DRAFT

Prepared for:

Hexcel Corporation

Focused Feasibility Study for the Hexcel Plant 1 Facility Located in Kent, Washington

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The Hexcel Corporation (Hexcel) Plant 1 is located at 19819 84th Avenue South in Kent, Washington. The purpose of this focused feasibility study (FFS) is to evaluate regulatory cleanup standards, and review remedial alternatives that reach these cleanup standards as a requirement of Enforcement Order No. DE 2552 (EO) issued by the State of Washington Department of Ecology (Ecology). Additional objectives include:

- Definition of a reasonable cleanup end point.
- Provide preliminary estimates of time and cost to achieve goals; and
- Review impediments to goals or uncertainties.

2. SITE DESCRIPTION AND BACKGROUND

A thorough listing of the site history is provided in the Focused Remedial Investigation (FRI; Clear Creek, 2018) with only Hexcel purchase descriptions provided here.

The adjacent, upgradient, site is called Parcel G and is owned by B.S.B. Diversified, Inc. (BSB). In 2005, Ecology issued Agreed Order No. DE 2551 (AO) to BSB for environmental actions on Parcel G (Figure 1). The AO required BSB to operate a groundwater pumping system on Parcel G. In 2011, BSB entered into Consent Decree No. 11-2-27288-5 with Ecology that contained a Cleanup Action Plan stipulating a remedy consisting of a cap and a sub-surface soil-bentonite cutoff wall for containment of contaminants on Parcel G. Construction of the Parcel G remedy was completed in 2012.

Hexcel acquired the facility in 1995 as follows:

- September 29, 1995: Ciba-Geigy (including Heath Tecna) and Hexcel Corporation sign a Strategic Alliance Agreement to combine their composite businesses on a worldwide basis to be operated under the Hexcel name.
- December, 22, 1995: Executed agreement between BSB and Hexcel; Assignment of APA with PWC/Ciba (dated January 25, 1988) and Agreement between BSB and Heath Tecna (dated April 10, 1989) regarding joint pump and treat system. Hexcel had acquired Parcels A through F from the Ciba-Geigy Corporation and acquired all assets and assumed all liabilities of the Ciba-Geigy Corporation relating to Parcels A through F (see Focused Remedial Investigation (FRI) Figure 4, Clear Creek, 2018). BSB retained liabilities for Parcel G.

The site is an operating manufacturing facility. A site map of monitoring wells for the BSB and Hexcel sites is provided in Figure 1.

3. HYDROGEOLOGY

Since the late 1980s, numerous environmental investigations (soil, soil gas and groundwater) have been completed at the Hexcel facility (Clear Creek, 2018). Key hydrogeologic conditions relevant to the evaluation of a groundwater remedy are described below:

- The groundwater flow and dissolved contaminant migration direction is consistently to the northeast on the west side of Plant 1, and to the north on the east side of Plant 1. The ambient groundwater flow gradient (i) is estimated to range from about 0.001 to 0.002 feet/foot.
- Multiple groundwater hydrostratigraphic layers have been identified at the site, but the zones of primary groundwater flow and contaminant migration are the B and D layers that are predominantly sand materials. The B- and D-Layers are separated by a silt layer beneath the BSB site (see FRI Figures 7-8). The silt layer does not extend to beneath the Hexcel site, thus allowing hydraulic communication between the B- and D-layers. The hydraulic conductivity (K) for these sand zones ranges from 20 to 80 ft/day, with the best estimate of 51 ft/day, based on calibrated groundwater model (Papadopulos, 2003). The porosity (n) is estimated to be 0.25.
- The groundwater seepage velocity (v) for groundwater flow can be calculated using the Darcy groundwater velocity equation $v=Ki/n$. Using a $K=51$ ft/day, and a groundwater gradient of 0.001 feet/foot, the calculated groundwater migration velocity is approximately 75 feet/year.

4. HISTORICAL REMEDIAL ACTIONS

Section 5 of the FRI provides a comprehensive discussion of remedial actions performed at the Hexcel facility. The following is a summary of those actions.

From 1992 to 2009, BSB performed groundwater extraction at the BSB site via two wells (HYR-1 and -2). The BSB groundwater extraction program removed contaminant mass, but did not provide complete control of offsite contaminant migration onto Hexcel's property. In 2012, BSB completed the installation of a low-permeability slurry wall, significantly mitigating offsite migration of residual chlorinated volatile organic compound (VOC) mass in the shallow aquifer onto the Hexcel property. BSB has performed no remedial actions for the deep aquifer.

Since 1992, groundwater extraction has been performed at the Hexcel site through four groundwater extraction wells (CG-1 through CG-4). The remedy has provided hydraulic control of offsite migration of dissolved VOCs and has also removed contaminant mass from the aquifer. Operation and performance have been documented in routine monitoring reports to Ecology. Following the control of the shallow aquifer source by BSB, and after consultation and approval by Ecology, Hexcel systematically turned off extraction wells as monitoring confirmed Model Toxics Control Act (MTCA) cleanup standards had been met, beginning with CG-1 and continuing to CG-3. CG-4, the last extraction well to be turned off, was shut down in December 2016 in advance of the expanded Enhanced In Situ Bioremediation (EISB) pilot injections.

Naturally occurring biodegradation of trichloroethylene (TCE), cis-1,2-dichloroethylene (cDCE), and vinyl chloride (VC) was described and further investigated in 2003, as part of Hexcel's voluntary source investigation (Hydro Geo Chem, 2003b). The results of the assessment provided evidence that conditions were appropriate for biodegradation to be occurring at the site. Genetic marker testing in 2003 (Hydro Geo Chem, 2004) confirmed the subsurface presence of *Dehalococcoides*, the primary microbe responsible for the dechlorination of VC and cDCE.

Following isolation of the Parcel G source, Hexcel implemented an EISB program to reduce concentrations of residual VOCs at the site that included a laboratory testing that demonstrated the conceptual feasibility of EISB (Geosyntec, 2015a and 2015b). A pilot EISB injection study in the shallow aquifer in the vicinity of HEX-8 occurred in October 2015 followed by 6 months of groundwater monitoring (Geosyntec, 2015c). The positive results of the pilot test, including evidence of a viable microbial population and degradation of cDCE and VC, led to implementation of an expanded scale EISB field test (Geosyntec, 2017).

The expanded scale EISB field test was implemented in June 2017 in the area between PS-1 and CG-4. As of June 2018, the results of groundwater sampling were encouraging; showing appropriate geochemical transitions, significant VOC reductions, and the production of ethene from the breakdown of VC (Geosyntec, 2018). Continued groundwater monitoring expanded scale EISB field test is scheduled through the second quarter of 2019.

In September 2017, there were no detections of cDCE above MTCA Method A cleanup levels for groundwater (Clear Creek Associates. 2017), making VC the sole remaining constituent of concern (see FRI Section 4.2.2; Clear Creek, 2018). Natural attenuation, due in part to the intrinsic biodegradation of VC, in the shallow aquifer at Plant 1 reduced VC concentrations in wells CG-1, CG-2, and CG-3 from as high as 750 µg/L in 1996 to less than the MTCA Method A cleanup level of 0.2 µg/L in 2016. The EISB expanded-scale pilot test is expected to significantly reduce VC concentrations in the portion of the aquifer containing a residual zone of groundwater with concentrations greater than 1 µg/L VC, including at CG-4 and HEX-8.

Concentrations of VC in groundwater in samples from wells on the upgradient boundary of Plant 1 (i.e., HEX-1, HEX-2, HEX-3, HEX-4, and HEX-5) ranged from 0.14 µg/L to 1.9 µg/L in September 2017, indicating an ongoing loading of VC from offsite sources (Clear Creek Associates, 2017). Despite the loading from offsite sources, VC concentrations at Plant 1 have declined to non-detect at the downgradient CG wells, with the exception of CG-4 which is being treated by the EISB Interim Measure.

Additional focused applications of EISB, if needed, could be an effective means of destroying VC in-situ and meeting the groundwater cleanup level at the property boundary.

5. CONTAMINANT GEOCHEMISTRY

As described in detail in the FRI, the primary source of chlorinated solvent impacts to the local environment occurred at the disposal sites on the BSB Parcel G site (Clear Creek, 2018). Numerous historic groundwater investigations and routine sampling events detected a broad array of VOCs. As summarized in the FRI, VC concentrations exceed the MTCA Method A Cleanup Standard[1] of 0.2 µg/L in several wells. The interior well HEX-8 typically has the highest VC concentrations. The FRI figures 13-15 provide plume delineation estimates, and documentation of groundwater plume contraction, at the Hexcel site for 1988, 1998, and 2008.

As shown in graphs of historical concentration data (FRI figures 18-20; Clear Creek, 2018), VC concentrations have declined over time, but several of the wells remain above the VC cleanup standard.

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[1] State of Washington Model Toxics Control Act Statutes and Regulation, Publication No. 94-06, Revised November 2007.

A fundamental component of groundwater remediation planning and design is evaluating if natural processes are contributing to observed decline in VOC concentration. Considerable studies have documented the degradation of tetrachloroethylene (PCE) and TCE via biodegradation by naturally occurring microorganisms (Wiedemeier, et al, 1999). The degradation process leads to a decline in PCE and TCE and to the creation of the degradation by-products cDCE and VC, and ultimately to ethene and/or ethane. This well-known degradation sequence, at least to the point of VC production, is apparent in the Hexcel groundwater data. Further, past testing at the site has confirmed the presence of the necessary solvent-degrading microbial populations of *Dehalococcoides sp.*. The combination of these observations, decline of TCE, increase in cDCE and VC and confirmed presence of *Dehalococcoides sp.,* provide several lines of evidence that natural attenuation by in situ biodegradation has been occurring at the Hexcel site.

Work at other sites has found a narrow range of geochemical conditions must exist for the *Dehalococcoides* populations to degrade cDCE and VC completely to non-toxic ethene (Wiedemeier, et al, 1999). *Dehalococcoides* populations are detectable in the aquifer at the site. Based on bench scale testing of soil and groundwater from Plant 1, following by a pilot scale and an expanded scale field deployment, it was concluded that augmentation of the current natural biological degradation process, using injected microbes, nutrients, and geochemical amendments, was successful in reducing concentration of VC in groundwater in the vicinity of HEX-8 and CG-4 (Geosyntec, 2015a, 2015b, 2018).

6. CLEANUP STANDARDS

6.1 Cleanup Standards

Cleanup standards consist of two components:

- Cleanup levels (chemical concentrations); and
- Points of compliance (at which the cleanup levels must be met).

Typically, preliminary cleanup standards are developed during the RI, proposed cleanup standards for remedial alternative evaluation are presented in the FS, and final cleanup standards are established during the corrective action plan (CAP) development process to be prepared following completion of the FS. The cleanup standards presented are the proposed cleanup standards for remediation at the Site. The cleanup standards proposed in this FFS Report were developed in accordance with WAC 173-340-700 through -730.

6.1.1 Identification of ARARS

MTCA requires that all cleanup actions comply with applicable state and federal laws (WAC 173-340-360(2)). MTCA defines applicable state and federal laws to include "legally applicable requirements" and "relevant and appropriate requirements." MTCA's requirements are substantially the same as CERCLA Section 121 where remedial actions are required to achieve ARARs. Per CERCLA, ARARs are defined as any legally applicable or relevant and appropriate standard, requirement, criterion, or limitation that has been promulgated under federal or state environmental laws. For convenience, this FFS Report uses the ARAR terminology in the development of cleanup standards and the subsequent evaluation of cleanup action alternatives.

This section presents the proposed ARARs and the draft guidance regulations that have been identified for remediation of the Site. ARARs are determined on a case-by-case basis for each site. Guidance documents are not legally binding and do not have the same status as ARARs. However, these may be used in evaluating the cleanup alternatives and are included in the evaluation of ARARs.

CERCLA identifies three categories of ARARs: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs include health- or risk-based numerical values or methodologies applied to Site-specific conditions. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location-specific ARARs set restrictions on activities based on Site characteristics or the surrounding environment. Action-specific ARARs include technology-based requirements for hazardous waste management. The proposed ARARs for the Site are presented in **Table 1**.

6.1.2 Cleanup Levels

The RI Report evaluated potential Site risks and exposure pathways (Clear Creek, 2018). The regulations implementing MTCA, WAC Chapter 173-340, require groundwater cleanup levels to be based on the highest beneficial use of the water under current and future conditions. The regulations presume that the highest beneficial use of groundwater at any site will be drinking water, per WAC 173-340-720(1). Therefore, groundwater in the vicinity of the Site is considered as a potential source of drinking water, although the groundwater ingestion pathway is considered incomplete based on use and availability of municipal water supply (City of Kent). For soil and soil gas, it was concluded that there were no unacceptable exposures to VOCs (see FRI; Clear Creek, 2018). Hydraulic data for the Site indicate groundwater may discharge to Springbrook Creek; however, VOCs were not detected in surface water, suggesting no unacceptable exposures to VOCs.

