Work Plan
Bioremediation Injection – Remedy Stagnation Areas
Boeing Portland Troutdale Gravel Aquifer
Gresham, Oregon
ECSI #13

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Prepared for

The Boeing Company

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LIST OF ABBREVIATIONS AND ACRONYMS

µg/L ..... Micrograms per Liter
AMEE ..... Acetylene, Methane, Ethane, and Ethene
Boeing ..... The Boeing Company
cDCE cis-1,2-Dichloroethene
cVOC ..... Carcinogenic VOC
DNAPL ..... Dense Nonaqueous Phase Liquid
ft ..... Feet/Foot
gpm ..... Gallons per Minute
GWTS ..... Groundwater Treatment System
hp ..... Horsepower
LAI ..... Landau Associates, Inc.
lb ..... Pound
NAPL ..... Nonaqueous Phase Liquid
ODEQ ..... Oregon Department of Environmental Quality
Order ..... Order on Consent
ORP ..... Oxygen Reduction Potential
PCE ..... Tetrachloroethene
Psi ..... Pounds per Square Inch
ROI ..... Radius of Influence
Site ..... Boeing Facility
TCE ..... Trichloroethene
TGA ..... Troutdale Gravel Aquifer
TOC ..... Total Organic Carbon
UIC ..... Underground Injection Program
VC ..... Vinyl Chloride
VOC ..... Volatile Organic Compound

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1.0 INTRODUCTION

This document presents a work plan for conducting a bioremediation at The Boeing Company (Boeing) Facility (Site) in Gresham, Oregon to be completed as a part of the Troutdale Aquifer (TGA) remedy being implemented at the Site (Figure 1). Bioremediation injection will be conducted at two remedy stagnation areas as an additional corrective measure to be conducted to supplement the consent order corrective measure (pump and treat). The two remedy stagnation areas include well BOP-9(i) and the area near well BOP-10(i), which includes nearby wells E-6 and E-7, as shown on Figure 2. These wells have not been previously injected with bioremediation substrates. This bioremediation injection work plan is submitted on behalf of Boeing under the State of Oregon Department of Environmental Quality (ODEQ) Order on Consent (Order) DEQ No. LWSR-NWR-04-12.

1.1 Background

The groundwater treatment system (GWTS) has been actively removing dissolved volatile organic compound (VOC) mass from the shallow TGA since the phased startup in 1989. Approximately 4,300 pounds (lbs) of VOC mass has been removed and approximately 4.5 million gallons of groundwater has been extracted (LAI 2017b). The GWTS has been effective in assisting with the dissolved plume concentration reductions from the historical maximum trichloroethene (TCE) concentration of 39,000 micrograms per liter (µg/L) to the current maximum of 24 µg/L. However, two areas of the dissolved plume have been more persistent and show slower TCE concentration reductions compared to other areas of the plume. These two remedy stagnation areas are characterized by groundwater analytical results from well BOP-9(i) and the area near wells BOP-10(i), E-6, and E-7 (see Figure 2).

At well BOP-9(i), TCE concentrations have decreased from the historical maximum of 1,600 µg/L (January 1989) to concentrations ranging from 4.9 to 62 µg/L (2017 semiannual results). However, the decreasing TCE concentration trends at well BOP-9(i) appear to have plateaued since 2012 and show a much slower decrease trend with an average TCE concentration of 33 µg/L. Similar TCE concentration reduction trends are observed in the BOP-10(i) remedy stagnation area (includes analytical data from BOP-10(i), E-6, and E-7) where historical concentrations indicate steady decreases during the early stages of the GWTS operation followed by a more recent plateau between 2012 and 2017. In the BOP-10(i) stagnation area, TCE maximum historical concentrations were 2,900 µg/L at BOP-10(i), 8,400 µg/L at E-6, and 5,800 µg/L at E-7. By 2012, TCE concentrations had decreased to between 15 and 30 µg/L in this area. Since 2012, the average TCE concentration in this area is 19.4 µg/L, indicating a slower mass removal rate than previously observed.

Historical TCE analytical results for the two remedy stagnation areas are summarized in Table 1. TCE concentration trend lines for the two stagnation areas are shown on Figure 3.

1.2 Objectives and Evaluation Criteria

The overall objective of bioremediation injection is to evaluate the implementability and effectiveness of in situ anaerobic bioremediation in the TGA in the two remedy stagnation areas of the VOC dissolved plume. The injection will evaluate whether bioremediation, applied as a supplement to the existing Site remedy, can more quickly achieve cleanup goals at these wells. Specific evaluation criteria are as follows:

1. Extent of treatment resulting from injection.
2. Longevity of biotreatment resulting from injection.
3. The effect of treatment on the concentrations of TCE and biodegradation breakdown products.
4. Potential biofouling effects at the extraction wells utilized for the GWTS remedy. Note: the nearest extraction well [DP-1, at approximately 140 foot (ft) upgradient from nearest injection well] will be shut down for the duration of the injection. The next nearest extraction well (E-16) is approximately 310 ft from the injection wells and unlikely to be substantially affected by electron donor injections.

2.0 STIMULATION OF ANAEROBIC BIOREMEDATION OF TCE

In situ anaerobic bioremediation of chlorinated volatile organic compounds (cVOCS; e.g. TCE) requires injection of electron donor substrate injections. Bioremediation is an in situ treatment option that can be implemented via existing Site wells, often with minimal additional infrastructure required. Accordingly, anaerobic bioremediation can serve as a cost-effective treatment option to augment existing remedies and achieve cleanup goals.

Bioremediation is generally accepted as an effective remedy for a wide range of cVOC concentrations. Bioremediation can be effective for both reducing low level cVOC concentrations and very high cVOC concentrations that occur near the solubility limit (1,100,000 µg/L for TCE) in dense non-aqueous phase liquid (DNAPL) source zones (Parsons 2004). There is some concern that bioremediation can be less effective at the lower concentrations due to insufficient mass of contaminants to support robust growth of dechlorinating bacteria. However, Landau Associates, Inc. (LAI) has successfully applied bioremediation at another Pacific Northwest Boeing site with similarly low concentrations [tetrachloroethene (PCE) and TCE concentrations generally ranging 10 to 50 µg/L] (LAI 2017a). Anaerobic bioremediation of TCE and breakdown products has been successful in meeting Site cleanup levels in the West and Downgradient Action Areas (LAI 2009) and in the Building 85-001 former degreaser source (LAI 2017b).

Anaerobic bioremediation of cVOCs is stimulated through injection of electron donor substrates (i.e., fermentable organic carbon). Upon injection of electron donor substrates to a groundwater aquifer, indigenous bacteria ferment substrates to electron donors (i.e., fatty acids and hydrogen), which are used as "food" by micro-organisms to reduce electron acceptors. Electron acceptors include target contaminants (e.g., TCE and breakdown products) and natural electron acceptors (e.g., dissolved oxygen (DO), nitrate, iron, manganese (IV), sulfate, and carbon dioxide). Ideal electron donor substrates are injectable, easily distributed in the aquifer, result in highly reduced aquifer conditions, and provide abundant electron donor for bioremediation. The mechanisms of and requirements for successful bioremediation are discussed in more detail below.

2.1 TCE Biodegradation

Stimulation of anaerobic bioremediation results in TCE degradation to intermediary breakdown products and innocuous end products through reductive dechlorination. By reductive dechlorination, chloride ions present on the cVOC molecule are replaced with hydrogen, resulting in the formation of successively less chlorinated molecules. TCE is reductively dechlorinated by sequential removal of chloride ions to breakdown products cis-1,2-dichloroethene (cDCE), vinyl chloride (VC), and innocuous end products ethene and/or ethane, as shown below:

TCE→cDCE→VC→ethene/ethane

Ethene and ethane are non-toxic and are further degraded to carbon dioxide and water. The presence of ethene and/or ethane indicates complete reductive dechlorination.

Stimulation of anaerobic bioremediation also results in other complementary treatment processes. Biostimulation can provide indirect stimulation of beneficial abiotic (nonbiological) degradation processes (e.g., anaerobic reduction of TCE and cDCE by iron-sulfides formed due to iron- and sulfate-reducing aquifer conditions). Desorption and dissolution of sorbed contaminant mass and nonaqueous phase liquids (NAPL) mass are also significantly enhanced by a number of mechanisms attributable to the electron donor substrates and biodegradation occurring in the aqueous phase (Parsons 2004, Suthersan et al. 2003).

2.2 Required Aquifer Redox Conditions

Specific aquifer redox conditions are required for complete reductive dechlorination of TCE and breakdown products. Reductive dechlorination occurs through microbially mediated reactions whereby micro-organisms obtain energy through oxidation-reduction (redox) reactions. Electron donors (fatty acids, hydrogen, etc.) are used by microbes together with various natural electron acceptors [DO, nitrate, manganese (IV), ferrous iron, sulfate, and carbon dioxide] and contaminant electron acceptors (TCE, cDCE, and VC) to obtain energy.

Bacteria obtain the greatest energy yield by using oxygen as an acceptor, as it is highly oxidized and can, therefore, be reduced easily and to a large degree. When oxygen is depleted in an uncontaminated aquifer, bacteria sequentially use the less oxidized electron acceptors in sequential order: nitrate, manganese (IV), iron (III), sulfate, and carbon dioxide.

