWQS cannot apply as the cleanup level upland for groundwater, in the groundwater plume, or in soil. But if it were legal to do so, the only way to apply the SWQS as a groundwater cleanup level consistent with the CWA and EPA regulations and guidance would be to use the required point of compliance in the surface water itself. Sampling ten football fields away from surface water for surface water criteria is just plain out of the question.

Of course, setting the point of compliance in Powder Mill Creek is consistent with the approach Ecology provided when it promulgated proper MTCA groundwater cleanup standards whose proper design (unlike here) is to achieve the SWQS in nearby surface waters. Specifically, Ecology said: "where [groundwater] cleanup levels are based on protecting nearby surface water, compliance with those standards [e.g., the surface water quality criteria,] *will generally be based on surface water monitoring performed as close as possible to the groundwater/surface water interface . . . .*"[46] Any groundwater cleanup levels for the protection of surface water based on surface water quality criteria are to be measured as against an SWQS sampled for in the receiving waterbody, not in the groundwater. This is the only approach consistent with the regulatory scheme under the CWA and its associated SWQS.

---

[44] WQS and Underground Waters Guidance at 2.
[45] Amendments to the Water Quality Standards Regulations that Pertain to Standards on Indian Reservations, Final Rule, 56 FR 64,876, 64,892 (Dec. 12, 1991), 1991 WL 260534, at *30.
[46] *See* Responsiveness Summary at 203 (emphasis added).

V. If SWQS Applied Here Under MTCA to Upland Groundwater and Soils, Which They do not, Everett Additionally Meets all of the Factors for a MTCA Conditional Point of Compliance.

If Ecology erroneously persists in requiring the SWQS be used as the groundwater and soil cleanup levels, it must apply a surface water point of compliance as discussed above. In addition, under MTCA, a conditional point of compliance ("CPOC") is also to be approved if it is not practicable to meet groundwater cleanup levels throughout the site in a reasonable restoration timeframe. WAC 173-340-170(8)(c). Consistent with the SWQS, MTCA allows for a CPOC located "within the surface water as close as technically possible to the point or points where groundwater flows into the surface water" as long as the additional requirements of WAC 173-340-720(8)(d)(i) are met. Boeing easily meets all of these requirements, and if Ecology improperly maintains the surface water quality criteria as groundwater cleanup levels, Ecology must set the CPOC and compliance sampling in the Powder Mill Creek surface water. WAC 173-340-720(8)(d)(i).

a. Ecology's required use of the SWQS as the cleanup level for groundwater makes it impracticable under any alternative to meet groundwater cleanup levels within a reasonable timeframe.

As Ecology has already acknowledged, none of the cleanup alternatives meet the reasonable timeframe requirement; thus a CPOC is justified. In its August 2016 letter to Boeing, Ecology stated that a 55-year time frame is not a reasonable restoration timeframe, and that even 32 to 46-year timeframes are "long timeframes":

> The FS report estimates that it will take 55 years, 46 years, 32 years, and 32 years to attain groundwater cleanup levels employing remedial alternatives 1, 2, 3, and 4, respectively. These are long timeframes.
>
> Ecology believes that **Alternative 1** does not meet the "reasonable restoration timeframe" threshold requirement . . . .[47]

As explained above, Ecology is attempting to apply the inapplicable and needlessly stringent SWQS as the groundwater and soil cleanup levels in the groundwater and soil. If Ecology persists with this arbitrary approach, modeling estimates demonstrate that the restoration timeframes for all of the alternatives would be 50 years or greater: Alternative 1: 59 years; Alternative 2: 57 years; and Alternative 4: 53 years.

By Ecology's own terms, applying the SWQS as the groundwater cleanup level results in none of the alternatives meeting the cleanup levels within a reasonable timeframe.[48] Because none of the alternatives meet the reasonable restoration timeframe threshold requirement per WAC 173-340-720(8)(c), Ecology should approve a CPOC, regardless of which alternative is selected.

---

[47] Letter from D. Yasuda, Ecology, to D. Taege, Boeing, re Ecology Contingent Approval and Modifications to the Draft Boeing Everett Uplands and Powder Mill Gulch Feasibility Study (FS) Report, dated November 13, 2015, at 33 (Aug. 18, 2016) ("August 2016 Letter") (emphasis in original).

[48] *See* August 2016 Letter at 33.

b. **As demonstrated in Boeing's November 2, 2016 Technical Memorandum, the conditions specified in WAC 173-340-720(8)(d)(i) for an off-property CPOC are also satisfied.**

WAC 173-340-720(8)(d)(i) sets forth additional conditions that must be met in order for Ecology to set a CPOC in the Powder Mill Creek surface water. As Boeing already demonstrated in its November 2, 2016 Technical Memorandum, these conditions are also satisfied and the CPOC should be set within the Powder Mill Creek surface water, with permit compliance sampling to occur within the surface water as close as possible to the creek bed where groundwater enters the creek.

For Ecology's convenience, Boeing again provides the analysis demonstrating that each WAC 173-340-720(8)(d)(i) condition (paraphrased below) is met for setting the CPOC in the Powder Mill Creek surface water: (*responses to the conditions in italics*):

- It must be demonstrated that contaminated groundwater will continue to enter the surface water even after implementation of the cleanup.

  Groundwater and surface water sampling data from the remedial investigation has demonstrated that some sVOC-contaminated groundwater will continue to discharge to the creek.

- It must be demonstrated that it is not practicable to meet the cleanup level at a point within the groundwater before entering the surface water within a reasonable restoration timeframe.

  As indicated above, meeting the surface water cleanup level in groundwater is anticipated to take at least 50 years regardless of the remedial alternative selected.

- Use of a mixing zone to demonstrate compliance is not allowed.

  No use of a mixing zone is proposed.

- All known available and reasonable methods of treatment (AKART) must be provided to groundwater discharges prior to release to surface water.

  The Groundwater Extraction and Treatment (GET) system currently provides AKART for the groundwater discharges and substantial source area treatment has been completed.

- Groundwater discharges must not violate sediment quality values.

  Sediment quality is not impacted by current TCE and other cVOC discharges.

- Groundwater and surface water monitoring shall be conducted to assess long-term performance including for potential bioaccumulation.

  Long-term monitoring will be performed as required; TCE and other cVOCs at the site are not known to bioaccumulate.

- Notice of the proposal shall be provided to the natural resource trustees, the Department of Natural Resources, and the US Army Corps of Engineers.

  Such notice can be provided.

*   *   *

For all of the foregoing reasons, Ecology cannot apply the SWQS as cleanup levels in the Everett groundwater and soil. If it takes that improper approach, it must set the point of compliance in the surface water, at the point as close as technically possible to where the groundwater flows into the creek.

Boeing Legal Contact:

Stanley N. Alpert
Senior Environmental Counsel
Environment, Health and Safety Law Group
The Boeing Company
P.O. Box 3707 MC 7A-XP
Seattle, WA 98124-2207
Telephone: (425) 865-1073
stanley.n.alpert@boeing.com

1916 | 2016 100