Based on evaluation of potential exposure pathways, the development of cleanup levels for VOCs are limited to groundwater and groundwater to surface water pathways, as follows:

- Potential future drinking water beneficial use;
- Groundwater to surface water pathway: Acute or chronic effects to aquatic organisms resulting from exposure to constituents in groundwater discharging to adjacent surface water; and,
- Human ingestion of organisms contaminated by releases of affected Site groundwater to adjacent surface water.

Groundwater cleanup criteria were developed based on the exposure pathways above to be adequately protective of human health and aquatic organisms, and of humans that ingest these organisms. Groundwater and surface water cleanup levels were compiled in accordance with WAC 173-340-720(4) and WAC 173-340-730(3), including:

- Federal and state Maximum Contaminant Levels (MCLs) for drinking water;
- Standard MTCA Method A cleanup levels for carcinogens and non-carcinogens protective of human health, obtained from Ecology's CLARC database (Washington Department of Ecology, 2015); and,
- MTCA Method A fresh surface water cleanup levels protective of aquatic organisms and human health (WAC 173-340-730[3]), including:
    - Water quality criteria published in the Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A);
    - Water quality criteria based on the protection of aquatic organisms (acute and chronic criteria) and human health published under Section 304 of the Federal Clean Water Act (CWA); and,
    - Concentrations established under the National Toxics Rule (NTR; Code of Federal Regulations [CFR] Title 40, Part 131).

The groundwater cleanup levels are presented in **Table 2**.

The selection process requires that the most stringent cleanup level from the groundwater and surface water ARARs be selected. Of the Cleanup Levels, MTCA Method A is the most stringent with a VC criterion of 0.20 µg/L based on human health consumption for water and organisms. The NTR criterion is 2.0 µg/L for the same receptor. However, because VC has not been detected in surface water directly downgradient of the site and surface water is not and will not likely be used for drinking water, the most stringent CWA and NTR values for protection of human health are 2.4 and 2.4 µg/L, respectively, based on consumption of organisms. Therefore, for this FFS Report the most stringent ARAR for VC in groundwater is 0.20 µg/L, which is the MTCA Method A value (**Table 2**).

6.1.3 Points of Compliance

The point of compliance is defined by MTCA as the point or points where cleanup levels shall be achieved (WAC 173-340-200). The compliance monitoring points for groundwater will be approved by Ecology and presented in a forthcoming CAP for the Site. A standard point of compliance is proposed for this Site, which includes the Site property to the depth of the shallow aquifer (WAC 173-340-720(8)(b)).

6.2 Area and Volume of Groundwater above Cleanup Levels

Site-specific conditions, the nature and extent of the VC groundwater plume, and the cleanup standards were taken into consideration to estimate the areal extent and volume of groundwater to be addressed by potential cleanup actions.

Figure 2 illustrates the estimated areal extent of the VC plume exceeding the cleanup level of 0.20 µg/L in September 2017 (Clear Creek Associates, 2017). The area of the VC plume in groundwater is conservatively estimated to be approximately 7.3 acres. An estimated aquifer thickness of 40 ft and an effective porosity of 0.25 were used to calculate the pore volume of 23.8 million gallons of groundwater exceeding the 0.20 µg/L isoconcentration contour for VC.

7. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

WAC 173-340-350(8)(b) states that "An initial screening of alternatives to reduce the number of alternatives for the final detailed evaluation may be appropriate. The person conducting the feasibility study may initially propose cleanup action alternatives or components to be screened from detailed evaluation." During the initial screening stage, the preliminary analysis may eliminate potential alternatives based on two typical criteria. First, alternatives that clearly do not meet the minimum requirements specified in WAC 173-340-360 may be eliminated. This includes those alternatives for which costs are clearly disproportionate under WAC 173-340-360 (3)(e). Second, alternatives that are not technically feasible for site conditions may also be eliminated.

The identification and screening of remedial technologies and process options described in this Section was conducted in accordance with the substantial requirements of WAC 173-340-350(8)(b). As a first step, a wide range of potential remedial approaches were assembled for initial screening on the basis of technical implementability and potential effectiveness given Site conditions. The technologies and process options considered included groundwater extraction and treatment, in-situ chemical, biological or thermal treatment, and monitored natural attenuation (MNA). **Table 3** presents the results of the identification and initial screening of remedial technologies and process options. On the basis of the initial screening, several process options were eliminated from further consideration, including:

- Vapor intrusion monitoring;
- Extraction trench;
- Permeability enhancements;
- Vacuum-enhanced extraction;
- Air sparging;
- In-well air stripping; and,
- Thermal treatment.

The rationale for elimination of these process options is provided in **Table 3**.

As a next step, remedial technologies and process options deemed potentially effective in the initial screening process were further evaluated based on permanence, effectiveness, implementability (technical and administrative), and cost (capital and operations & maintenance (O&M)). **Table 4** presents the evaluation of technology process options. An assessment of each process option's potential to achieve the cleanup standards as a stand-alone option was considered. On the basis of this evaluation, process options were either retained or rejected for detailed comparative analysis in Section 8. Two process options were not retained for alternative development, including:

- Chemical oxidation; and,
- Chemical reduction.

Comments supporting the elimination of these process options are provided in **Table 4**. The remaining remedial technologies/process options were retained for cleanup alternative development, as discussed in Section 8.

8. DEVELOPMENT AND DETAILED ANALYSIS OF CLEANUP ACTION ALTERNATIVES

In this section, four cleanup action alternatives are assembled using the remedial technologies and process options that were retained from the initial screening process. The MTCA criteria used to evaluate the cleanup action alternatives are presented in context of the current Site conditions. A detailed analysis of the cleanup action alternatives using the MTCA criteria is then presented. Based on the detailed analysis, the recommended alternative is identified.

8.1 Cleanup Action Alternative Development

The alternatives developed for the Site are presented in **Table 5**, and listed below:

- Alternative 1: Site-wide groundwater extraction;
- Alternative 2: Full Scale EISB;
- Alternative 3: Site-wide MNA with contingency for supplemental EISB; and
- Alternative 4: Site-wide MNA.

These alternatives represent an appropriate range of cleanup approaches capable of achieving the Site cleanup standards presented in Section 6.

8.2 MTCA Evaluation Criteria

WAC 173-340-360(2) specifies the minimum requirements for cleanup actions. There are two basic categories of cleanup action requirements: (i) threshold requirements, and (ii) additional requirements. Sections 8.2.1 and 8.2.2 discuss the components of the threshold and additional requirements, respectively. It is important to note that the regulations acknowledge (WAC 173-340-360(2)) that "the department recognizes that some of the requirements contain flexibility and will require the use of professional judgment in determining how to apply them at particular sites."

8.2.1 MTCA Threshold Requirements

The threshold requirements for cleanup actions performed under MTCA are listed in WAC 173-340-360(2)(a), and indicate that a cleanup action shall:

- **Protect Human Health and the Environment** – Cleanup actions must ensure that both human health and the environment are protected during and after cleanup action implementation. As stated in WAC 173-340-702(5), *"Cleanup actions that achieve cleanup levels at the applicable point of compliance under Methods A, B, or C (as applicable) and comply with applicable state and federal laws shall be presumed to be protective of human health and the environment."*

- **Comply with Cleanup Standards** – Compliance with cleanup standards requires that cleanup levels are met at the applicable points of compliance. The proposed cleanup standards for the Site were developed in accordance with WAC 173-340-720/730 and are presented in Section 6 of this FFS Report.

- **Comply with Applicable State and Federal Laws** – Cleanup actions conducted under MTCA must comply with applicable state and federal laws. The term "applicable state and federal laws" (i.e., ARARs) includes legally applicable requirements and those requirements that Ecology determines to be relevant and appropriate as described in WAC 173-340-710. The ARARs for the Site were presented in **Table 1**.

- **Provide for Compliance Monitoring** – The cleanup action must allow for compliance monitoring in accordance with WAC 173-340-410. Compliance monitoring consists of protection monitoring, performance monitoring, and confirmational monitoring.

8.2.2 Additional MTCA Requirements

The additional requirements for cleanup actions performed under MTCA are listed in WAC 173-340-360(2)(b). The regulation requires that when selecting from cleanup action alternatives that fulfill the threshold requirements, the selected action shall:

- **Use Permanent Solutions to the Maximum Extent Practicable** – WAC 173-340-730(3)(b) states "To determine whether a cleanup action uses permanent solutions to the maximum extent practicable, the disproportionate cost analysis specified in (e) of this subsection shall be used. The analysis shall compare the costs and benefits of the cleanup action alternatives evaluated in the feasibility study." As defined by MTCA, "Practicable" means capable of being designed, constructed and implemented in a reliable and effective manner including consideration of cost. When considering cost under this analysis, an alternative shall not be considered practicable if the incremental costs of the alternative are disproportionate to the incremental degree of benefits provided by the alternative over other lower cost alternatives. The criteria for conducting the disproportionate cost analysis (DCA) are described in Section 8.2.3.

- **Provide for Reasonable Restoration Time Frame** –WAC 173-340-360(4) describes the requirements and procedures for determining whether a cleanup action provides for a reasonable restoration time frame. The factors to be considered during the evaluation include the following [WAC 173-340-360(4)(b)]:

  (i) Potential risks posed by the site to human health and the environment;

  (ii) Practicability of achieving a shorter restoration time frame;

  (iii) Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

  (iv) Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

  (v) Availability of alternative water supplies;

  (vi) Likely effectiveness and reliability of institutional controls;

  (vii) Ability to control and monitor migration of hazardous substances from the site;

  (viii) Toxicity of the hazardous substances at the site; and,

  (ix) Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

- **Consider Public Concerns** – Per WAC 173-340-600, public participation is considered an integral part of Ecology's responsibilities under MTCA. The goal of this requirement is to provide the public with timely information and meaningful opportunities for participation that are appropriate for each site. As part of the process, Ecology will consider public comments submitted during the FRI/FFS process during its selection of the preliminary cleanup action alternative. This preliminary selection is subject to further public review and comment when the proposed remedy is published by Ecology in a draft CAP.

8.2.3 MTCA Disproportionate Cost Analysis Procedure & Criteria

As required per WAC 173-340-360(3)(e), the MTCA DCA is an analysis that is performed on the cleanup action alternatives that meet the threshold requirements. The purpose of the DCA is to determine which of these cleanup action alternatives is protective to the maximum extent practicable. To make this determination, the costs and benefits of the alternatives are quantified using the DCA criteria described below. The alternatives are then ranked from most to least permanent based on the benefit scorings. To facilitate comparison of the alternatives, WAC 173-340-360(3)(e)(ii)(B) states that "The most practicable permanent solution evaluated in the feasibility study shall be the baseline cleanup action alternative against which cleanup action alternatives are compared." Typically, the low cost alternative is set as the baseline alternative. The other cleanup alternatives are then compared against the baseline to determine if their incremental costs are not disproportionate to their potential incremental benefits.

The evaluation criteria for the DCA are specified in WAC 173-340-360(3)(f), and include protectiveness, permanence, cost, long-term effectiveness, management of short-term risks, implementability, and consideration of public concerns. It is typical to more heavily weight the evaluation criteria associated with the primary objectives of the cleanup action. For example, criteria pertaining to protection and permanence are weighted more heavily than criteria such as implementability. The MTCA criteria used in the DCA and the weighting factors ascribed to the criteria are described below.

<u>Protectiveness</u>

Protectiveness is defined in WAC 173-340-360(3)(f)(i) as the "Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and offsite risks resulting from implementing the alternative, and improvement of the overall environmental quality." Although protectiveness is one of seven criteria to be considered, a weighting factor of 30 percent was used in the numeric benefit analysis given that protection of human health and the environment is one of the primary objectives of the cleanup action.

Permanence

Permanence is defined in WAC 173-340-360(3)(f)(ii) as "The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated." A weighing factor of 20 percent was used in the numeric benefit analysis. Given the emphasis placed by Ecology on the permanence of cleanup actions, this criterion was given the second highest weighting factor.

Cost

Cost is defined in WAC 173-340-360(3)(f)(iii) as "The cost to implement the alternative, including the cost of construction, the net present value of any long-term costs, and agency oversight costs that are cost recoverable. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls. Cost estimates for treatment technologies shall describe pretreatment, analytical, labor, and waste management costs. The design life of the cleanup action shall be estimated and the cost of replacement or repair of major elements shall be included in the cost estimate." The costs of the four cleanup action alternatives were used to determine whether an alternative's cost was disproportionate to potential incremental benefits. As such, no weighting factor was applied to this category to estimate the numeric benefits.

Long-Term Effectiveness

Long-term effectiveness is defined in WAC 173-340-360(3)(f)(iv) as including "the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: Reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or offsite disposal in an engineered, lined and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring." A weighting factor of 20 percent was assigned to the long-term effectiveness criterion based on the importance of achieving final environmental cleanup without the need for future actions to ensure protection of human health and the environment.