TCE and its breakdown products can also be used as electron acceptors by specific micro-organisms. TCE can be reduced under mildly iron-reducing conditions (Chapelle 1996). cDCE and VC require successively more reduced aquifer conditions for degradation; cDCE under sulfate-reducing or methanogenic conditions (Chapelle 1996, Vogel et al. 1987) and VC under highly reducing, methanogenic conditions (Ballapragada et al. 1997, Freedman and Gossett 1989, Maymó-Gatell et al. 1995, Vogel and McCarty 1985).

If aquifer conditions are not naturally reduced enough to facilitate dechlorination of TCE and associated breakdown products, often the injection of donor substrate can induce the highly reduced redox conditions necessary for treatment. This occurs as microbial degradation of existing electron acceptors in the aquifer (e.g., oxygen, nitrate, sulfate) is stimulated by the addition of donor substrate, creating sulfate-reducing to methanogenic conditions and providing the redox conditions necessary for complete degradation of TCE and associated breakdown products. Successful implementation of previous bioremediation at the Site indicates that appropriate reducing conditions for complete reductive dechlorination can be achieved and maintained despite baseline aerobic conditions.

2.3 Electron Donor Substrate

Electron donor substrates used for stimulation of anaerobic bioremediation include soluble substrates (e.g., glycerin, sugar, molasses, sodium lactate, cheese whey) and insoluble substrates (e.g., vegetable oil, wood mulch) (Parsons 2004, Suthersan et al. 2003). Various characteristics of soluble and insoluble substrates are as follows:

- Soluble substrates (e.g., glycerin, molasses) are fast-release, resulting in high concentrations of electron donor immediately after injection and substantial downgradient migration away from the injection well in the direction of groundwater flow. However, soluble substrates are relatively short-lived (months to a year) and can require frequent injections.
- Insoluble substrates (e.g., vegetable oil) are slow-release and longer lasting (1 to 4 years), resulting in very good donor longevity and a continuous treatment zone extending downgradient from the injection wells. Depending on the concentration of substrate injected, insoluble substrates can persist in the aquifer for years. This longevity may or may not be desirable depending on Site conditions and project objectives.
- Combined use of soluble, fast-release donor and insoluble, slow-release donor is often used as it can be can be effective in achieving strong reducing conditions, an aerially extensive treatment zone, and a reasonable interval between donor injection events. Slow-release vegetable oil was used in the 2008 bioremediation injection in the West and Downgradient Action Areas at the Site. A combination of slow-release vegetable oil and fast-release substrates (lactate and glycerin) have been used for the Building 85-001 bioremediation injections (LAI 2017b).

3.0 BIOREMEDIATION INJECTION

This section presents design elements consisting of potable water injection testing results, design injection volume, and design quantities of electron donor substrates.

3.1 Potable Water Injection Testing Results

A potable water injection was completed October 30-31, 2017 at four potential injection wells to assess the injectability of each well. These relatively large injection test volumes were needed to observe the steady-state injection rate. Site potable water dechlorinated with a pond dechlorinator product (sodium thiosulfate) was used to conduct the test. Results of this injection testing were used to select well E-6 for donor injection over nearby well BOP-10(i), and to refine injection volumes and injection time estimates for each well. Injection volumes of approximately 500 to 2,000 gallons were used at each well.

The potable water injection test at each well was performed in three steps of increasing injection flow and pressure using procedures approved by ODEQ (Thiessen 2017). The data from the potable water injection indicates a range of maximum (full-throttle) injection rates of 12 to 80 gallons per minute (gpm). Injection rates above 5 to 10 gpm are generally considered conducive to large volume injection. Injection rates were substantially higher for the pumped injection steps than for the gravity step. The lowest full-throttle injection rate (12 gpm) was measured at BOP-10(i), which was evaluated as an alternative injection well for E-6. Based on a higher full-throttle injection rate (51 gpm), well E-6 along with well E-7 will be utilized for donor injection in the BOP-10(i) remedy stagnation area. Potable water injection test results are presented in Table 2.

3.2 Design Injection Volume

The design injection volumes target radial distribution of injected donor fluid out to 100 ft during the period of injection. This target distribution is known as the radius of injection (ROI). Additional downgradient distribution will occur with the flow of groundwater after injections are completed. Injection of wells E-6 and E-7 will result in overlapping ROIs in the BOP-10(i) remedy stagnation area (Figure 2).

The injection volume was calculated based on aquifer parameters and the desired thickness and ROI, using the following aquifer pore volume equation:

$$V = \pi \cdot ROI^2 \cdot h \cdot n_{ef}$$

Where:

ROI – Targeted ROI of 100 ft for each injection well. Though this ROI is relatively large, it is not inappropriate given the low effective porosity of the aquifer measured previously at the Site, which results in extensive distribution of dye tracers and donor substrates within the aquifer (LAI 2008, 2009).

h (assumed injection thickness) – Based on the screened interval of each well.

n_{ef} (aquifer effective porosity for flow) (Payne et al. 2008) –Extensive TGA tracer testing completed prior to bioremediation in the West and Downgradient Areas estimated a range of n_{ef} of 0.01 to 0.02 (LAI 2008). n_{ef} of 0.01 was used for the injection volume calculation[1].

The input parameters and corresponding injection volume for each well are shown below in imbedded Table A.

Table A. Substrate Injection Volume Calculation

Injection Well	ROI (ft)	h (ft)	V[(a)] (gallons)
BOP-9(i)	100	20	47,000
E-6	100	20	47,000
E-7	100	15	35,300
		Total Injection Volume	129,300

(a) Rounded to the nearest hundred gallons.

3.3 Donor Substrate

A combination of two fast-release electron donor substrates will be utilized for this injection. The previous use of slow-release donor for bioremediation in the West and Downgradient Areas and a combination of fast-/slow-release donors at the Building 85-001 former degreaser (Section 2.3) was intended to optimize the longevity of treatment. Generally, combined use of soluble and insoluble donor is a beneficial strategy to maximize the downgradient extent of treatment and the treatment period between injection events. However, persistence of electron donor is not desired for this injection event, which will include injecting electron donor solution directly into monitoring wells. If donor were to persist at these wells for years, it would limit the usefulness of the wells as monitoring points, as they may not be representative of conditions in the aquifer. The use of soluble donor substrates for the injection is intended to provide relatively rapid treatment of relatively low residual contaminant concentrations without extended persistence of donor.

Crude glycerin and blackstrap molasses will be the electron donor substrates utilized for the injection. Both are completely soluble and relatively cheap electron donors. Both are considered fast-release. Crude glycerin (Whole-Energy or equivalent) is a byproduct of biodiesel production in the region; biodiesel is produced from used fryer oil collected from restaurants. Blackstrap molasses is a byproduct of sugar production from sugar cane. Using a mixture of electron donors provides a more complex food source for bacteria that is thought to enhance bacterial growth and may enhance donor longevity.

Each well will receive the respective injection volume calculated in Section 3.1.2 mixed with approximately 9.5 percent electron donor in the form of molasses and glycerin[2]. This is a moderately

[1] Use of the higher n_{ef} of 0.02 would double the calculated injection volume to achieve the 100-ft ROI.
[2] Injection fluid will contain approximately 5.3 percent by weight glycerin and 4.2 percent by weight sugar from molasses.

high concentration of soluble donor intended to provide substantial treatment before it is completely degraded.

3.4 Procedures

This section describes the permitting required to complete the injections, donor substrates, and procedures for mixing and injection. A total of three wells will be injected as a part of the donor substrate injection for the two remedy stagnation areas, BOP-9(i), E-6, and E-7, each screened within the lower portion of the TGA. BOP-9(i) will be the sole well injected in the BOP-9(i) remedy stagnation, while injection into the other two wells (E-6 and E-7) will provide treatment for the BOP-10(i) remedy stagnation area. Field activities will be conducted in accordance with the site-specific health and safety plan (Appendix B) and the Site Supplier Manual (Boeing 2016).

3.4.1 Underground Injection Control Registration

All four wells (BOP-9(i), BOP-10(i), E-6, and E-7) have been registered with the Oregon State Underground Injection Control (UIC) program. The addition of these four wells to the permit constituted a modification of the UIC registration (UIC registration # 11329) that exists for the Site due to prior bioremediation injections.

3.4.2 Donor Substrate

Each of the three wells will receive its respective injection volume, calculated in Section 3.1.2, consisting of water mixed with crude glycerin and molasses as electron donors[3], ferrous chloride, and yeast extract. Injection fluid components are described below and presented for each injection well in Table 3). The component safety data sheets (SDSs) or material safety data sheets (MSDSs) are presented in Appendix A.

- Glycerin and molasses electron donors will each be delivered separately by tanker truck and offloaded to temporary onsite tanks (Baker tanks). Crude glycerin and molasses will each be diluted by half with water prior to delivery to reduce viscosity and allow for product transfer, batch mixing, and injection despite cold weather conditions. A total of four tanker loads (160,000 lbs, 14,787 gallons) of diluted glycerin (46.5 percent) and three tanker loads (135,240 lbs, 13,800 gallons) of diluted molasses (39.5 percent) will be utilized for injection. Delivery of these substrates will be scheduled, as needed, to refill the product storage tanks.
- A total of six drums (3,780 lbs) of 33 percent weight ferrous chloride will be utilized for injection. Ferrous chloride will be added to the injection fluid to complex with sulfate present in the molasses; sulfate will be reduced to sulfide as electron donors are utilized and the aquifer becomes more reducing. The resulting in situ formation of iron sulfides on the aquifer matrix is beneficial for abiotic degradation (i.e., reductive elimination) of PCE, TCE, and cDCE (Kennedy et al. 2006). Precipitation of iron sulfides will also prevent the accumulation of sulfide, which can be inhibitory to reductive dechlorination (Parsons 2004). According to manufacturer specifications, the molasses product (Cincinnati Can; refer to Appendix A for

[3] Resulting in a batch concentration of 10.1 percent glycerin, based on the 92 percent concentration of glycerin in the crude glycerin.