Management of Short-Term Risks

Management of Short-Term Risks is defined in WAC 173-340-360(3)(f)(v) as "The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks." A weighting factor of 10 percent was assigned to the Management of Short-Term Risks. This criterion is weighted relatively low given the ability to satisfactorily mitigate most short-term risks with implementation of appropriate engineering controls.

Implementability (Technical and Administrative)

Implementability is defined in WAC 173-340-360(3)(f)(vi) as the "Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary offsite facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions." Similar to short-term risk, a weighting factor of 10 percent was assigned to the numeric benefit analysis. Compared to protectiveness, permanence, and long-term effectiveness, this criterion is considered less critical to the overall cleanup action objectives.

Consideration of Public Concerns

Consideration of Public Concerns is described in WAC 173-340-360(3)(f)(vii) to account for "Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site." The weighting factor used for this criterion was 10 percent based on the observation that public concerns are typically related to protectiveness and permanence, and as such, public concerns are implicitly accounted for in these two previous criteria.

8.3 MTCA Threshold Requirement Evaluation of Cleanup Action Alternatives

8.3.1 Alternative 1 – Site-Wide Groundwater Extraction

This section describes the groundwater extraction alternative and evaluates whether it satisfies the MTCA Threshold Requirements for a cleanup action.

Technical Description & Cost

The groundwater extraction alternative would be a continuation of the prior interim remedial action of site wide groundwater pumping. The extraction well system is located along the eastern the property boundary. Extraction wells CG-4, CG-3, CG-2, and CG-1 are located from south to the north of the main plume along the property boundary. Each of the extraction wells is connected to a groundwater conveyance system that discharges to the municipal sanitary system.

The capture zone width was estimated based on modeling the objective of capturing groundwater containing VC above the Cleanup Level of 0.20 µg/L. The desired capture zone width for extraction system is approximately 500-1,000 feet. Groundwater modeling was used to estimate the extraction needed at each well to achieve the design capture width (Papadopulos, 1993, 2003). The extraction rate required to develop the appropriate capture width was determined to be 6,545 ft^3/day, or 34 gpm (Papadopulos, 1993, 2003).

Typically, groundwater extraction of multiple aquifer "pore volumes (PVs)" is required to achieve groundwater cleanup for chlorinated solvents, due to their sorption to aquifer materials. The restoration of groundwater requires that sufficient groundwater be flushed through the contaminated zone to remove dissolved contaminants and contaminants that will desorb from the aquifer material. The PV represents the actual volume of groundwater present within the pore space of the aquifer. The PV is calculated as follows:

$$PV = B \times \eta \times A$$

Where,

B = average thickness of the target plume area (ft)

η = formation porosity

A = area of targeted plume (ft^2)

The area of groundwater containing VC at concentrations above 0.20 µg/L was estimated to be approximately 320,000 ft^2 (7.3 acres). As described in the FRI, the average thickness of the target plume area is approximately 40 feet. Assuming a porosity of 0.25, the PV is approximately 3,177,850 ft^3 (23,771,969 gallons). The PV would be addressed by CG-4.

At many pump and treat sites, numerous PVs must be flushed through the contamination zone to attain cleanup standards (EPA, 1997). Assuming linear sorption, absence of NAPL or soil source, no biodegradation, and discounting dispersion, the number of PVs required for restoration is a function of the retardation factor (R), which is the ratio of the groundwater velocity to the dissolved VC transport velocity. The number of PVs is calculated as follows (EPA 1997):

$$\text{No. of } PVs = -R \times \ln (Cwt/Cwo)$$

Where,

Cwt = cleanup concentration goal for VC (0.20 µg/L)

Cwo = current groundwater VC concentration (26 µg/L at HEX-8)

Assuming a fractional organic carbon content of 0.0001 for the sandy aquifer and VC partition coefficient of 22.9 L/kg (EPA, 1996), R is calculated to be approximately 1.01. Using the VC Cwt = 0.20 µg/L (i.e., MTCA Method A Standard for GW) and VC Cwo = 26 µg/L (HEX-8), the numbers of PVs that would need to be extracted to restore the Site plume is 4.92. To account for the fact that the extraction wells will also extract water containing VC at concentrations less than 0.20 µg/L, a safety factor of 2 was applied to estimate the total volume of water to be extracted to achieve the target cleanup level. Thus, it was estimated that the extraction system would have to extract ~10 PVs to achieve cleanup objectives. At the estimated extraction rates (34 gpm), the extraction system would operate for approximately 13.3 years.

Minimum costs associated with implementation of Alternative 1 are estimated to be approximately $200,000/yr. Yearly O&M costs are associated with system operator labor, electricity, system maintenance, and groundwater monitoring. The alternative proposes to make use of the existing monitoring well network to evaluate remedial progress and performance. Because the existing system has been in place for 25 years, there are unknown capital costs associated with rehabilitation of extraction wells and replacement of aging infrastructure. In addition, uncertainty of the magnitude and duration of upgradient loading to the site could extend the required remedial timeframe for the groundwater extraction alternative. Total cost for implementing Alternative 1 would be $200,000 for 13 years, or $2,600,000.

Compliance with Threshold Requirements

Alternative 1 was evaluated against the four minimum threshold requirements specified under MTCA. It was concluded that Alternative 1 satisfies the four threshold requirements as described below:

- **Protect Human Health and the Environment** – Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. As described in the FRI, there are presently no unacceptable risks to human health or the environment. Specifically, the drinking water pathway for VC in groundwater was not complete due to an available public water supply. Further, there are no unacceptable risks associated with soil or soil vapor gas. Lastly, VC has not been detected in either surface water samples or sediment samples. As such, VC discharge to surface water or sediments does not appear to present unacceptable risk.

  Based on the performance evaluation presented, it is estimated that the Site Cleanup Standards will be achieved within approximately 13.3 years.

  Therefore, Alternative 1 is consistent with WAC 173-340-702(5) that states *"Cleanup actions that achieve cleanup levels at the applicable point of compliance under Methods A, B, or C (as applicable) and comply with applicable state and federal laws shall be presumed to be protective of human health and the environment."*

- **Comply with Cleanup Standards** – Site Cleanup Standards are anticipated to be achievable under Alternative 1. As noted under the previous requirement, the anticipated performance of Alternative 1 will likely result in Site Cleanup Standards being met within 13.3 years. Therefore, it was concluded that Alternative 1 satisfies this threshold requirement.

- **Comply with Applicable State and Federal Laws** – Based on the analysis of potential ARARs, it is anticipated that Alternative 1 would satisfy the applicable state and federal laws. Therefore, it was concluded that Alternative 1 satisfies this threshold requirement.

- **Provide for Compliance Monitoring** – Alternative 1 will include compliance monitoring, and therefore satisfies this threshold requirement.

The analysis of threshold requirements is summarized in **Table 5**. Based on the evaluation, Alternative 1 is considered compliant with the four MTCA Threshold Requirements and thus meets the minimum requirements of an acceptable cleanup action. The permanence and practicality of this Alternative are evaluated in Section 8.5.

8.3.2 Alternative 2 – Full Scale Enhanced In Situ Bioremediation

This section describes the EISB alternative and evaluates whether it satisfies the MTCA Threshold Requirements for a cleanup action.

<u>Technical Description & Cost</u>

The full scale EISB alternative would cover the groundwater plume area above 0.2 µg/L concentration that is accessible to injection. Because of the active manufacturing activities at the site limiting access, the full scale EISB cannot target the entire groundwater plume above 0.2 µg/L. Based on the prior EISB pilot studies performed at the site, the depth of injection would be from approximately 15 to 30 feet below ground surface (bgs).

The performance of a full-scale EISB alternative is anticipated to be similar to the pilot and expanded field treatability deployment of EISB already performed at the Site. Because EISB does not increase the flow of groundwater, the rate of VC reduction in the groundwater plume outside the area of the EISB injections will be unaffected. These areas not subjected to EISB will continue to see concentrations declines at MNA rates, with remedy duration of about ~4 years, same as MNA (see Section 8.3.4).

It is anticipated that the VC mass reduction due to the EISB will enhance the attenuation process within the plume and downgradient of the EISB area. However, the effect of EISB on the downgradient plume edges, as well as areas unavailable to injection, is not likely to be significant (i.e., VC concentrations at the lateral and longitudinal extents of the plume are likely to decline at the same rate as predicted for Alternative 3 & 4). The remedial duration of Alternative 2 is likely ~4 years.

Costs associated with implementation of Alternative 2 include deployment of EISB for an estimated cost of $350,000. In addition, the MNA cost would include yearly O&M

expenses associated with groundwater monitoring, which are estimated at $50,000/yr. The alternative proposes to make use of the existing monitoring well network to evaluate remedial progress and performance. Cost to implement Alternative 2 over four years would be $350,000 for EISB deployment plus $200,000 for MNA, for a total cost of $550,000.

Compliance with Threshold Requirements

Alternative 2 was evaluated against the four minimum threshold requirements specified under MTCA. It was concluded that Alternative 2 satisfies the four threshold requirements as described below:

- **Protect Human Health and the Environment** – Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. Similar to evaluation of Alternative 1, there are presently no unacceptable risks to human health or environment. Based on the performance evaluation presented, it is estimated that the Site Cleanup Standards will be achieved within approximately ~4 years.

  Therefore, Alternative 2 is consistent with WAC 173-340-702(5) that states *"Cleanup actions that achieve cleanup levels at the applicable point of compliance under Methods A, B, or C (as applicable) and comply with applicable state and federal laws shall be presumed to be protective of human health and the environment."*

- **Comply with Cleanup Standards** – Site Cleanup Standards are anticipated to be achievable under Alternative 2. As noted under the previous requirement, the anticipated performance of Alternative 2 will likely result in Site Cleanup Standards being met within ~4 years. Therefore, it was concluded that Alternative 2 satisfies this threshold requirement.

- **Comply with Applicable State and Federal Laws** – Based on the analysis of potential ARARs, it is anticipated that Alternative 2 would satisfy the applicable state and federal laws. Therefore, it was concluded that Alternative 2 satisfies this threshold requirement.

- **Provide for Compliance Monitoring** – Alternative 2 will include compliance monitoring, and therefore satisfies this threshold requirement.

The analysis of threshold requirements is summarized in **Table 5**. Based on the evaluation, Alternative 2 is considered compliant with the four MTCA Threshold

Requirements and thus meets the minimum requirements of an acceptable cleanup action. The permanence and practicality of this Alternative are evaluated in Section 8.5.

8.3.3 Alternative 3 – Site Wide MNA with Contingency for supplemental EISB

This section describes the MNA alternative combined with the contingency of using EISB when and where needed, and evaluates whether this alternative satisfies the MTCA Threshold Requirements for a cleanup action.

Technical Description & Cost

Natural attenuation is the process by which natural processes clean up or attenuate contaminants in groundwater. The term "monitored natural attenuation," refers to the reliance on natural processes to achieve site-specific remedial objectives, with on-going monitoring. Natural attenuation processes include a variety of physical, chemical, and/or biological processes that, under favorable conditions, reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants (EPA, 1999).

The concentration trends for VC in the shallow aquifer through June 2018 at the on- and off-Site monitoring wells are shown in Figures 18-20 in the FRI (Clear Creek, 2018). Since 2012, subsequent to completion of the source area control actions for Parcel G at the adjacent BSB property, the mass of VOC dissolved in groundwater has been subject to various fate and transport mechanisms, destructive and non-destructive, that have influenced the observed distributions of VC. The VC concentrations along the flow path have been decreasing and will continue to decrease under the influence of the following mechanisms: (i) continued enhanced biodegradation, (ii) advective-based dispersion, (iii) recharge of groundwater that does not contain VC, (iv) sorption to aquifer solids. As pointed out above, the evolution of VOCs at the site, from TCE to cDCE and VC, indicates that natural attenuation processes by biodegradation are active at the site.

The time trend data can be analyzed to estimate average site-specific degradation rate constants. Degradation rate constants were estimated for select monitoring wells using methods outlined in *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies* (EPA, 2002). The degradation rate constant, based on monitoring results from 2015 to 2018, was estimated from trend plots for PS-1 and HEX-8 (Figure 3a). Degradation rates of VC for HEX-6 and CG-4 were also estimated from trend plots (Figure 3b). Using the VC Cleanup Standard of 0.20 µg/L, it is anticipated the cleanup standard will be achieved at these individual monitoring wells in between approximately 3 years and 7 years from 2015, or 2018 and 2022. The degradation rates for PS-1, HEX-8, and CG-4 are influenced by the recent expanded EISB field deployment, and will require recurring evaluation as new monitoring data are acquired.

The graphs plotted in Figure 3a and 3b are forecasts of future conditions based on historical data that are designed for remedial planning purposes. However, site groundwater conditions are subject to seasonal water level and geochemistry fluctuations that may affect actual future VC concentrations.

A plot of concentration of VC vs. distance to the property boundary, or point of compliance, indicates that the degradation rates and times estimated as described above and illustrated in Figure 3 will be effective in reaching cleanup standards in groundwater prior to groundwater migrating off-site (Figure 4). The estimated travel time from HEX-8 to the property boundary, based on aquifer properties described in the FRI (Clear Creek, 2018), is approximately 7 years. Both this estimated travel time, and data plotted on Figure 4 for downgradient groundwater wells, indicate sufficient time for MNA processes to meet remedial objectives.

As pointed out in the FRI (Clear Creek, 2018), upgradient loading continues to occur from Parcel G. The plots of VC concentrations vs. time and distance (Figures 3 and 4) indicate that at present this upgradient loading is interpreted to occur at a rate that is less than natural attenuation occurring in groundwater at the Hexcel Plant. The contingency for supplemental EISB will be considered if upgradient loading is determined to exceed MNA processes at the site.

The CAP will fully describe the implementation of the preferred alternative, but for an MNA with contingency for supplemental EISB alternative, the CAP could include response actions such as targeted EISB deployments under specified circumstances. Supplemental EISB would be targeted at specific locations where MNA alone is not meeting remedial goals, as outlined in the CAP and compliance monitoring work plan.

Capital costs associated with implementation of Alternative 3 are low to moderate. The alternative proposes to make use of the existing monitoring well network to evaluate remedial progress and performance. Yearly O&M costs will consist of expenses associated with groundwater monitoring and reporting. The cost of this alternative is estimated to be $50,000/year for MNA costs. Supplemental EISB costs assume one additional deployment of similar size as the expanded EISB deployment in the summer of 2017, with an estimated cost of $150,000. Total cost for this alternative would be approximately $350,000 over four years.

Compliance with Threshold Requirements

Alternative 3 was evaluated against the four minimum threshold requirements specified under MTCA. It was concluded that Alternative 3 satisfies the four threshold requirements as described below:

- **Protect Human Health and the Environment** – Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. As described in the FRI, there are presently no unacceptable risks to human health or the environment. Specifically, the drinking water pathway for VC in groundwater was not complete due to an available public water supply. Further, there are no unacceptable risks associated with soil or soil vapor gas. Lastly, VC has not been detected in either surface water samples or sediment samples. As such, VC discharge to surface water or sediments does not appear to present unacceptable risk.

  Based on the VC concentration trend analysis in groundwater, it is estimated that the Site Cleanup Standards will be achieved in approximately four years at the on-Site monitoring well with the current highest VC concentration (e.g., HEX-8). Off-Site wells are already below Cleanup Standards.

  Therefore, Alternative 3 is consistent with WAC 173-340-702(5) that states *"Cleanup actions that achieve cleanup levels at the applicable point of compliance under Methods A, B, or C (as applicable) and comply with applicable state and federal laws shall be presumed to be protective of human health and the environment."*

- **Comply with Cleanup Standards** – Site Cleanup Standards are anticipated to be achievable under Alternative 3. As noted under the previous requirement, the VC concentration trend analysis for PS-1 and HEX-8 indicate that Site Cleanup Standards will be met on-Site in approximately four years. Travel times for present concentrations of groundwater at PS-1 and HEX-8 to the northern property boundary are on the order of seven years. Therefore, it was concluded that Alternative 3 satisfies this threshold requirement.

- **Comply with Applicable State and Federal Laws** – Based on the analysis of potential ARARs, it is anticipated that Alternative 3 would satisfy the applicable state and federal laws. Therefore, it was concluded that Alternative 3 satisfies this threshold requirement.

- **Provide for Compliance Monitoring** – Alternative 3 will include compliance monitoring, and therefore satisfies this threshold requirement.

The analysis of threshold requirements is summarized in Table 5. Based on the evaluation, Alternative 3 is considered compliant with the four MTCA Threshold Requirements and thus meets the minimum requirements of an acceptable cleanup action. The permanence and practicality of this Alternative are evaluated in Section 8.5.

8.3.4 Alternative 4 – Site-Wide MNA

This section describes the MNA alternative and evaluates whether it satisfies the MTCA Threshold Requirements for a cleanup action.

Technical Description & Cost

Natural attenuation is the process by which natural processes clean up or attenuate contaminants in groundwater. The term "monitored natural attenuation," refers to the reliance on natural processes to achieve site-specific remedial objectives, with on-going monitoring. Natural attenuation processes include a variety of physical, chemical, and/or biological processes that, under favorable conditions, reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants (EPA, 1999).

The concentration trends for VC in the shallow aquifer through June 2018 at the on- and off-Site monitoring wells are shown in Figures 18-20 in the FRI (Clear Creek, 2018). Since 2012, subsequent to completion of the source area control actions for Parcel G at the adjacent BSB property, the mass of VOC dissolved in groundwater has been subject to various fate and transport mechanisms, destructive and non-destructive, that have influenced the observed distributions of VC. The VC concentrations along the flow path have been decreasing and will continue to decrease under the influence of the following mechanisms: (i) continued enhanced biodegradation, (ii) advective-based dispersion, (iii) recharge of groundwater that does not contain VC, (iv) sorption to aquifer solids.

The time trend data can be analyzed to estimate average site-specific degradation rate constants. Degradation rate constants were estimated for select monitoring wells using methods outlined in *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies* (EPA, 2002). The degradation rate constant, based on the monitoring results from 2015-2018, was estimated from trend plots for PS-1 and HEX-8 (Figure 3a). Degradation rates of VC for HEX-6 and CG-4 were also estimated from trend plots (Figure 3b). Using the VC Cleanup Standard of 0.20 µg/L, it is anticipated the cleanup standard will be achieved at these individual monitoring wells in between approximately three years and seven years from 2015, or 2018 and 2022. These degradation rates for PS-1, HEX-8, and CG-4 are influenced by the recent expanded EISB field deployment, and will require recurring evaluation as new monitoring data are acquired.

The graphs plotted in Figure 3a and 3b are forecasts of future conditions based on historical data that are designed for remedial planning purposes. However, site groundwater conditions are subject to seasonal water level and geochemistry fluctuations that may affect actual future VC concentrations.

A plot of concentration of VC vs. distance to the property boundary, or point of compliance, indicates that the degradation rates and times estimated as described above and illustrated in Figure 3 will be effective in reaching cleanup standards in groundwater prior to groundwater migrating off-site (Figure 4). The estimated travel time from HEX-8 to the property boundary, based on aquifer properties described in the FRI (Clear Creek, 2018), is approximately seven years. Both this estimated travel time, and data plotted on Figure 4 for downgradient groundwater wells, indicate sufficient time for MNA processes to meet remedial objectives.

As pointed out in the FRI (Clear Creek, 2018), upgradient loading continues to occur from Parcel G. The plots of VC concentrations vs. time and distance (Figures 3 and 4) indicate that at present this upgradient loading is interpreted to occur at a rate that is less than natural attenuation occurring in groundwater at the Hexcel Plant.

Capital costs associated with implementation of Alternative 4 are low. The alternative proposes to make use of the existing monitoring well network to evaluate remedial progress and performance. Yearly O&M costs will consist of expenses associated with groundwater monitoring and reporting. The cost of this alternative is estimated to be $50,000/year. Total cost to implement Alternative 4 would be $200,000 over four years.

Compliance with Threshold Requirements

Alternative 4 was evaluated against the four minimum threshold requirements specified under MTCA. It was concluded that Alternative 4 satisfies the four threshold requirements as described below:

- **Protect Human Health and the Environment** – Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. As described in the FRI, there are presently no unacceptable risks to human health or the environment. Specifically, the drinking water pathway for VC in groundwater was not complete due to an available public water supply. Further, there are no unacceptable risks associated with soil or soil vapor gas. Lastly, VC has not been detected in either surface water samples or sediment samples. As such, VC discharge to surface water or sediments does not appear to present unacceptable risk.

  Based on the VC concentration trend analysis in groundwater, it is estimated that the Site Cleanup Standards will be achieved within approximately four years at the on-Site monitoring well with the current highest VC concentration (e.g., HEX-8). Off-Site wells are already below Cleanup Standards.

  Therefore, Alternative 4 is consistent with WAC 173-340-702(5) that states *"Cleanup actions that achieve cleanup levels at the applicable point of compliance under Methods A, B, or C (as applicable) and comply with applicable state and federal laws shall be presumed to be protective of human health and the environment."*

- **Comply with Cleanup Standards** – Site Cleanup Standards are anticipated to be achievable under Alternative 4. As noted under the previous requirement, the VC concentration trend analysis for PS-1 and HEX-8 indicate that Site Cleanup Standards will be likely be met on-Site in approximately four years. Travel times for present concentrations of groundwater at PS-1 and HEX-8 to the northern property boundary are on the order of seven years. Therefore, it was concluded that Alternative 4 satisfies this threshold requirement.

- **Comply with Applicable State and Federal Laws** – Based on the analysis of potential ARARs, it is anticipated that Alternative 4 would satisfy the applicable state and federal laws. Therefore, it was concluded that Alternative 4 satisfies this threshold requirement.

- **Provide for Compliance Monitoring** – Alternative 4 will include compliance monitoring, and therefore satisfies this threshold requirement.

The analysis of threshold requirements is summarized in Table 5. Based on the evaluation, Alternative 4 is considered compliant with the four MTCA Threshold Requirements and thus meets the minimum requirements of an acceptable cleanup action. The permanence and practicality of this Alternative are evaluated in Section 8.5.

8.4 Disproportionate Cost Analysis

A DCA was performed to determine which of the cleanup action alternatives is protective to the maximum extent practicable. The estimated benefit of each alternative was quantified using the DCA criteria described in Section 8.2.3. For each cleanup action alternative, rating values ranging from 1 (least favorable) to 5 (most favorable) were assigned for each of the MTCA criteria. **Tables 5 and 6** provides the numeric ratings and corresponding rationale for each alternative and criteria. The conclusions provided in **Tables 5 and 6** are discussed below:

8.4.1 Protectiveness

The four alternatives were determined to be protective of human health and environment. As noted previously, there are presently no unacceptable risks to human health or the environment based on the pathway and receptor evaluation. As such, each alternative was initially given a value of 5 for protectiveness. However, this criterion requires that "on-site and offsite risks resulting from implementing the alternative, and improvement of the overall environmental quality" be considered. Therefore, Alternative 1 and 2 were give a value of 4 due to risks associated with implementation of both of these including safety and sustainability creating a greater overall environmental footprint (e.g. increased energy use and construction impacts).

8.4.2 Permanence

Each of the alternatives provides for a reduction in VC toxicity, mobility, and volume. Alternatives 1, 2, and 3 were given a rating of 4, and Alternative 4 was given a rating of 3. Alternative 1 would achieve VC mass reduction through the extraction of groundwater. Operation of the extraction system would target containment of groundwater containing VC at concentrations above the cleanup level of 0.20 μg/L. Alternative 1 did not receive a rating of 5 given the inefficiency of the system (i.e., high volume of extraction compared to the rather small mass of VC removal; higher energy usage; disruption of groundwater resources; and overall low sustainability). Alternative 2 would achieve VC mass reduction through in situ treatment of VC in groundwater. Alternative 2 did not receive a rating of 5 given that a portion of the VC plume would not be actively targeted for treatment because of site access limitations. Alternative 3 achieves mass reduction through ongoing destructive natural attenuation processes such as hydrolysis and anaerobic degradation, combined with contingency of EISB should these processes not occur at sufficient rates. Alternative 3 was given a rating of 4 for these reasons. Alternative 4 achieves mass reduction through ongoing destructive natural attenuation processes such as hydrolysis and anaerobic degradation. In addition, VC mobility is reduced through sorption to aquifer solids. Toxicity is also reduced via dilution due to dispersion, groundwater recharge, and other physical processes. Alternative 4 is not rated as high as the other Alternatives because of the possibility for a longer timeframe for Alternative 4 caused by stalled MNA processes. The permanence of all four alternatives assumes the Parcel G remedy remains effective.

8.4.3 Cost

Alternative 4 is estimated to have the lowest cost (~$50,000/yr over ~4 years; ~$200,000 total cost) and was given a rating of 5. Alternative 1 is estimated to have the highest cost (~ $200,000/yr for up to ~13 years; ~$2,600,000 total cost); Alternative 1 was given a rating of 2. The estimated cost of Alternative 2 is $550,000 ($350,000, plus $200,000 MNA costs) and was given a rating of 3. Alternative 3 is estimated to have the second lowest cost (~$50,000/years over ~4 years; plus $150,000 for additional contingency EISB injections, for a total Alternative 3 cost of $350,000) and was given a rating of 5. As noted previously, no weighting factor was applied to this criterion in the calculation of each alternatives overall numeric benefit.

The extended timeframe for Alternative 1 (~13 years for groundwater extraction) compared with Alternative 4 (~4 years for MNA), highlights the advantage of *in situ* degradation vs. mass removal.