MSDS) contains 0.49 percent sulfur in the form of sulfate. Therefore, the design quantity of molasses contains 1,026 lbs (227 moles) of sulfate. A nearly equivalent molar mass of ferrous iron (210 moles) will be added in the form of six drums (3,780 lbs) of 33 percent ferrous chloride solution. Following injection, the sulfate from the molasses will be biologically reduced in the aquifer to sulfide, which will complex with provided ferrous iron and naturally occurring ferrous iron to form iron sulfide precipitates within the aquifer matrix.

- Yeast extract will be added to provide micro-nutrients for bacterial function. Yeast extract will be added at 1 lb per 1,000 gallons, for a total of 129 lbs. Yeast extract provides macro- and micro-nutrients for bacterial cell growth.
- Water for mixing (approximately 100,000 gallons) will be obtained from on-site fire hydrants. A pond water dechlorinating product containing sodium thiosulfite (Chlor-No-More, www.PondRX.com) will be added to the potable water per product directions to remove residual chlorine prior to mixing in other additives.

3.4.3 Mixing and Injection Procedures

The total 129,000 gallons of injection fluid will be mixed in 25.8 batches of 5,000 gallons each. Two batch tanks will be utilized for maximum efficiency of mixing and injection. Use of two batch tanks will allow for simultaneous injection and mixing of the next batch.

Donor fluid will be mixed and injected using a gasoline-powered centrifugal pump [3 inch, 8 horsepower (hp), 290 gpm]. The injection pump will be operated at a reduced throttle, if necessary, to keep injection pressures below 40 pounds per square inch (psi), to avoid leakage of injection fluid up through the pavement. If leakage occurs, the pressure will be reduced further by throttling down the pump or, if necessary, the pump will be stopped and the injection will continue under gravity flow.

To remove potential particulates in the crude glycerin and molasses, these donor substrates will be passed through a bag filter (10 micron) during batch mixing, as described below:

- Mixing tank will be filled with approximately 3,880 gallons of potable water.
- Tank water will be dechlorinated by addition of sodium thiosulfate.
- While recirculating water from the tank through the filter and back to the tank with the mixing pump, 573 gallons of glycerin and 535 gallons of molasses will be added from their respective product tanks.
- A small amount of liquid, food-grade defoaming agent (NO FOAM distributed by Wilbur-Ellis) will be added to the batch tank, as needed, to minimize foaming of the injection solution.
- Following addition of glycerin and molasses and adequate recirculation for mixing, the tank contents will be injected to the wells, with valves adjusted to bypass the filter. During injection, the following substrates will added inline to the flow (i.e., metered in on the suction site of the pump); substrates will be added periodically during the injection period for proportional dosing:
  - Approximately 12 gallons of ferrous chloride (33 percent solution). In-line addition of ferrous chloride prevents filtering of any fine iron sediments that may be present.

Oxygen scavenger ™ by RNAS will be added at 200 grams per ferrous chloride drum prior to use to re-dissolve any iron precipitate that may be present.

- 5 lbs of yeast extract mixed with 10 gallons of water.

A reduction in flow rate or differential pressures greater than 15 to 18 psi across the filter housing are indications that the filter needs to be changed. If needed, filter changes will occur as follows:

1) Open valves on the dual filter housing to direct flow through the other filter and close valves to isolate the clogged filter.
2) Slowly release pressure in clogged filter housing by partially unscrewing the lid; allow pressure to dissipate before removing lid.
3) Remove filter for inspection.
4) Install new 10-micron filter.
5) Slightly open inlet and outlet valves to allow filter housing to fill with water to within 3 to 4 inches of the top of the housing before tightening the lid back down on the top of the filter housing to seal the filter assembly.
6) Flow can be diverted to the new filter when the other filter becomes plugged.

To minimize the injection time, an injection manifold with individual well totalizers will be used to inject wells E-6 and E-7 concurrently. Well BOP-9(i) will be injected by itself, as it is located distant from the other wells.

After completing the injection volume at each injection well, the well will be flushed with approximately 200 gallons of unamended potable water. This flushes concentrated donor from the well and sand pack in order to reduce the potential for later biofouling of the well.

Precautions will be taken to prevent unplanned leaks of injection fluid. Each of the two product tanks (glycerin and molasses) and two batch tanks will be located within individual secondary containment berms. The bag filter, mixing/injection pumps, and drums of ferrous chloride will also be located within the tank secondary containments. Injection hose Kamlock connections will be taped closed and hoses will be monitored for leaks. The well seal of injection wells and surrounding pavement and any nearby subsurface vaults will be monitored for potential water discharge indicative of injection short-circuiting to the surface. If any potential, minor leaks occur during injection or when disconnecting hoses, these will be collected and contained using buckets and a wet/dry vacuum. Potential incidental spills inside the secondary containment due to mixing operations will be cleaned up using the wet/dry vacuum. In addition, a spill kit will be set up at the injection location and will contain: cat litter, adsorbent pads, and berming material to contain larger spills. Nearby storm drain catch basins, if any, will be covered with a foam rubber drain mat.

Extraction well DP-1 will be shut down for the BOP-10(i) remedy stagnation area injection. Extraction well DP-1 will remain shut down until monitoring results indicate that total organic carbon (TOC) concentrations at that well are near baseline.

4.0 GROUNDWATER MONITORING

Groundwater monitoring will be conducted quarterly at five wells [BOP-9(i); BOP-10(i), E-6, E-7, and DP-1; Figure 2] for one year in order to evaluate injection effectiveness and longevity. Upon the completion of 4 quarterly events, the data will be evaluated and modifications to the monitoring plan will be discussed with ODEQ. Quarterly monitoring at DP-1 may be discontinued 2 quarters after pumping is resumed (Section 3.2.2). Groundwater monitoring parameters include analysis of contaminants, aquifer redox, and electron donor as follows:

- Laboratory analysis will be performed for VOCs; TOC; sulfate; and dissolved gases acetylene, methane, ethene, and ethane (AMEE).
- Field parameters will be collected for DO, oxidation reduction potential (ORP), pH, and ferrous iron.

Table 4 presents analytical methods and information provided by the various field and laboratory parameters. Groundwater monitoring for VOCs will be performed using diffusion bags, as is the practice for other areas of the Site. Samples for other laboratory parameters will be collected using a non-dedicated bladder pump and low-flow purge and sampling procedures. A flow through cell will be used to measure field parameters.

Based on these monitoring data, the effectiveness of the additional corrective measure will be compared to treatment goals to evaluate if additional measures are needed in these two areas of the dissolved VOC plume. .

5.0 SCHEDULE AND REPORTING

It is anticipated that the activities described in this work plan will be conducted in December 2017. A summary of the injection test activities and results, as well as evaluation of these results, will be included in the annual Site TGA remedy report.