8.4.4 Long-Term Effectiveness

Several factors [WAC 173-340-360(3)(f)(iv)] were considered to rate the four alternatives on their long-term effectiveness. The factors and their evaluation with respect to the four alternatives are described as follows:

- Degree of certainty that the alternative will be successful – each alternative is expected to be successful in achieving site remediation if implemented. It is anticipated that Alternative 1 may be the least efficient of the alternatives given that the performance of the groundwater extraction system may be limited by lenses of low hydraulic conductivity and/or rate-limited desorption. While rate-limiting factors will affect all four alternatives, under active pumping conditions these rate-limiting mechanisms will have a greater influence on Alternative 1 performance than under the ambient flow conditions present for Alternatives 2, 3, and 4.

- Reliability of the alternative during the period of time VC may remain at concentrations that exceed cleanup levels – Alternatives 2, 3, and 4 are expected to have a greater degree of reliability than Alternative 1 for the following reasons. First, there is no current unacceptable risk associated with the presence of VC in groundwater. Given that Alternatives 2, 3, and 4 provide mass reduction in situ, there is limited potential for human exposure to VC during remedy implementation. In contrast, Alternative 1 requires the extraction, conveyance, and effluent management of groundwater containing VC. If an equipment malfunction associated with operation of the pump and treat system occurs, there is the potential for human exposure and/or an environmental impact.

- Magnitude of residual risk with the alternative in place – the residual risk associated with each alternative is anticipated to be within acceptable levels.

Based on these factors, Alternatives 2, 3, and 4 were given a rating of 5 while Alternative 1 was given a rating of 4.

8.4.5 Management of Short-Term Risks

Alternatives 3 and 4 were given a rating of 5 because they minimize impacts to human health and the environment in the short term by minimizing invasive activities associated with implementation. In contrast, Alternatives 1 and 2 would involve significant activities as part of implementation creating higher short-term risks. Examples of short term risk include system shutdown or conveyance failure for Alternative 1, and surfacing of injected material or unexpected plume migration during implementation for Alternative 2. Alternative 1 was rated a 4 and Alternative 2 was rated a 3.

8.4.6 Implementability (Technical and Administrative)

Alternatives 3 and 4 are readily implementable and was given a rating of 5.

Alternative 1 is implementable. Based on low concentrations of VC in groundwater, the hydraulic conductivity of the aquifer, and lateral extent of the plume, a pumping rate of approximately 34 gpm will be expected. Alternative 1 would require the removal of substantial amount of water in order to remove a small amount of VC mass. Overall, Alternative 1 was rated a 4 for implementability.

Alternative 2 is implementable, subject to access limitations at the site caused by facility infrastructure restricting access to the entire groundwater plume. Alternative 2 is rated a 3 for implementability.

8.4.7 Consideration of Public Concerns

It is anticipated that each of the alternatives will address potential concerns the public may have regarding alternative implementation. However, it is anticipated that MNA or MNA with contingency for supplemental EISB may be favored by the public on the basis of lower impact from implementation, and better sustainability metrics (less energy use and emissions, better safety metric). As such, MNA and MNA with contingency for supplemental EISB were rated 5, whereas groundwater extraction and EISB were each rated a 3.

8.4.8 Weighted Ratings & DCA

The absolute ratings above were adjusted using the DCA weighting factors described in Section 8.2.3. **Table 6** presents the weighted ratings and the estimated benefit of each alternative. The estimated benefit of Alternative 3 (normalized to a value of 5) is 4.8. The estimated benefits of Alternatives 1 and 2 were each 3.9, and alternative 4 is 4.6. Given that Alternative 3 is the highest rated alternative and not significantly higher in cost than the lowest cost alternative, a formal DCA is not required per MTCA.

8.5 Reasonable Restoration Timeframe Analysis

The MTCA specified factors were considered to determine whether Alternative 3 (i.e., the highest rated alternative based on the DCA) provides for a reasonable restoration time frame. The evaluation factors and analysis are summarized below:

- **Potential risks posed by the site to human health and the environment** – There are no current or likely future unacceptable risks at the Site, therefore the estimated restoration time frame for the highest concentration areas is reasonable.

- **Practicability of achieving a shorter restoration time frame** – Based on the evaluation of the DCA criteria, it is not practicable to reduce the restoration time frame.

- **Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site** – Based on existing conditions, there are no anticipated effects on current uses that would result during the anticipated restoration time frame.

- **Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site** – Based on likely future uses within the plume area, it is unlikely that potential future uses will be negatively impacted by the presence of VC in the groundwater during the anticipated restoration time frame.

- **Availability of alternative water supplies** – Connections to City of Kent water supply are available for all affected properties.

- **Likely effectiveness and reliability of institutional controls** – Water supply by the City of Kent provides an effective and reliable means to prevent human exposure to VC in groundwater.

- **Ability to control and monitor migration of hazardous substances from the site** – Compliance monitoring will be implemented as part of the remedy and will provide adequate data to evaluate whether remediation is progressing as anticipated. It will also provide data to evaluate whether unacceptable migration of the plume is occurring.

- **Toxicity of the hazardous substances at the site** – VC concentrations at the Site are relatively close to the proposed cleanup level of 0.20 µg/L. Given the absence of a complete exposure pathway for groundwater, there are no anticipated negative effects due to VC toxicity.

- **Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions** – The VC time trend analysis and the estimated first-order decay rates indicate that natural processes are reducing the concentrations of VC at the Site.

Based on this analysis, the estimated restoration time frame for Alternative 3 is considered reasonable.

8.6 Consider Public Concerns

It is anticipated that the public will support the acceptance of Alternative 3 for several reasons:

- There are no unacceptable risks currently at the Site;
- VC concentrations are declining and are less than cleanup levels at off-property locations, and will meet cleanup levels in approximately four years on Site;
- There are no use restrictions imposed by Alternative 3 that are not already met as a result of local municipal water supply;
- Alternative 3 does not require, or may require minimal, construction activities and thus will not inconvenience residents or property owners during implementation; and
- Alternative 3 is more sustainable than Alternatives 1 and 2, consuming substantially less energy, producing substantially less CO_2 emissions, and having by far the best safety/accident risk metric.

Based on the above evaluation the public is likely to prefer Alternative 3.

8.7 Recommended Cleanup Action Alternative

Based on the analyses presented in the FRI and this FFS Report, the recommended cleanup action alternative for the Site is Alternative 3 - Monitored Natural Attenuation with a contingency for supplemental EISB implementation. WAC 173-340-370 states the expectations that Ecology has for the development of cleanup action alternatives under WAC 173-340-350 and the selection of cleanup actions under WAC 173-340-360. The factors pertinent to the recommendation of Alternative 3 are summarized below:

- **WAC 173-340-370(6):** *The department expects that, for facilities adjacent to a surface water body, active measures will be taken to prevent/minimize releases to surface water via surface runoff and groundwater discharges in excess of cleanup levels. The department expects that dilution will not be the sole method for demonstrating compliance with cleanup standards in these instances.* – Based on the non-detect samples for surface water and sediment during monitoring, attenuation of the VC plume to concentrations less than the cleanup levels is occurring, preventing unacceptable risks to Springbrook Creek. The attenuation processes are likely to include hydrolysis, anaerobic degradation, and sorption, thus dilution is not the sole mechanism resulting in compliance.

- **WAC 173-340-370(7):** *The department expects that natural attenuation of hazardous substances may be appropriate at sites where:*

  (a) *Source control (including removal and/or treatment of hazardous substances) has been conducted to the maximum extent practicable* – Source area control was conducted for Parcel G. Subsequent source investigations indicated that VC was not present in soil and soil gas within the Plant 1 footprint.

  (b) *Leaving contaminants on-site during the restoration time frame does not pose an unacceptable threat to human health or the environment* – There are no current or anticipated future unacceptable risks associated with the presence of VC at the Site.

  (c) *There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site* – The presence of VC is an indication that biodegradation of parent VOCs has occurred. VC is known to degrade via hydrolysis and anaerobic biodegradation pathways. The VC time trend analysis and the estimated first-order decay rates indicate that VC concentrations are decreasing at significant rates within the plume footprint.

  (d) *Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected* – Compliance monitoring will be performed as part of Alternative 3, thus satisfying this requirement.

- **WAC 173-340-370(8):** *The department expects that cleanup actions conducted under this chapter will not result in a significantly greater overall threat to human health and the environment than other alternatives* – As demonstrated during the DCA, Alternative 3 minimizes potential risks to human health during remedy implementation and has the second smallest environmental footprint of the four alternatives considered in this FFS Report.

In addition to the above listed expectations, overall sustainability of Alternative 3 is higher, based on expected energy use and environmental impacts associated with energy use, than Alternatives 1 and 2. Based on this review of Ecology expectations for cleanup action alternatives, Alternative 3 is consistent MTCA requirements and thus is proposed as the recommended alternative for the Site.

9. CONCLUSIONS

Geosyntec has evaluated a variety of remedial alternatives for the Hexcel site in order to meet cleanup standards for VC impacts to groundwater. The preferred alternative that is consistent with regulatory requirements is Alternative 3 – MNA with a contingency for supplemental EISB. Implementation will follow conclusion of the EISB expanded pilot test, and with details of the approach to compliance and confirmational monitoring detailed in a Cleanup Action Plan.

10. REFERENCES

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Tables

Table 1
Applicable, Relevant and Appropriate Requirements (ARARs)
Hexcel Plant 1, Kent, Washington

Action	Citation	Requirements	Comments
Construction	29 CFR Part 1910.120 Occupational Safety and Health Standards - Hazardous Waste Operations and Emergency Response	Federal regulation requiring that remedial activities must be in accordance with applicable Occupational Safety and Health Administration (OSHA) requirements.	Applicable to construction phase of remedial alternatives.
	29 CFR Part 1926 Safety and Health Regulations for Construction	Federal regulation requiring that remedial construction activities must be in accordance with applicable OSHA requirements.	Applicable to construction phase of remedial alternatives.
	King County Title 20	County regulations covering construction and infrastructure regulations.	Applicable to construction of treatment system alternatives.
Treatment	42 USC 6902 (RCRA)	Defines Hazardous waste management requirements.	Applies to management of hazardous/dangerous waste. If wastes are accumulated in treatment system they will be managed in accordance with these requirements.
	RCW 70.105D.090 (Model Toxics Control Act)	Defines hazardous waste cleanup policies.	Remedial activities will comply with substantive requirements of ARARS.
	WAC 173-340 (MTCA regulations)	Establishes administrative processes and standards to identify, investigate and clean up facilities where hazardous substances have come to be located.	Applies to any facility where hazardous substance releases to the environment have been confirmed.
	State Hazardous Waste Management Act (HWMA) RCW 70.105	Defines threshold levels and criteria to determine whether materials are hazardous/dangerous waste.	Applies to designation, handling, and disposal of wastes. Treatment system wastes meeting these criteria will be handled and disposed of in accordance with regulatory requirements.
Extraction wells	Well Construction RCW 18.104 WAC 173-160	Requirements that apply to wells and well construction.	Applies to construction of extraction wells for pump and treat alternative.
Transportation	40 CFR 261, 262, 264; 49 CFR 171, 172, 173, 174 Hazardous Materials Transportation	Defines requirements for off-site transportation of wastes.	Applicable to transportation of waste off-site. Applies to treatment alternative. Actions will comply with these requirements.
	WAC 446-50 Transportation of hazardous/dangerous waste	Defines requirements for off-site transportation of wastes.	Applicable to transportation of waste off-site. Applies to treatment alternative. Actions will comply with these requirements.