6.0 USE OF REPORT

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

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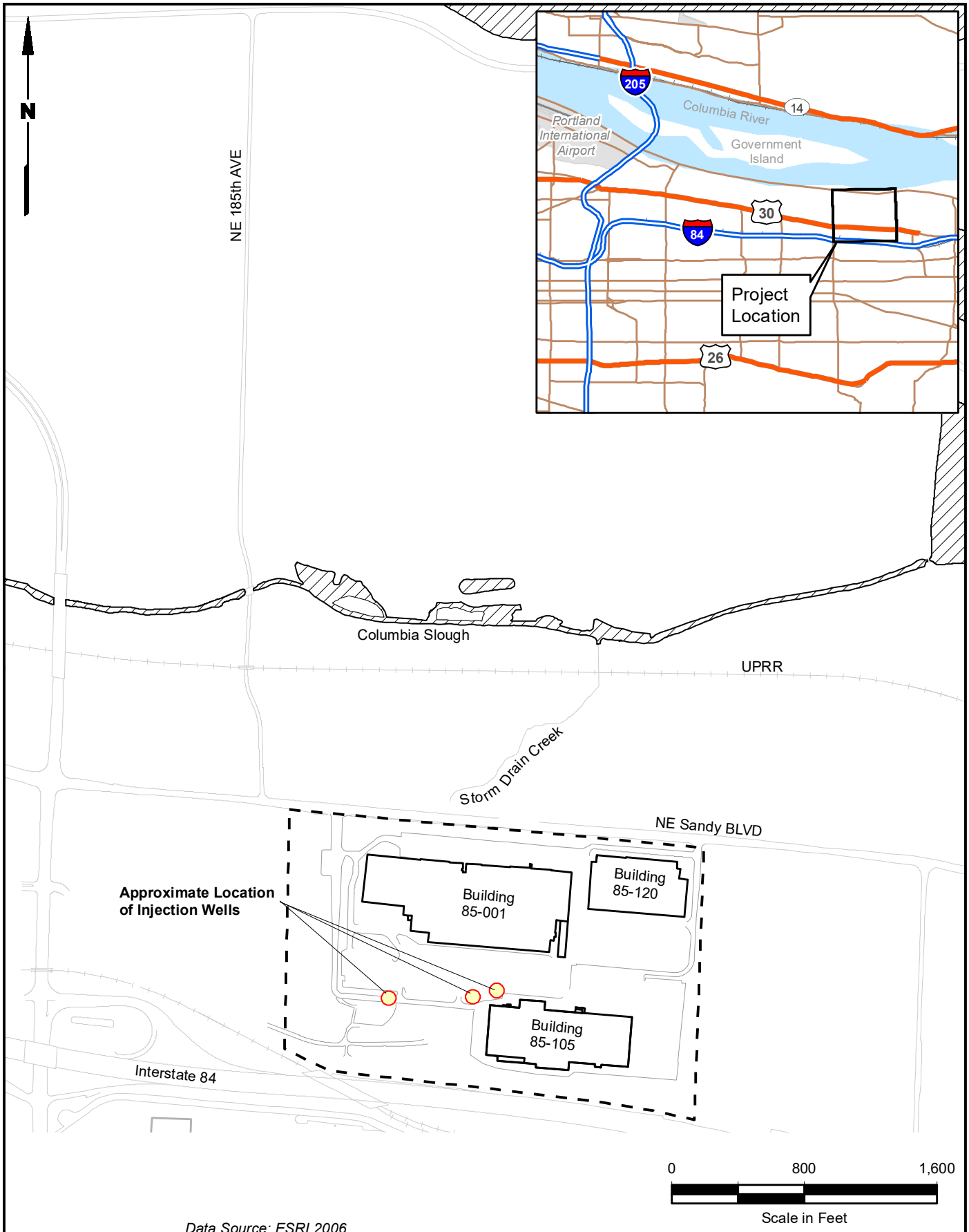


Data Source: ESRI 2006

G:\Projects\025\116\115\430\2015 Prog-Perf Report\Figure 01 VicMap LocationsApprox.mxd 11/3/2017

LANDAU ASSOCIATES

Boeing Portland Gresham, Oregon	**Boeing Portland Site Map**	Figure 1

G:\Projects\025\116\210\F02 RemedyStagnation InjectionMWLocations.mxd 11/8/2017

Notes

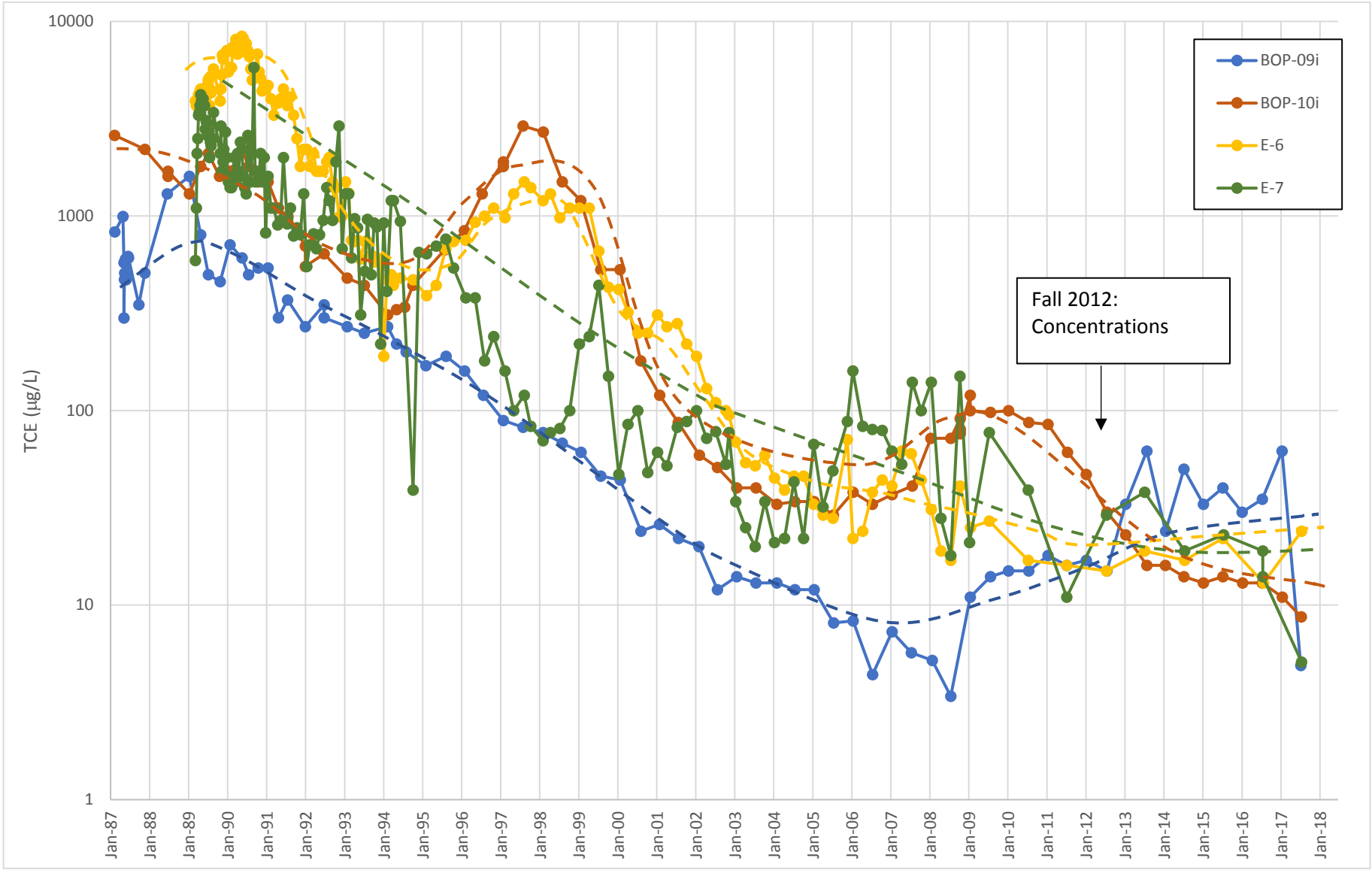
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Boeing Portland
Gresham, Oregon

Remedy Stagnation Areas - Injection and Monitoring Well Locations

Figure 2



LANDAU ASSOCIATES

Boeing Portland
Gresham, Oregon

TCE Concentration Trends

Figure
3

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
BOP-09i	3/4/1987	830
BOP-09i	5/20/1987	996
BOP-09i	5/27/1987	575
BOP-09i	5/29/1987	299
BOP-09i	6/1/1987	471
BOP-09i	6/3/1987	510
BOP-09i	6/10/1987	600
BOP-09i	6/17/1987	470
BOP-09i	6/24/1987	490
BOP-09i	7/2/1987	490
BOP-09i	7/6/1987	620
BOP-09i	7/10/1987	610
BOP-09i	10/15/1987	350
BOP-09i	12/9/1987	510
BOP-09i	7/7/1988	1300
BOP-09i	1/30/1989	1600
BOP-09i	5/17/1989	800
BOP-09i	7/26/1989	500
BOP-09i	11/15/1989	460
BOP-09i	2/15/1990	710
BOP-09i	6/8/1990	610
BOP-09i	8/7/1990	500
BOP-09i	11/6/1990	540
BOP-09i	2/7/1991	540
BOP-09i	5/15/1991	300
BOP-09i	8/8/1991	370
BOP-09i	1/21/1992	270
BOP-09i	7/15/1992	350
BOP-09i	7/15/1992	300
BOP-09i	2/17/1993	270
BOP-09i	7/27/1993	250
BOP-09i	3/2/1994	270 J
BOP-09i	5/24/1994	220
BOP-09i	8/23/1994	200
BOP-09i	2/23/1995	170
BOP-09i	9/1/1995	190
BOP-09i	2/21/1996	160
BOP-09i	8/16/1996	120
BOP-09i	2/18/1997	89
BOP-09i	8/21/1997	82
BOP-09i	2/26/1998	77
BOP-09i	8/25/1998	68
BOP-09i	2/17/1999	61
BOP-09i	8/21/1999	46
BOP-09i	2/18/2000	44
BOP-09i	8/30/2000	24
BOP-09i	2/21/2001	26 J
BOP-09i	8/16/2001	22
BOP-09i	2/24/2002	20
BOP-09i	8/16/2002	12
BOP-09i	2/13/2003	14
BOP-09i	8/13/2003	13
BOP-09i	2/24/2004	13

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
BOP-09i	8/12/2004	12
BOP-09i	2/9/2005	12
BOP-09i	8/9/2005	8.1
BOP-09i	2/8/2006	8.3
BOP-09i	8/10/2006	4.4
BOP-09i	2/8/2007	7.3
BOP-09i	8/8/2007	5.7
BOP-09i	2/19/2008	5.2
BOP-09i	8/11/2008	3.4
BOP-09i	2/9/2009	11
BOP-09i	8/18/2009	14
BOP-09i	2/3/2010	15
BOP-09i	8/11/2010	15
BOP-09i	2/7/2011	18
BOP-09i	8/3/2011	16
BOP-09i	2/2/2012	17
BOP-09i	8/14/2012	15
BOP-09i	2/4/2013	33
BOP-09i	8/21/2013	62
BOP-09i	2/13/2014	24
BOP-09i	8/5/2014	50
BOP-09i	2/3/2015	33
BOP-09i	8/5/2015	40
BOP-09i	2/1/2016	30
BOP-09I	8/8/2016	35
BOP-09I	2/8/2017	62
BOP-09I	8/3/2017	4.9
BOP-10i	3/2/1987	2600
BOP-10i	12/9/1987	2200
BOP-10i	7/14/1988	1600
BOP-10i	7/14/1988	1700
BOP-10i	1/30/1989	1300
BOP-10i	5/17/1989	1800
BOP-10i	7/26/1989	2100
BOP-10i	11/7/1989	1600
BOP-10i	2/15/1990	1600
BOP-10i	2/15/1990	1700
BOP-10i	6/8/1990	2200
BOP-10i	8/7/1990	1800
BOP-10i	11/6/1990	1500
BOP-10i	2/7/1991	1500
BOP-10i	5/15/1991	1100
BOP-10i	8/9/1991	980
BOP-10i	8/9/1991	1000
BOP-10i	1/21/1992	700
BOP-10i	1/21/1992	550
BOP-10i	7/15/1992	640
BOP-10i	2/17/1993	480 J
BOP-10i	7/27/1993	440
BOP-10i	3/2/1994	310 J
BOP-10i	5/24/1994	330
BOP-10i	8/10/1994	340

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
BOP-10i	10/24/1994	440
BOP-10i	8/18/1995	670
BOP-10i	2/19/1996	840
BOP-10i	8/5/1996	1300
BOP-10i	2/18/1997	1900
BOP-10i	2/18/1997	1800
BOP-10i	8/21/1997	2900
BOP-10i	2/27/1998	2700
BOP-10i	8/24/1998	1500
BOP-10i	2/15/1999	1200
BOP-10i	8/20/1999	530
BOP-10i	2/17/2000	530
BOP-10i	8/29/2000	180
BOP-10i	2/22/2001	120 J
BOP-10i	8/15/2001	87
BOP-10i	2/28/2002	59
BOP-10i	8/16/2002	51
BOP-10i	2/13/2003	40
BOP-10i	8/12/2003	40
BOP-10i	2/24/2004	33
BOP-10i	8/12/2004	34
BOP-10i	2/9/2005	34
BOP-10i	8/8/2005	29
BOP-10i	2/8/2006	38
BOP-10i	8/7/2006	33
BOP-10i	2/9/2007	37
BOP-10i	8/16/2007	41
BOP-10i	2/7/2008	72
BOP-10i	8/11/2008	72
BOP-10i	11/7/2008	91
BOP-10i	11/7/2008	76
BOP-10i	11/7/2008	80
BOP-10i	11/7/2008	80
BOP-10i	11/7/2008	78
BOP-10i	2/9/2009	120
BOP-10i	2/9/2009	100
BOP-10i	8/18/2009	98
BOP-10i	2/3/2010	100
BOP-10i	8/11/2010	87
BOP-10i	2/7/2011	85
BOP-10i	8/10/2011	61
BOP-10i	2/2/2012	47
BOP-10i	8/14/2012	30
BOP-10i	2/4/2013	23
BOP-10i	8/21/2013	16
BOP-10i	2/11/2014	16
BOP-10i	8/5/2014	14
BOP-10i	2/3/2015	13
BOP-10i	8/5/2015	14
BOP-10i	2/5/2016	13
BOP-10i	8/8/2016	13
BOP-10i	2/10/2017	11
BOP-10i	8/8/2017	8.7

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-6	3/28/1989	3900
E-6	4/6/1989	3700
E-6	4/12/1989	3900
E-6	4/18/1989	3800
E-6	4/25/1989	4200
E-6	5/2/1989	4300
E-6	5/9/1989	3900
E-6	5/16/1989	4500
E-6	5/23/1989	3900
E-6	5/30/1989	3900
E-6	6/7/1989	3800
E-6	6/13/1989	4100
E-6	6/20/1989	4200
E-6	6/27/1989	4300
E-6	7/5/1989	4600
E-6	7/11/1989	4200
E-6	7/18/1989	4300
E-6	7/25/1989	5000
E-6	8/1/1989	5100
E-6	8/8/1989	3700
E-6	8/15/1989	5200
E-6	8/22/1989	4300
E-6	8/29/1989	4400
E-6	9/5/1989	5300
E-6	9/12/1989	5700
E-6	11/15/1989	3900
E-6	11/21/1989	4500
E-6	11/28/1989	5300
E-6	12/5/1989	6700
E-6	12/12/1989	6400
E-6	12/19/1989	6800
E-6	1/4/1990	6900
E-6	1/17/1990	7100
E-6	1/31/1990	5500
E-6	2/14/1990	5800
E-6	2/28/1990	5800
E-6	3/14/1990	7400
E-6	3/28/1990	7400
E-6	4/11/1990	8100
E-6	4/25/1990	6800
E-6	5/8/1990	6900
E-6	5/22/1990	7700
E-6	6/6/1990	8400
E-6	6/19/1990	8200
E-6	7/3/1990	7000
E-6	7/17/1990	7700
E-6	7/31/1990	7100
E-6	8/14/1990	6600 B
E-6	8/28/1990	5700
E-6	9/11/1990	5000
E-6	9/27/1990	5800
E-6	10/9/1990	5600

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-6	10/29/1990	6800
E-6	11/14/1990	5500
E-6	11/28/1990	5100
E-6	12/11/1990	4400
E-6	1/2/1991	4700
E-6	1/15/1991	4500
E-6	2/5/1991	4700
E-6	3/5/1991	4000
E-6	4/2/1991	3300
E-6	5/7/1991	3800
E-6	6/3/1991	4000
E-6	7/1/1991	4500
E-6	8/5/1991	3700
E-6	9/3/1991	4100
E-6	10/2/1991	3300
E-6	11/4/1991	2500
E-6	12/4/1991	1800
E-6	1/6/1992	2200
E-6	2/4/1992	2200
E-6	3/3/1992	1800
E-6	4/6/1992	2100
E-6	5/4/1992	1700
E-6	6/2/1992	1700
E-6	7/6/1992	1700
E-6	8/10/1992	1900
E-6	9/1/1992	2000
E-6	10/1/1992	1500
E-6	11/2/1992	1400
E-6	12/1/1992	990
E-6	1/1/1993	1000
E-6	2/1/1993	1500
E-6	3/3/1993	1310
E-6	3/29/1993	750
E-6	4/28/1993	740
E-6	5/25/1993	750
E-6	6/23/1993	600
E-6	7/30/1993	740
E-6	8/25/1993	740
E-6	9/29/1993	630
E-6	10/27/1993	580
E-6	11/22/1993	600
E-6	12/27/1993	600
E-6	1/26/1994	190
E-6	2/23/1994	470
E-6	4/4/1994	500
E-6	4/26/1994	440
E-6	6/29/1994	480
E-6	10/26/1994	470
E-6	3/3/1995	390 J
E-6	6/1/1995	440
E-6	8/29/1995	680
E-6	11/9/1995	740
E-6	3/4/1996	750

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-6	5/31/1996	930
E-6	8/26/1996	1000
E-6	11/20/1996	1100
E-6	3/6/1997	980
E-6	5/27/1997	1300
E-6	9/2/1997	1500
E-6	11/3/1997	1400
E-6	2/24/1998	1200
E-6	5/5/1998	1300
E-6	8/3/1998	980
E-6	11/2/1998	1100
E-6	2/1/1999	1100
E-6	5/3/1999	1100
E-6	8/2/1999	660
E-6	11/1/1999	430
E-6	2/4/2000	420
E-6	5/1/2000	320
E-6	8/2/2000	250
E-6	11/1/2000	250
E-6	2/1/2001	310 J
E-6	5/1/2001	270
E-6	8/6/2001	280
E-6	11/1/2001	220
E-6	2/2/2002	190
E-6	5/8/2002	130
E-6	8/1/2002	110
E-6	11/4/2002	100
E-6	12/4/2002	95
E-6	2/4/2003	69
E-6	5/7/2003	54
E-6	8/6/2003	52
E-6	11/5/2003	59
E-6	2/3/2004	45
E-6	5/6/2004	39
E-6	8/3/2004	46
E-6	11/1/2004	46
E-6	2/3/2005	33
E-6	5/3/2005	29
E-6	8/2/2005	28
E-6	12/16/2005	71
E-6	2/6/2006	22
E-6	5/9/2006	24
E-6	8/8/2006	38
E-6	11/9/2006	44
E-6	2/6/2007	41
E-6	5/10/2007	62
E-6	8/8/2007	60
E-6	11/8/2007	44
E-6	2/11/2008	31
E-6	5/12/2008	19
E-6	8/11/2008	17
E-6	11/6/2008	41
E-6	2/12/2009	25