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Table 2
Potential Groundwater Cleanup Levels for Vinyl Chloride
Hexcel Plant 1, Kent Washington

	Groundwater Protection (µg/L)		Concentration Protective of Surface Water (µg/L)									
			National Toxics Rule (1)				National Recommended Water Quality Criteria				MTCA Method B	
Analyte	Federal & State MCL	MTCA Method A	Protection of Aquatic Life - Freshwater		Protection of Human Health (Water & Organisms) (4)	Protection of Human Health (Organisms Only)	Protection of Aquatic Life - Freshwater		Protection of Human Health (Water & Organisms) (4)	Protection of Human Health (Organisms Only)	Carcinogen	Non-Carcinogen
			Acute	Chronic			Acute	Chronic				
Vinyl Chloride	2.0	0.20	--	--	0.025	2.4	--	--	0.025	2.4	3.7	24.0

Notes:

(1) Ambient water quality criteria for protection of human health from 40 CFR Part 131d (National Toxics Rule, 2008)

(2) National Recommended Water Quality Criteria (Clean Water Act Section 304, 2006)

(3) Ambient water quality criteria for protection of aquatic life from WAC 173-201A-240

(4) Criterion is not applicable because surface water near and directly downgradient of the Site is not and will not likely be used for drinking water

[yellow box] Most stringent applicable cleanup level

Table 3
Identification and Initial Screening of Remedial Technologies
Hexcel Plant 1, Kent Washington

General Response Action	Remedial Technology	Process Option	Description	Screening Comments	Retained for Process Evaluation
Institutional actions	Monitoring	Groundwater and surface water monitoring	Periodic sampling and analyses of groundwater as a means of detecting changes in constituent concentrations in groundwater	Potentially applicable	Yes
		Vapor intrusion (VI) evaluation/monitoring	Evaluation of VI risk in future inhabitable structures within the areal extent of the groundwater VOC plume	Based on the evaluation, there is no potential pathway of concern for VC exposure via vapor intrusion	No
	Use restrictions	Institutional restrictions	Restrictions on groundwater use where applicable until risk to groundwater exposure becomes acceptable	Potentially applicable	No
Collection/ Hydraulic containment	Extraction	Extraction wells	Installation of extraction wells to extract contaminated groundwater and control groundwater migration	Applicable. No ongoing groundwater extraction at Site. Starting in June 1990, an on-Site groundwater extraction pumped at a target rate of 34 gallons per minute; groundwater was pumped from a up to four wells (CG-1 to CG-4). The system was sequentially turned off. Last pumping well (CG-4) was turned off in late 2016	Yes
		Extraction trench	Removal of groundwater by pumping from extraction trenches	Trench length (>500 feet) makes this technology impractable	No
Collection/ treatment enhancements	Permeability enhancement	Pneumatic fracturing	Injection of high pressure air to create channels or fractures in subsurface material	Based on the observed site soil lithology, and as confirmed by relatively high yield of the extraction system, permeability enhancements are not required at the site	No
		Hydraulic fracturing	Injection of water, with or without a propping agent, into the subsurface to create permeable channels in subsurface material	Based on the observed site soil lithology, and as confirmed by relatively high yield of the extraction system, permeability enhancements are not required at the site	No
	Extraction enhancement	Vacuum-enhanced extraction	Simultaneous extraction of groundwater and soil vapor from one or more vacuum-enhanced extraction wells. Extracted groundwater and vapor are treated, followed by discharge or reinjection into the subsurface	No evidence of VOCs in vadose zone. Absence of impacted vadose zone. Enhanced extraction techniques for the site saturated zone are not necessary based on the yield of the extraction system	No
Monitored natural attenuation	Monitored natural attenuation	Monitored natural attenuation	Long-term monitoring of the natural attenuation and biotic and abiotic degradation/transformation of vinyl chloride	Potentially applicable. Time trend analysis of existing monitoring wells indicates declining VC concentrations throughout the footprint of the plume. The declining trends observed over the past 5 to 10 years are consistent with the occurrence of degradation/transformation processes indicative of ongoing attenuation	Yes

General Response Action	Remedial Technology	Process Option	Description	Screening Comments	Retained for Process Evaluation
In situ treatment	Biological treatment	Enhanced bioremediation	Injection of microbial populations, nutrient sources, electron donors, or other amendments into groundwater through injection wells to enhance biological degradation	Applicable, although the low level concentrations and large areal extent of the plume may limit the effectiveness of this technology	Yes
	Chemical treatment	Chemical oxidation	Injection of oxidants such as permanganate, hydrogen peroxide, or sodium persulfide into groundwater. Oxidation reactions chemically convert constituents to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert	Potentially applicable, although the low level concentrations and large areal extent of the plume may limit the effectiveness of this technology	Yes
		Chemical reduction	Injection of a reducing agent such as nanoscale or microscale zero valent iron into groundwater. Reduction reactions chemically convert constituents to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert	Potentially applicable, although the low level concentrations and large areal extent of the plume may limit the effectiveness of this technology	Yes
	Physical treatment	Air sparging	Injection of air into the saturated zone to volatilize constituents, which are collected in the unsaturated zone by a soil vapor extraction (SVE) system and treated if necessary	Technology is not well suited for low concentration large area groundwater plume	No
		In-well air stripping	Air is injected into the water column to volatilize constituents. Groundwater is circulated in situ, with groundwater entering the well at one screen and discharging through a second screen. Air is collected in the unsaturated zone by a SVE system and treated if necessary. Can be combined with vacuum-enhanced extraction for low permeability applications	Technology is not well suited for low concentration large area groundwater plume	No
	Thermal treatment	Hot water/steam injection	Injection of hot water/steam through injection wells to enhance the recovery of organic constituents. The injected hot water/steam heats the subsurface, volatilizing organic contaminants, with subsequent collection and treatment through a series of vapor extraction wells	Technology is best suited for source removal and not well suited for low concentration large area groundwater plume. Size of VOC plume will lead to significant cost	No
		Electrical resistance heating	A series of electrodes are installed around a central neutral electrode. Volatilized contaminants, produced by the heating of the subsurface surrounding the electrodes, are recovered using vapor extraction wells and subsequently treated at the surface	Technology is best suited for source removal and not well suited for low concentration large area groundwater plume. Size of VOC plume will lead to significant cost	No
		Thermal conduction/desorption	Heat is applied to groundwater through steel wells via thermal conduction and convection processes. Organic contaminants are volatilized through heating, and subsequently collected by a vapor extraction system for ex situ treatment	Technology is best suited for source removal and not well suited for low concentration large area groundwater plume. Size of VOC plume will lead to significant cost	No
		Radio frequency heating	Heating of the treatment zone using a configuration of electrodes to enhance the recovery of organic constituents. The subsurface area targeted for heating is bound by two rows of electrodes that act as ground electrodes. A third row of electrodes is implanted halfway between the ground rows, acting as a capacitor. Electromagnetic energy is applied, directly heating the volume of material contained within the ground electrodes, causing organic contaminants to vaporize. Vapor extraction wells remove contaminant vapors for ex situ treatment	Technology is best suited for source removal and not well suited for low concentration large area groundwater plume. Size of VOC plume will lead to significant cost	No

Table 4
Evaluation of Process Options
Hexcel Plant 1, Kent Washington

General Response Action	Remedial Technology	Process Option	**Effectiveness 1**	Implementability	Cost	**Retained for Alternative Development**	**Comments**
Institutional actions	Monitoring	Groundwater monitoring	Effective method for monitoring changes in groundwater CTC concentrations and thus identifying potential risk exposures. As a stand-alone process option, potential risk exposures (if identified) are not directly mitigated, but instead groundwater monitoring provides the data to assess the need for active exposure prevention measures (e.g., institutional restrictions). Useful for evaluating remedy effectiveness.	Readily implementable.	Low capital Low O&M	Yes	
	Use restrictions	Institutional restrictions	Limits the use of groundwater until groundwater presents no unacceptable risk.	Readily implementable	Low capital No O&M	No	Offsite groundwater meets cleanup standards. No potable use of local groundwater expected.
Collection/ Hydraulic containment	Extraction	Extraction wells	Effectiveness limited, primarily due to the large areal extent of the low-level CTC plume. It is anticipated that operation of an extraction system would require large volumes of groundwater to be pumped with little mass reduction or overall acceleration of site cleanup.	Previously implemented. Extraction wells and infrastructure for conveyance and treatment currently installed.	Medium to High capital Medium O&M	Yes	
Monitored natural attenuation (MNA)	Monitored natural attenuation	Monitored natural attenuation	Effective for reducing the volume and toxicity of low-level dissolved CTC in groundwater. Based on observed time trend analyses of VC concentrations in existing monitoring wells, permanent VC mass/concentration reduction is occurring and appears likely to meet remedial goals within an acceptable timeframe. The effectiveness of MNA to achieve permanent VC mass/concentration reduction is considered to be similar to, or better than, the effectiveness of the groundwater extraction process options (i.e., wells) because the remedial timeframes are likely to be similar.	Readily implementable. The existing monitoring well network appears adequate for monitoring of this process option.	Low capital Low O&M	Yes	
In situ treatment	Biological treatment	Enhanced bioremediation	Potentially effective in reducing the volume and toxicity of dissolved CTC in groundwater. Given the low level CTC concentrations in groundwater, it may be difficult to sustain bioremediation activities. Past experience has shown that the energy produced through the biodegradation of low level CTC (and other VOC) concentrations does not provide sufficient motive force to sustain the biodegradation processes.	Laboratory bench scale and field scale pilot tests previously implemented. Amendments readily available - many are food-grade and/or inexpensive. May require additional rounds of electron donor injection.	Medium capital Medium O&M	Yes	Due to the low level concentrations and large areal extent of the CTC plume, full scale enhanced bioremediation may not be a viable approach. The ability to sustain bioremediation processes is limited.
	Chemical treatment	Chemical oxidation	Potentially effective in reducing the volume and toxicity of dissolved VC in groundwater. Limits to technology may be the generally low concentrations and the extensive area needed to be treated. The low level of VC concentrations in the groundwater plume would result in competing chemical reactions limiting effectiveness of technology. Diffuse, widespread nature of VC groundwater plume makes technology deployment cost prohibitive.	Oxidizing agents readily available. Transportation and storage of large quantities of treatment chemicals requires compliance with appropriate permits and regulations. Potential health and safety hazards involved when handling large quantities of treatment chemicals.	Medium capital Medium O&M	No	Due to the low level concentrations and large areal extent of the VC plume, chemical oxidation is not considered a viable approach. Oxidation of the VC may be limited due to competing reactions.
		Chemical reduction	Potentially effective in reducing the volume and toxicity of dissolved VC in groundwater. Limits to technology may be the generally low concentrations and the extensive area needed to be treated. The low level of VC concentrations in the groundwater plume would result in competing chemical reactions limiting effectiveness of technology. Diffuse, widespread nature of VC groundwater plume makes technology deployment cost prohibitive.	Reducing agents readily available. Transportation and storage of large quantities of treatment chemicals requires compliance with appropriate permits and regulations. Potential health and safety hazards involved when handling large quantities of treatment chemicals.	Medium capital Medium O&M	No	Due to the low level concentrations and large areal extent of the VC plume, chemical reduction is not considered a viable approach. Reduction of the VC may be limited due to competing reactions.

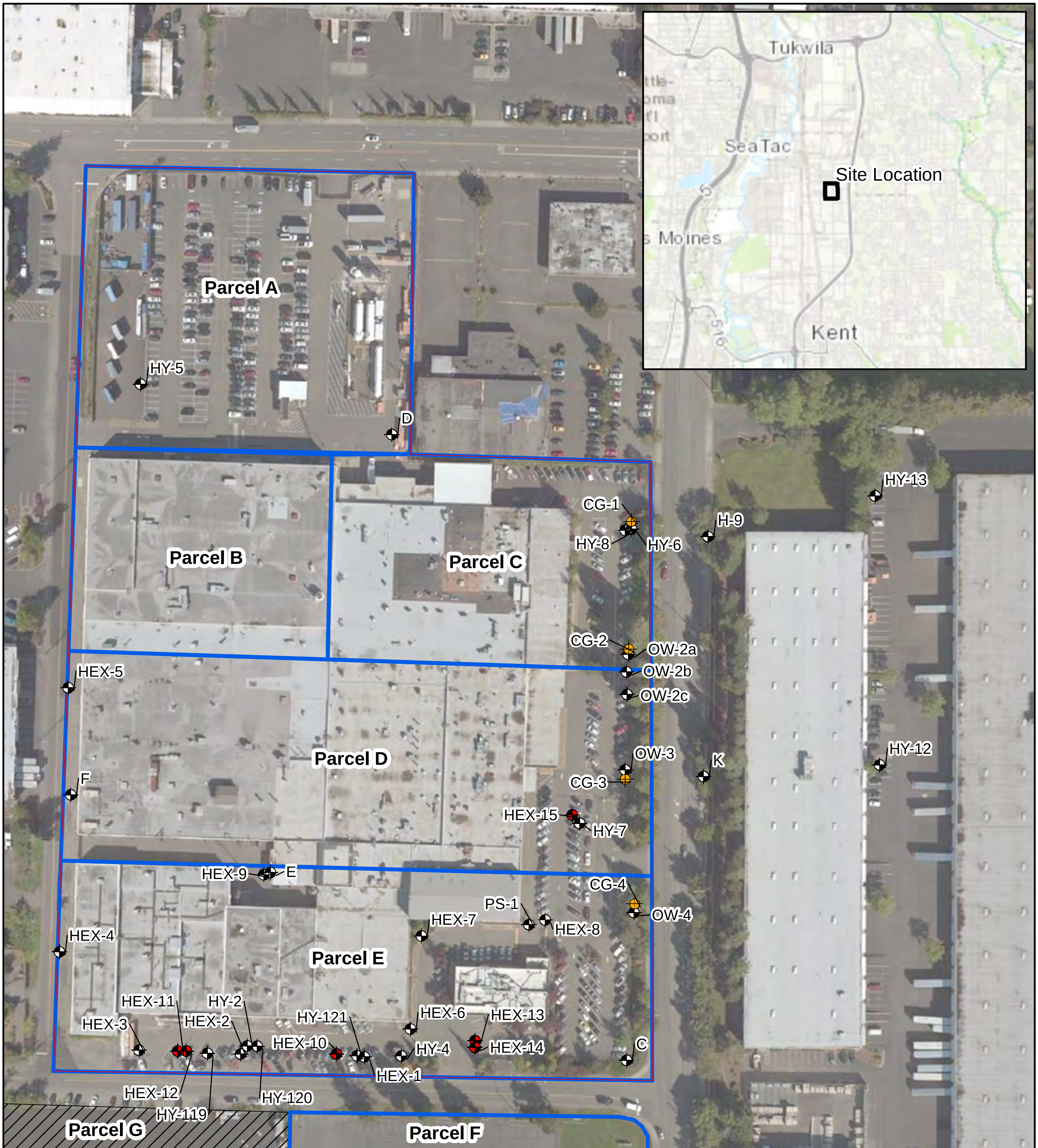
Table 5
Summary of Ratings for Detailed Analysis of Cleanup Action Alternatives
Hexcel Plant 1, Kent, Washington