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-6	8/6/2009	27
E-6	8/6/2010	17
E-6	8/3/2011	16
E-6	8/8/2012	15
E-6	8/2/2013	19
E-6	8/12/2014	17
E-6	8/5/2015	22
E-6	8/18/2016	13
E-6	8/11/2017	24
E-7	3/28/1989	590
E-7	4/6/1989	1100
E-7	4/12/1989	2100
E-7	4/18/1989	2500
E-7	4/25/1989	3300
E-7	5/2/1989	3400
E-7	5/9/1989	3700
E-7	5/16/1989	4200
E-7	5/23/1989	3900
E-7	5/30/1989	3900
E-7	6/7/1989	4000
E-7	6/13/1989	3700
E-7	6/20/1989	3700
E-7	6/27/1989	2800
E-7	7/5/1989	3100
E-7	7/11/1989	3000
E-7	7/18/1989	2600
E-7	7/25/1989	2700
E-7	8/1/1989	2700
E-7	8/8/1989	2000
E-7	8/15/1989	2400
E-7	8/22/1989	2300
E-7	8/29/1989	2500
E-7	9/5/1989	2500
E-7	9/12/1989	3400
E-7	11/15/1989	2100
E-7	11/21/1989	2900
E-7	11/28/1989	1700
E-7	12/5/1989	2100
E-7	12/12/1989	1900
E-7	12/19/1989	2200
E-7	1/4/1990	2700
E-7	1/17/1990	2000
E-7	1/31/1990	1500
E-7	2/14/1990	1400
E-7	2/28/1990	1400
E-7	3/14/1990	1600
E-7	3/28/1990	2000
E-7	4/11/1990	1500
E-7	4/25/1990	2100
E-7	5/8/1990	1700
E-7	5/22/1990	2400
E-7	6/6/1990	2200

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-7	6/19/1990	1600
E-7	7/3/1990	1400
E-7	7/17/1990	1300
E-7	7/31/1990	2600
E-7	8/14/1990	2500 B
E-7	8/28/1990	1500
E-7	9/10/1990	2100
E-7	9/27/1990	5800
E-7	10/9/1990	1500
E-7	10/29/1990	1700
E-7	11/14/1990	1600
E-7	11/28/1990	2100
E-7	12/11/1990	1500
E-7	1/2/1991	2000
E-7	1/15/1991	820
E-7	2/5/1991	1600
E-7	3/5/1991	1100
E-7	4/2/1991	1100
E-7	5/7/1991	900
E-7	6/3/1991	950
E-7	7/1/1991	2000
E-7	8/5/1991	910
E-7	9/3/1991	1100
E-7	10/2/1991	790
E-7	11/4/1991	870
E-7	12/4/1991	800
E-7	1/6/1992	1300
E-7	2/4/1992	550
E-7	3/3/1992	710
E-7	4/6/1992	810
E-7	5/4/1992	680
E-7	6/2/1992	800
E-7	7/6/1992	950
E-7	8/10/1992	1400
E-7	9/1/1992	1200
E-7	10/1/1992	950
E-7	11/2/1992	1900
E-7	12/1/1992	2900
E-7	1/1/1993	680
E-7	2/1/1993	1300
E-7	3/3/1993	1300
E-7	3/29/1993	610
E-7	4/28/1993	970
E-7	5/25/1993	870
E-7	6/23/1993	310
E-7	7/30/1993	520
E-7	8/25/1993	960
E-7	9/29/1993	500
E-7	10/27/1993	920
E-7	11/22/1993	880
E-7	12/27/1993	220
E-7	1/26/1994	920
E-7	2/23/1994	410

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-7	4/4/1994	1200
E-7	4/26/1994	1200
E-7	6/29/1994	940
E-7	10/26/1994	39
E-7	12/21/1994	650
E-7	3/3/1995	640 J
E-7	6/1/1995	700
E-7	8/29/1995	760
E-7	11/9/1995	540
E-7	3/4/1996	380
E-7	5/31/1996	380
E-7	8/26/1996	180
E-7	11/20/1996	240
E-7	3/6/1997	160
E-7	5/27/1997	100
E-7	9/2/1997	120
E-7	11/3/1997	83
E-7	2/24/1998	70
E-7	5/5/1998	77
E-7	8/3/1998	81
E-7	11/2/1998	100
E-7	2/1/1999	220
E-7	5/3/1999	240
E-7	8/2/1999	440
E-7	11/1/1999	150
E-7	2/4/2000	47
E-7	5/1/2000	85
E-7	8/2/2000	100
E-7	11/1/2000	48
E-7	2/1/2001	61
E-7	5/1/2001	52
E-7	8/6/2001	82
E-7	11/1/2001	88
E-7	2/2/2002	100
E-7	5/8/2002	72
E-7	8/1/2002	78
E-7	11/4/2002	53
E-7	12/4/2002	77
E-7	2/4/2003	34
E-7	5/7/2003	25
E-7	8/6/2003	20
E-7	11/5/2003	34
E-7	2/3/2004	21
E-7	5/6/2004	22
E-7	8/3/2004	43
E-7	11/1/2004	22
E-7	2/3/2005	67
E-7	5/3/2005	32
E-7	8/2/2005	49
E-7	12/16/2005	88
E-7	2/6/2006	160
E-7	5/9/2006	83
E-7	8/8/2006	80

Table 1
Groundwater Trichloroethene Analytical Results
Boeing Portland

Well ID	Sample Date	TCE (µg/L)
	TCE Cleanup Level:	5.0
E-7	11/9/2006	79
E-7	2/6/2007	62
E-7	5/10/2007	53
E-7	8/16/2007	140
E-7	11/8/2007	100
E-7	2/11/2008	140
E-7	5/12/2008	28
E-7	8/11/2008	18
E-7	11/4/2008	150
E-7	2/3/2009	21
E-7	8/6/2009	77
E-7	8/6/2010	39
E-7	8/3/2011	11
E-7	8/8/2012	29
E-7	8/2/2013	38
E-7	8/12/2014	19
E-7	8/12/2015	23
E-7	8/12/2016	19
E-7	8/12/2016	14
E-7	8/11/2017	5.1

Abbreviations and Acronyms:

ID = identification
µg/L = micrograms per liter
TCE = trichloroethene

Notes:

B = Analyte detected in as associated Method Blank at a concentration greater than one-half of ARI's Reporting Limit or 5% of the regulatory limit or 5 % of the analyte concentration in the sample.

J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.

= Exceeds Cleanup Level

Table 2
Potable Water Injection Test Results
Boeing Portland

Well ID	Potable Water Injection Test													Notes
		Gravity Flow Siphon Test				Partial Throttle Test				Full Throttle Test (a)				
	Injection Date	Injection Time (min)	Total Volume (gal)	Wellhead Pressure (psi)	**Rate (gpm) (b)**	Injection Time (min)	Total Volume (gal)	Wellhead Pressure (psi)	**Rate (gpm) (c)**	Injection Time (min)	Total Volume (gal)	Wellhead Pressure (psi)	**Rate (gpm) (c)**	
E6	10/30/17	22	180	0	**8.9**	18	927	0	**51.5**	15	941	0	**51.1**	Due to length of injection hose, pump was used to fill hoses, then turned off during gravity flow testing. For 20 psi test, pump was throttled to almost full throttle with no pressure noticed at wellhead.
E7	10/30/17	31	220	0	**9.6**	20	349	15-21.5	**19.8**	21	564	31-32	**25.8**	During gravity test, injection was paused intermittently to resolve malfunctioning flow meters.
BOP-9i	10/31/17	20	150	0	**5.1**	10	493	0 (d)	**49.3**	10	717	0 (d)	**79.7**	During entire injection test, a significant amount of suction was observed at the air bleed line, indicating rapid infiltration of injected water to the aquifer.
BOP-10i	10/31/17	24	95	0	**3.7**	23	125	15-16	**6.9**	20	226.00	32	**11.9**	Based on flow rate, E6 will be injected with electron donor instead of BOP-10i.

Abbreviations and Acronyms:
psi = pounds per square inch.
min = minute
gal = gallon
gpm = gallons per minute
ID = identification

Notes:

(a) 40 psi was not achieved at any of the wells with pump at full throttle.
(b) Rate calculated based on tank volume readings over injection time.
(c) Rate calculated based on data collected from flow meters.
(d) Pressure reading was zero, but the air bleed hose was under vacuum pressure.

Indicated pressures are gauge pressures measured at the top of the well casing.