Alternatives		MTCA Threshold Criteria				Disproportionate Cost Analysis (DCA)													
		Protection of Human Health and the Environment	Compliance with Cleanup Standards	Compliance with Applicable State and Federal Laws (i.e., ARARs)	Provision for Compliance Monitoring	Protectiveness		Permanence		Cost		Long-Term Effectiveness		Management of Short-Term Risks		Implementability (Technical and Administrative)		Consideration of Public Concerns	
							Rating		Rating		Rating		Rating		Rating		Rating		Rating
1	Groundwater Extraction	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	Complies with cleanup standards.	Complies with potential ARARs.	Provides for compliance monitoring.	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. Technology has greater overall environmental footprint compared to MNA.	4	Reduction of VC mass, mobility, and volume would occur upon initiation of groundwater extraction, although system may be inefficient (i.e., high volume of extraction compared to the rather small mass of VC removal and treatment).	4	Medium to high O&M costs. No existing extraction, occurring. Costs dependent on extent of groundwater plume targeted for pump and treat. O&M timeframe would be long.	2	P&T is expected to be successful in achieving site remediation, but the alternative is anticipated to be the least efficient alternative given that the performance of the P&T system may be limited by lenses of low hydraulic conductivity and/or rate-limited desorption. P&T is expected to be reliable, but the potential exists for contaminant exposure to receptors in the event of equipment malfunction. The magnitude of residual risk with the in-place system is anticipated to be within acceptable levels.	4	Implementation involve impacts to human health and the environment and short term-risks. This alternative had a medium safety/accident risk metric.	4	Implementable. Based on low concentrations of VC in groundwater, relatively high hydraulic conductivity of the aquifer, and lateral extent of the plume, a relatively high pumping rate would be required. The alternative would require the removal of a substantial amount of water in order to remove a small amount of VC mass.	4	Alternative is anticipated to address potential public concerns regarding alternative implementation.	3
2	EISB	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	Complies with cleanup standards.	Complies with potential ARARs.	Provides for compliance monitoring.	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards. Technology has greater overall environmental footprint compared to	4	Reduction of VC mass, mobility, and volume would occur for VC in groundwater.	4	Medium to high capital cost. Cost driven by area required to treat groundwater plume. O&M costs are low (monitoring only).	3	EISB is expected to be successful in achieving site remediation. EISB is expected to be reliable, and the magnitude of residual risk with the in-place system is anticipated to be within acceptable levels.	5	Construction activities and implementation involve impacts to human health and the environment and short term-risks. This alternative had the highest safety/accident risk metric.	3	Potentially implementable, subject to site operational challenges. Required area of groundwater remediation presents several implementation challenges.	3	Alternative is anticipated to address potential public concerns regarding alternative implementation.	3
3	MNA + EISB Contingency	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	Complies with cleanup standards.	Complies with potential ARARs.	Provides for compliance monitoring.	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	5	Reduction of VC mass, mobility, and volume would occur throughout the plume over time due to natural processes. VC mass reduction expected to be less than other alternatives.	4	Low capital and O&M cost.	5	Given the evidence of ongoing attenuation of the VC plume, MNA is expected to be successful in achieving site remediation. MNA is expected to be reliable, and the magnitude of residual risk with the in-place system is anticipated to be within acceptable levels.	5	Alternative minimizes impacts to human health and the environment in the short term by minimizing invasive activities associated with implementation.	5	Readily implementable.	5	Alternative is anticipated to address potential public concerns regarding alternative implementation.	5
4	MNA	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	Complies with cleanup standards.	Complies with potential ARARs.	Provides for compliance monitoring.	Human health and the environment will be protected during remedy implementation and upon achievement of the Site Cleanup Standards.	5	Reduction of VC mass, mobility, and volume would occur throughout the plume over time due to natural processes. VC mass reduction expected to be less than other alternatives.	3	Low capital and O&M cost.	5	Given the evidence of ongoing attenuation of the VC plume, MNA is expected to be successful in achieving site remediation. MNA is expected to be reliable, and the magnitude of residual risk with the in-place system is anticipated to be within acceptable levels.	5	Alternative minimizes impacts to human health and the environment in the short term by minimizing invasive activities associated with implementation.	5	Readily implementable.	5	Alternative is anticipated to address potential public concerns regarding alternative implementation.	5

Table 6
Disproportionate Cost Analysis
Hexcel Plant 1, Kent, Washington

Criteria	Alternatives			
	Groundwater Extraction	EISB	MNA + EISB Contingency	MNA
MTCA Threshold Criteria				
1. Protection of Human Health and the Environment	Yes	Yes	Yes	Yes
2. Compliance with Cleanup Standards	Yes	Yes	Yes	Yes
3. Compliance with ARARs	Yes	Yes	Yes	Yes
4. Provision for Compliance Monitoring	Yes	Yes	Yes	Yes
Restoration Time Frame	~13-14 Years	~4 Years	~4 Years	~4-7 Years
Unweighted Ratings (1 = Least Favorable; 5 = Most Favorable)				
Protectiveness	4	4	5	5
Permanence	4	4	4	3
Long-Term Effectiveness	4	5	5	5
Management of Short-Term Risks	4	3	5	5
Implementability	4	3	5	5
Consideration of Public Concerns	3	3	5	5
Estimated Benefit - Weighted Ratings				
Protectiveness (30%)	1.2	1.2	1.5	1.5
Permanence (20%)	0.8	0.8	0.8	0.6
Long-Term Effectiveness (20%)	0.8	1	1	1
Management of Short-Term Risks (10%)	0.4	0.3	0.5	0.5
Implementability (10%)	0.4	0.3	0.5	0.5
Consideration of Public Concerns (10%)	0.3	0.3	0.5	0.5
Benefit Rating	3.9	3.9	4.8	4.6
Disproportionate Cost Analysis				
Estimated Cost	~$200,000/yr $2,600,000 for 13 years	~$350,000 $550,000 for 4 years	~$50,000/yr + ~$150,000 EISB $350,000 for 4 years	~$50,000/yr $200,000 for 4 years
Cost Disproportionate to Incremental Benefits?	Yes	Yes	No	N/A (Baseline)
Overall Alternative Ranking	3	4	1	2
Cost Increase over Baseline (%)	1300%	275%	175%	

Figures



Legend

- Extraction Well
- Shallow Aquifer Monitoring
- Deep Aquifer Monitoring
- Site Location
- Parcel Boundary
- Parcel G

N

0 125 250 Feet

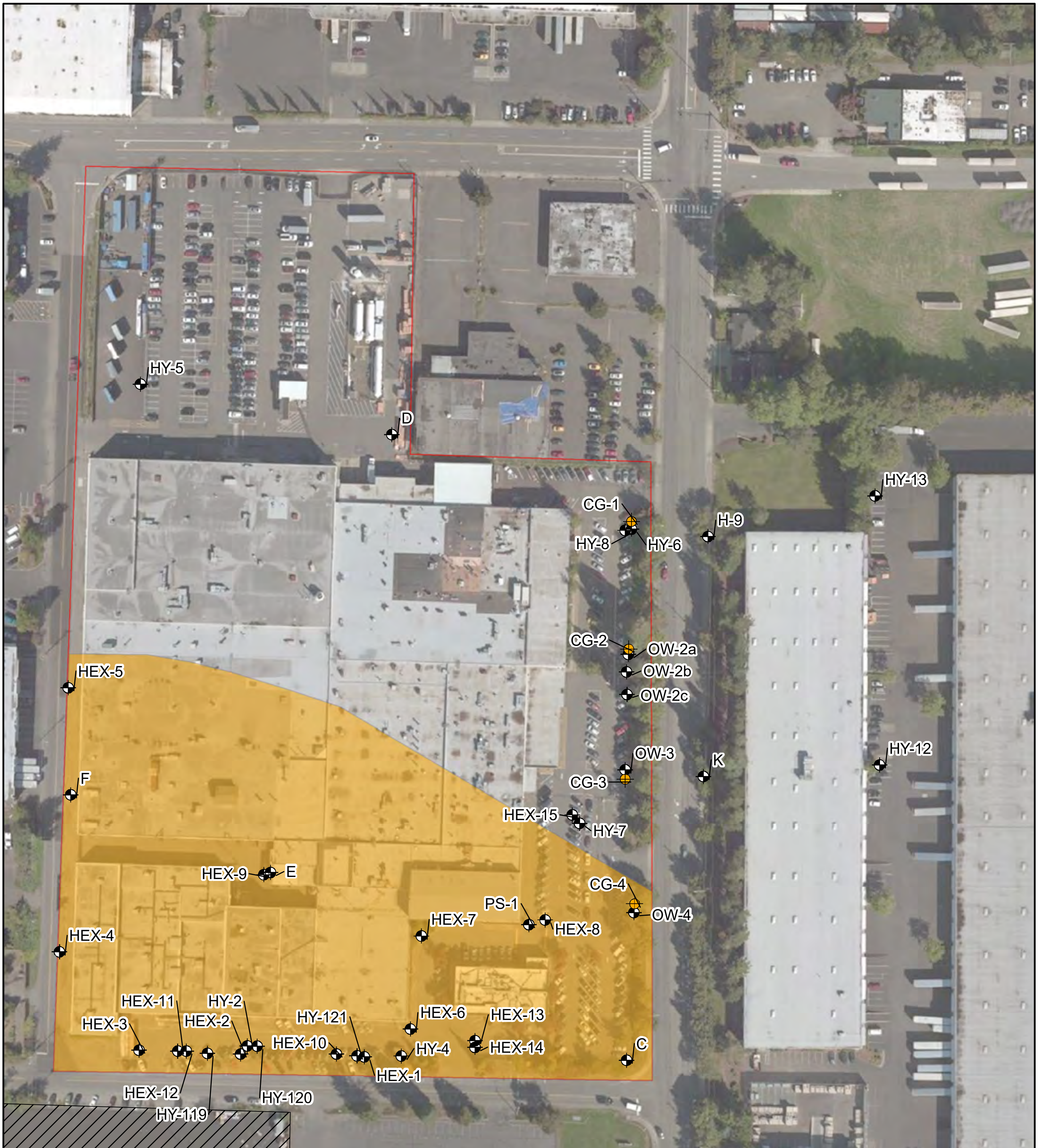
Groundwater Monitoring Well Locations
Hexcel Plant 1
Kent, Washington

Geosyntec consultants

Figure 1

Seattle | August 2018

P:\CAD_GIS\Projects\Hexcel_Kent\MXDs\Hexcel MW LocationsV2.mxd 8/29/2018 6:51:51 AM



Legend

- Extraction Well
- Monitoring Well
- Site Location
- Groundwater Plume – Area Above 0.20 µg/L Vinyl Chloride
- Parcel G

N

0 125 250 Feet

Groundwater Plume
Hexcel Plant 1
Kent, Washington

Geosyntec consultants

Seattle	July 2018

Figure
2

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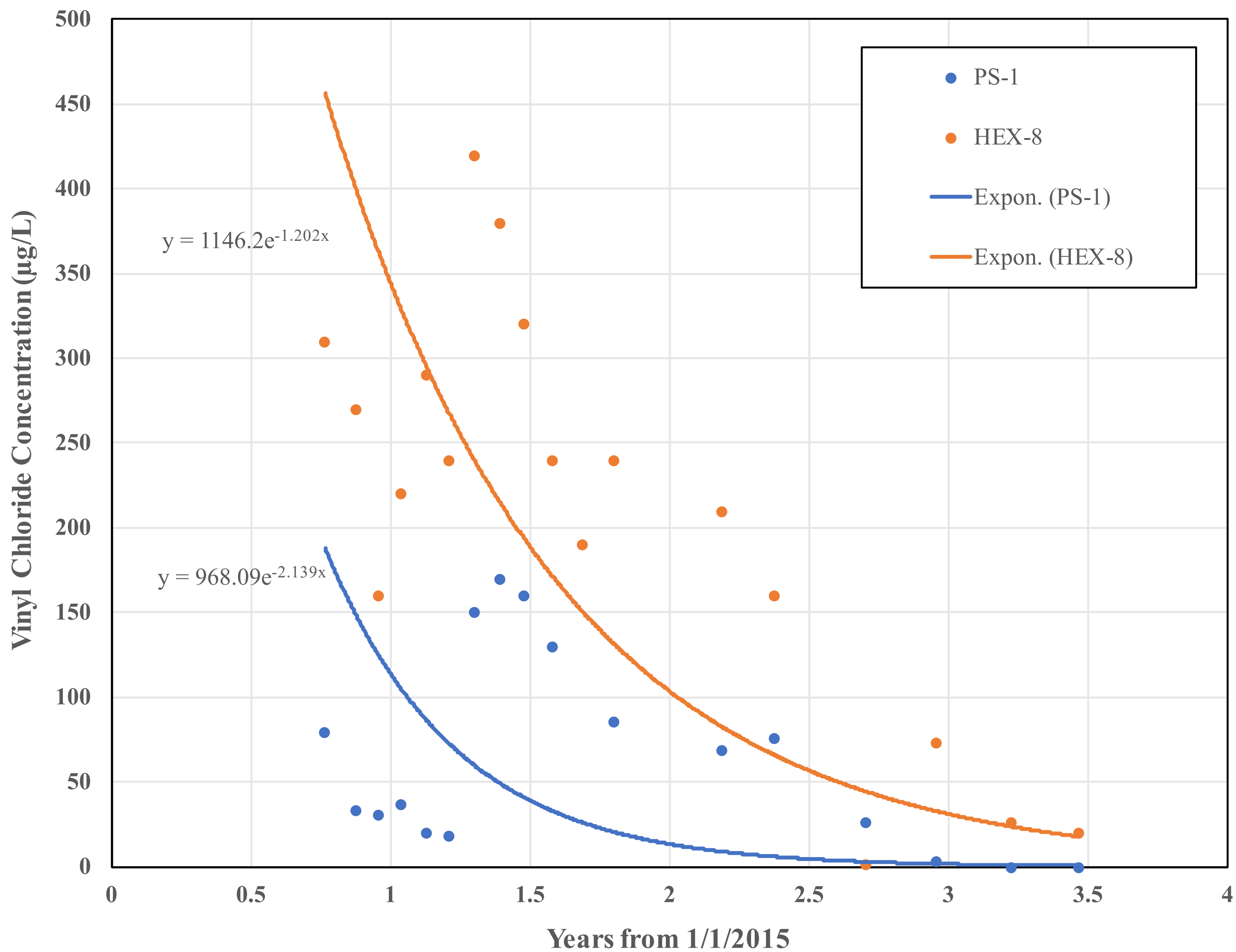

Calculation of MNA Time

		PS-1	HEX-8
t=(ln(Cgoal)/Cstart))/-k			
Cgoal =	0.2		
Cstart =	From Plot	968.09	1146.2
-k =	From Plot	-2.139	-1.202
t=		3.97	7.20

Plots of Vinyl Chloride Concentrations vs. Time
Select Groundwater Monitoring Wells
Hexcel Plant 1, Kent, WA

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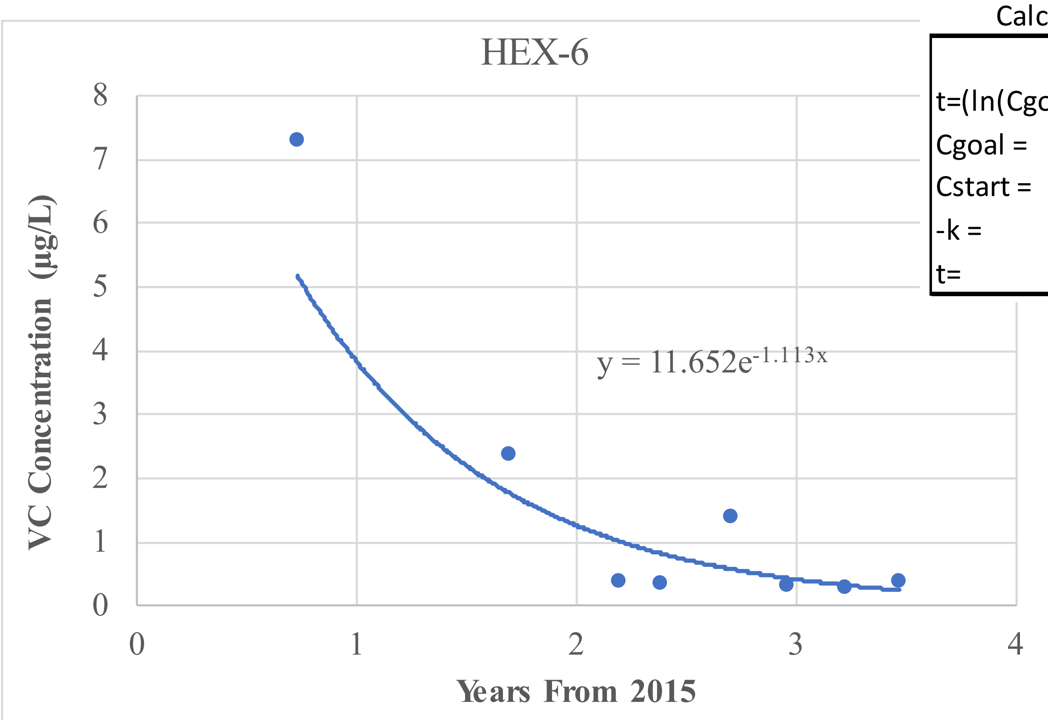
HEXCEL

Figure 3a

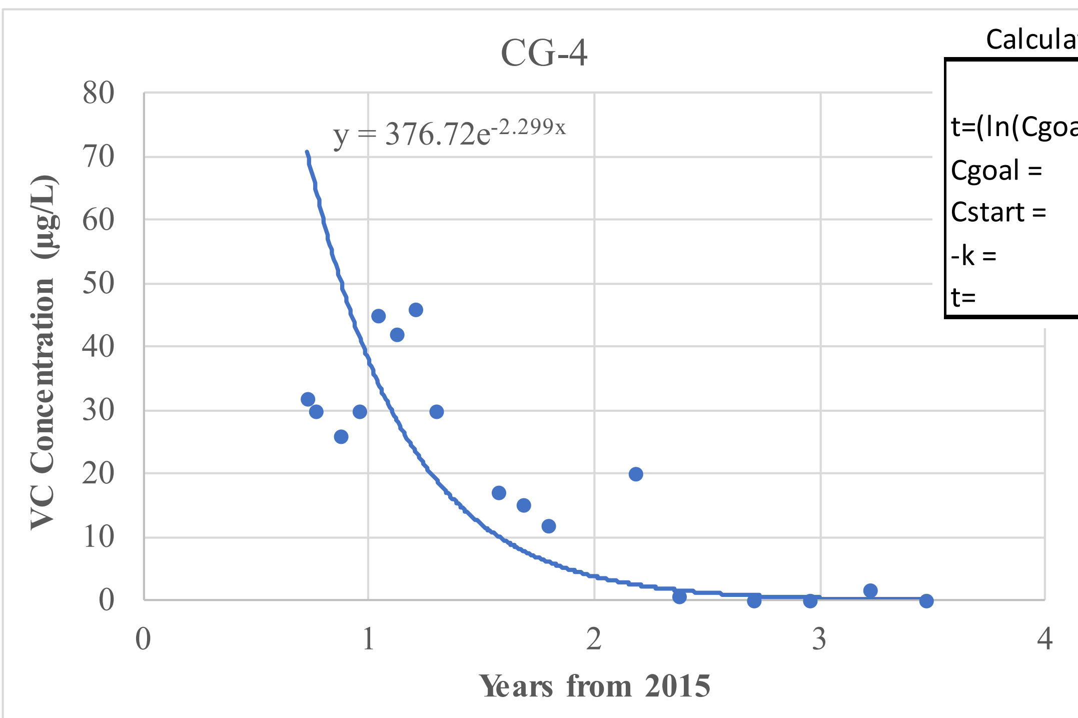
Seattle, WA

August 2018



Calculation of MNA Time

		HEX-6
t=(ln(Cgoal)/Cstart))/-k		
Cgoal =		0.2
Cstart =	From Plot	11.652
-k =	From Plot	-1.113
t=		3.65



Calculation of MNA Time

		CG-4
t=(ln(Cgoal)/Cstart))/-k		
Cgoal =		0.2
Cstart =	From Plot	376.72
-k =	From Plot	-2.299
t=		3.28

Plots of Vinyl Chloride Concentrations vs. Time
Select Groundwater Monitoring Wells
Hexcel Plant 1, Kent, WA

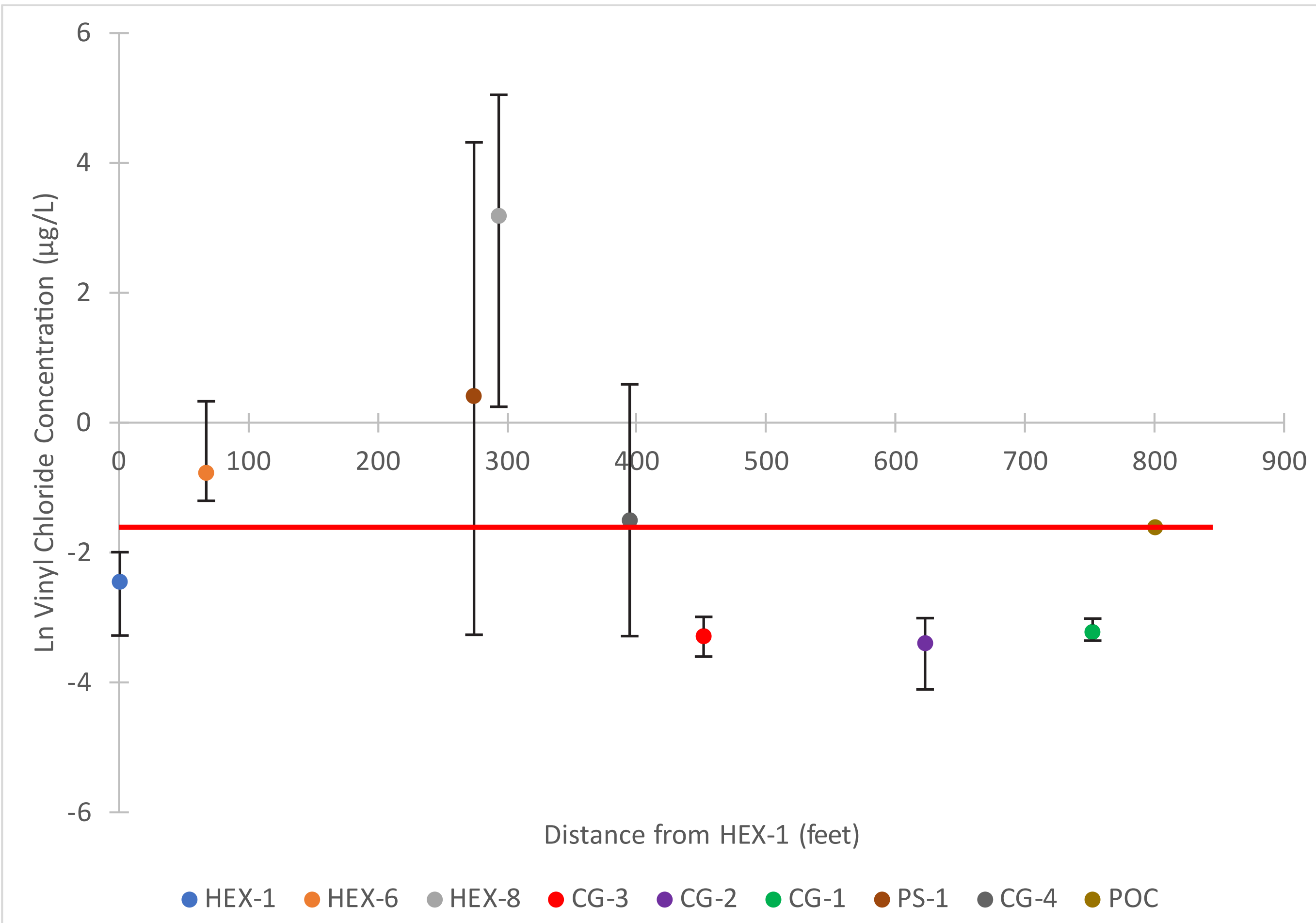
Geosyntec consultants

HEXCEL

Seattle, WA

August 2018

Figure 3b



Legend

Regulatory Cleanup Standard

Plots of Vinyl Chloride Concentrations vs. Distance
Select Groundwater Monitoring Wells
Hexcel Plant 1, Kent, WA

Geosyntec consultants

HEXCEL

Figure 4

Seattle, WA

August 2018