Table 3
Injection Design Details
Boeing Portland

Well ID	Screen Length (ft)	injection/Batch Volume (gal)	Crude Glycerin (a) (gal)	Blackstrap Molasses (a) (gal)	Ferrous Chloride (b) (gal)	Water (gal)	Yeast Extract (lb)
BOP-9(i)	20	47,000	5,388	5,028	116	36,469	47
E-6	20	47,000	5,388	5,028	116	36,469	47
E-7	10	35,000	4,012	3,744	86	27,158	35
		129,000	14,787	13,800	318	100,095	129
Quantities for Mixing Batches:							
# of batches	25.8	5,000	573	535	12	3,880	5

Abbreviations and Acronyms:

ft = feet
gal = gallons
ID = identification
lbs = pounds

(a) Products diluted by half with water prior to delivery to reduce viscosity and allow for product transfer, batch mixing, and injection despite cold weather conditions. Delivered products are approximately 46.5 percent glycerin and 39.5 percent molasses (sugar).
(b) 33 percent solution by weight

Table 4
Bioremediation Monitoring Parameters
Boeing Portland

Field Parameters	Information Provided
Dissolved Oxygen (DO) [field meter] (a)	Aquifer is considered anaerobic at DO concentrations less than 1.0 milligram per liter (mg/L).
Oxidation Reduction Potential (Redox) [field meter] (a)	Negative values indicate reducing conditions.
pH [field meter] (a)	May decrease due to injected donor. Considered acceptable for reductive dechlorination when greater than 4.0 at injection wells and greater than 5 at monitoring wells (Suthersan et al. 2002). (b)
Iron (II) [Hach test kit]	Concentrations above background indicate iron reducing conditions.
Laboratory Analyses	**Information Provided**
Volatile Organic Compounds (VOCs) [Method 8260] [3-40 ml VOA-HCl] (c)	Concentrations of chlorinated VOCs and breakdown products are indicative of reductive dechlorination and pathways.
Total Organic Carbon (TOC) [Method SM5310C][250 ml Amber-H2SO4]	Indicator of the presence of donor in the aquifer. Concentrations will increase due to arrival of volatile fatty acids released from injected donor substrate.
Sulfate [IC Method E300][500 ml poly]	Decreasing concentrations indicate sulfate-reducing conditions.
Acetylene/Methane/Ethene/Ethane (AMEE) [Method 8015 Mod] [3-40 ml VOA] (c)	Concentrations of ethene and ethane are indicative of reductive dechlorination and pathways. Increasing methane concentrations indicate methanogenic aquifer redox conditions. Acetylene indicates the the occurrence of abiotic reductive elimination.

(a) Measured using a flow-through cell.

(b) Suthersan, S.S., C.C. Lutes, P.L. Palmer, F. Lenzo, F.C. Payne, D.S. Liles, and J. Burdick. 2002. *Final Technical Protocol for Using Soluble Carbohydrates to Enhance Reductive Dechlorination of Chlorinated Aliphatic Hydrocarbons.* Submitted to ESTCP and AFCEE under Contract #41624-99-C-8032. December 19.

(c) Care to be taken during sample collection to minimize aeration and volatilization. Sample collected with no headspace.

APPENDIX A

Injection Safety Data Sheets/ Material Safety Data Sheets

Safety Data Sheet (SDS)

ID: SDS 200-US

Section 1 – Chemical Product and Company Identification

Product identifier:	Crude Glycerin
Other means of identification	
Synonyms:	1,2,3-Propanetriol, Glycerin 98, Technical grade glycerin, Glycerol, Glycerine, Glycerin 80-95
Recommended use:	Waste water treatment process additive, dust suppression, feedstock for various industries after further refining
Restrictions on use:	Not intended for direct human consumption
Supplier information:	Whole Energy Fuels Corp Emergency phone number: Chemtrec: (800) 424-9300

Section 2 – Hazard(s) Identification

Classification (in accordance with 29 CFR 1910.1200)

Hazard Class	Hazard Category	Route of Exposure
Skin Irritation	Category 2 (irritation)	Absorption
Eye Irritation	Category 2B (mildly irritating)	Absorption

Signal word: WARNING

Pictograms:

Hazard Statements:	May causes skin and eye irritation
Hazards not otherwise specified:	None
Precautionary statements	
Prevention:	Wear appropriate protective gloves, protective garments, and eye protection.
Response:	If on skin, wash thoroughly with soap and water. Take off contaminated clothing and wash it before reuse. If skin irritation or rash occurs, seek medical advice. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If irritation persists: Seek medical attention.
Storage:	Store in cool tightly closed container
Disposal:	Dispose of contents/container in accordance with local, state, and federal regulations.

Safety Data Sheet (SDS)

ID: SDS 200-US

Section 3 – Composition / Information on Ingredients

Note: This SDS represents a product with batch-to-batch variability and/or a group of substantially similar mixtures

Chemical Name	Common Name & Synonyms	CAS number	% of product
Glycerol	Glycerin, glycerine	56-81-5	80-100
Water	Water, H_20	7732-18-5	.5-15
Sodium chloride (NaCl)	Salt, NaCl	7647-14-5	1-3
Methyl alcohol	Methanol	67-56-1	< 0.3

Section 4 – First Aid Measures

First aid measures for exposure

Inhalation: Move to fresh air

Eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Skin: Wash affected skin with soap and water.

Ingestion: Take off contaminated clothing and wash it before reuse.

Most important symptoms / effects

Acute: May cause eye and skin irritation.

Delayed / Chronic: No information available

Indication of immediate medical attention and special treatment needed, if necessary: No special treatment identified. Treat symptomatically and supportively.

Section 5 – Fire Fighting Measures

Suitable extinguishing media: Water mist, firefighting foam, dry chemical, carbon dioxide, or clean extinguishing agents (such as Halon or Halotron)

Unsuitable extinguishing media: Do not use a solid water stream, as it may scatter and spread the fire

Specific hazards arising from the chemical: May burn if heated, but does not readily ignite.

Materials saturated with this product, such as oily rags, used oil dri, soaked insulation pads, etc., may spontaneously combust due to product decomposition in the presence of oxygen. Place all such materials into appropriate oily waste containers (such as metal cans with metal lids or oily waste dumpsters with lids), and dispose of according to local, state, and federal regulations.

Hazardous combustion products include: Carbon monoxide, carbon dioxide, nitrogen oxides, and hydrocarbons

Protective equipment and precautions for firefighters:	Incipient stage fires may be controlled with a portable fire extinguisher. For fires beyond the incipient stage, evacuate all unnecessary personnel. Emergency responders in the immediate area should wear standard firefighting protective equipment, including self-contained breathing apparatus (SCBA) and full bunker gear. In case of external fires in proximity to storage containers, use water spray to keep containers cool, if it can be done safely. Prevent runoff from entering streams, sewers, storm drains, or drinking water supply.

Section 6 – Accidental Release Measures

Personal precautions, protective equipment, and emergency procedures:	Keep all sources of ignition away from spill. Wear protective garments, impervious oil resistant boots,protective chemical-resistant gloves, and safety glasses. If product has been heated, wear appropriate thermal and chemical protective equipment. If splash is a risk, wear splash resistant goggles and face shield. Shut off source of spill, if safe to do so. Contain spill to the smallest area possible. Isolate immediate hazard area and remove all nonessential personnel. Prevent spilled product from entering streams, sewers, storm drains, unauthorized treatment drainage systems, and natural waterways. Place dikes far ahead of the spill for later recovery and disposal. Immediate cleanup of any spill is recommended. **If material spills into or upon any navigable waters and causes a film or sheen on the surface of the water, immediately notify the National Response Center at 1-800-424-8802.**

Methods for containment and clean-up

Small spill / incidental release:	Small spills can be cleaned up with a properly rated vacuum system, absorbent inert media (oil dri, sand, or earth), or absorbent pads. Use soapy water or degreaser to remove oily residue from the affected area, then rinse area with water. Place saturated materials in an appropriate oily waste container (metal can with a metal lid or an enclosed oily waste dumpster), and dispose of according to local, state, and federal regulations.
Large spill / release:	A spill remediation contractor with oil booms and skimmers may be needed for larger spills or spillsthat come into contact with a waterway or sensitive wetland. Recover as much product as possible by pumping it into totes or similar intermediate containers. Remove any remaining product with a properly rated vacuum system, absorbent inert media (oil dri, sand, or earth), or absorbent pads. Use soapy water or degreaser to remove oily residue from the affected area, then rinse area with water. Place saturated materials in an appropriate oily waste container (metal can with a metal lid or an enclosed oily waste dumpster), and dispose of according to local, state, and federal regulations.
Other information:	Materials saturated with this product, such as oily rags, used oil dri, soaked insulation pads, etc., may spontaneously combust due to product decomposition in the presence of oxygen. Place all such materials into appropriate oily waste containers (such as metal cans with metal lids or oily waste dumpsters with lids), and dispose of according to local, state, and federal regulations.

Section 7 – Handling and Storage

Precautions for safe handling:	Store the product in a cool dry place, in a tightly closed container. When transferring product, use pipes, hoses, and tanks that are electrically bonded and grounded to prevent the accumulation of static electricity. Storage tanks should have an appropriate ventilation and pressure relief system.
Conditions for safe storage, including incompatibilities:	Keep away from strong oxidizing agents, strong reducing agents, strong acids, and strong bases.

Safety Data Sheet (SDS)

ID: SDS 200-US

Section 8 – Exposure Controls / Personal Protection

Precautions for safe handling

Component exposure limits: OSHA PEL for Glycerin mist is 15 mg/m3 TWA

Appropriate engineering controls: Keep product enclosed in primary containment (hoses, pipes, tanks, etc.) to avoid contact with skin. Handle in accordance with good industrial hygiene and safety practices.

Personal protective equipment

Eyes / face: Wear safety glasses. If splash potential exists, use splash resistant goggles and a face shield.

Skin: Wear disposable nitrile or other similar chemical-resistant gloves for incidental contact. For more substantial contact, wear thicker nitrile or other similar chemical-resistant gloves. Wear protective garments, such as a chemical apron, chemical resistant coveralls, or chemical resistant coat and pants, along with impervious oil-resistant boots. Remove soaked protective equipment, decontaminate with soapy water, and rinse thoroughly before reuse. **Note**: product will cause natural rubbers to degrade at a very rapid rate. Such protective equipment will need to be carefully inspected after decontamination to see if it is still in serviceable condition. Any defective or worn out equipment should be immediately discarded.

Respiratory: OSHA PEL for glycerin mist is 15 mg/m3 TWA. Appropriate organic vapor or supplied air respiratory protection may be worn if irritation or discomfort is experienced. Respiratory protection must be provided and used in accordance with all local, state, and federal regulations.

Section 9 – Physical and Chemical Properties

Physical State:	Liquid to viscous liquid	Color:	Colorless to brown liquid
Odor:	Mild oil odor	Odor Threshold:	*No information available*
pH:	6.5 – 7.5 pH	Melting/Freezing Point:	< 0° C (< 32° F)
Boiling Point/Range:	115-125°C / 239-257°F (at 1 atm)	Flash Point:	160° C / 320° F
Evaporation Rate:	*No information available*	Flammability (solid/liq):	*No information available*
LFL:	*No information available*	UFL:	*No information available*
Vapor Pressure:	.000106 hPa	Vapor Density:	*No information available*
Relative Density:	*No information available*	VOC:	< 0.5% (residual methanol only)
Solubility (H20):	100,000mg/L (Miscible)	Solubility *(other)*:	*No information available*
Auto Ignition Temp.:	393° C	Decomposition Temp.:	280° C
Kinematic Viscosity:	21 cP @ 40° C	Partition coefficient (n-octanol/water) :	*No information available*
Density:	1.26 @ 20° C	Molecular Weight:	92.09382 g/mol

Section 10 – Chemical Stability and Reactivity Information

Reactivity: When handled and stored appropriately, no dangerous reactions are known

Chemical stability: Stable in closed containers at room temperature under normal storage and handling conditions

Possibility of hazardous reactions:	When handled and stored appropriately, no dangerous reactions are known See Sections 5 and 6 regarding spontaneous combustion of product-saturated absorbent materials.
Conditions to avoid:	Ignition sources, accumulation of static electricity, heating product to its flash point, or allowing the product to cool below its melting point (otherwise it may solidify and not be transferable until it is reheated).
Incompatible materials:	Keep away from strong oxidizing agents, strong reducing agents, strong acids, and strong bases.
Hazardous decomposition products:	Carbon oxides, hydrogen sulfide, nitrogen oxides, and hydrocarbons

Section 11 – Toxicological Information

Likely routes of exposure: Absorption, ingestion, and inhalation

Symptoms

Inhalation:	Coughing or irritation
Eye contact:	Mechanical irritation may cause tearing or blurred vision
Skin contact:	Hot product or prolonged exposure may cause redness or irritation to skin
Ingestion:	Nausea, vomiting, or feeling unwell

Acute toxicity

Oral:	LD50 >23,000 mg/kg (rat)
Dermal:	LD50 > 18,700 mg/kg bw (rabbit)
Inhalation:	No information was available

Skin corrosion / irritation: Experience has shown crude glycerin may be mildly irritating to skin

Serious eye damage / eye irritation: Experience has shown crude glycerin may be mildly irritating to the eyes

Sensitization *(Respiratory or Skin)*: Available data indicated that glycerol is not likely to be a skin sensitizer.

Germ cell mutagenicity: Available data indicated that glycerol is not likely to cause germ cell mutagenicity.

Carcinogenicity: Available data indicated that glycerol is not listed as a carcinogen (IARC monograph, NTP, OSHA)

Component carcinogenicity: Not applicable

Reproductive / developmental toxicity: No information available

Specific target organ toxicity

Single exposure:	No information available
Repeated exposure:	No information available

Aspiration hazard:
No information available

Section 12 – Ecological Information

Acute ecotoxicity - short-term exposure

Fish:	LC50 51000 - 57000 mg/L (Oncorhynchus mykiss 96 h) – Glycerol LC50= 13200 mg/L (Oncorhynchus mykiss 96 h) – Methanol NA – Sodium Chloride (NaCl)
Invertebrates:	EC50 > 500 mg/L 24 h – Glycerol EC50 = 1000 mg/L 48 h – Sodium Chloride (NaCl)
Algae:	No information available
Persistence and degradability:	Product is readily biodegradable
Bioaccumulative potential:	Accumulation in organisms is not to be expected
Mobility in soil:	Will likely be mobile in the environment due to its water solubility but will likely degrade over time.
Other adverse effects:	No information available

Chemical Name	Log Pow
Glycerol	-1.76
Methyl alcohol	-0.77

Section 13 – Disposal Considerations

Disposal *(waste / unwanted product)*:	This material, as supplied, is not a hazardous waste according to Federal regulations (40 CFR 261). This material could become a hazardous waste if chemical additions are made to this material, or if the material is processed or otherwise altered. Consult 40 CFR 261 to determine whether the altered material is a hazardous waste. Consult the appropriate local, state, regional, or federal regulations for additional requirements.
Disposal *(containers with residue)*:	Dispose of all containers with residue according to local, state, regional, and federal regulations.

Section 14 – Transport Information

UN number:	Not Regulated as a hazardous material
UN proper shipping name:	Not Regulated as a hazardous material
Transport hazard class:	Not Regulated as a hazardous material
Packing group:	Not Regulated as a hazardous material
Marine pollutant:	☐ Yes ☒ No

Transport in bulk requirements: Not Regulated as a hazardous material

Special transportation precautions: Not Regulated as a hazardous material

Section 15 – Regulatory Information

Inventory Listings

TSCA ☒ Listed ☐ Exempt

DSL ☒ Listed ☐ Exempt

U.S. Federal Regulations

SARA 313: Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product contains the following chemical(s) subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372:

Chemical Name	CAS-No	Weight %	SARA 313 – Threshold Values %
Methyl alcohol	67-56-1	<0.1	1.0

SARA 311/312 Hazard Categories:

Acute Health Hazard	☐ Yes	☒ No
Chronic Health Hazard	☐ Yes	☒ No
Fire Hazard	☐ Yes	☒ No
Sudden Release of Pressure Hazard	☐ Yes	☒ No
Reactive Hazard	☐ Yes	☒ No

Clean Water Act: This product does not contain any chemicals regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42).

CERCLA: This material, as supplied, does not contain any chemicals regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material.

U.S. State Regulations

California Proposition 65:

☒ WARNING! This product the following chemical(s) known to the State of California to cause cancer or reproductive harm:

This product may contain a small quantity of methanol, which was added to the Proposition 65 list on March 16, 2012.

U.S. State Right-to-Know Regulations:

Chemical Name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Glycerol	X	-	X	-	x

Section 16 – Other Information

Issuing Date: Aug 22, 2007

Revision Date: Jan 19, 2016

Version #: 20160119

Revision Note: Updated pH, boiling point, and evaporation rate in Section 9 at the request of the technical services team

WARNING: POTENTIALLY HAZARDOUS MATERIAL. IMPROPER USE OR MISHANDLING CAN RESULT IN SERIOUS INJURY OR DEATH. THIS PRODUCT CONTAINS SUBSTANCES WHICH, IF MODIFIED, MAY BE FLAMABLE AND MAY BURN OR EXPLODE IF HEATED OR EXPOSED TO FLAME OR OTHER IGNITION SOURCE OR WATER, OXIDIZING AGENTS, ACIDS OR OTHER CHEMICALS. AVOID INGESTION, INHALATION AND CONTACT WITH SKIN AND EYES.

Disclaimer:
The information provided on this SDS is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

End of SDS

Material Safety Data Sheet

Catalog Number: 103304
Revision date: 26-Apr-2006

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY INFORMATION

Catalog Number: 103304

Product name: YEAST HYDROLYSATE ENZYMATIC

Supplier:
MP Biomedicals, LLC
29525 Fountain Parkway
Solon, OH 44139
tel: 440-337-1200

Emergency telephone number: CHEMTREC: 1-800-424-9300 (1-703-527-3887)

2. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS Number	Weight %	ACGIH Exposure Limits:	OSHA Exposure Limits:
YEAST HYDROLYSATE ENZYMATIC	N/A	90 - 100%	None	None

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: May cause skin irritation and/or dermatitis

Principle routes of exposure: Skin
Inhalation: May cause irritation of respiratory tract
Ingestion: May be harmful if swallowed.
Skin contact: May cause allergic skin reaction
Eye contact: Avoid contact with eyes

Statements of hazard MAY CAUSE ALLERGIC SKIN REACTION.
Statement of Spill or Leak - ANSI Label Eliminate all ignition sources. Absorb and/or contain spill with inert materials (e.g., sand, vermiculite). Then place in appropriate container. For large spills, use water spray to disperse vapors, flush spill area. Prevent runoff from entering waterways or sewers.

4. FIRST AID MEASURES

General advice: In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
Inhalation: Move to fresh air. Call a physician immediately.
Skin contact: Rinse immediately with plenty of water and seek medical advice
Ingestion: Do not induce vomiting without medical advice.
Eye contact: In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
Protection of first-aiders: No information available
Medical conditions aggravated by exposure: None known

5. FIRE FIGHTING MEASURES

Suitable extinguishing media: Use dry chemical, CO2, water spray or "alcohol" foam
Specific hazards: Burning produces irritant fumes.
Unusual hazards: None known
Special protective equipment for firefighters: As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear
Specific methods: Water mist may be used to cool closed containers.
Flash point: Not determined
Autoignition temperature: Not determined
NFPA rating:

NFPA Health:	0
NFPA Flammability:	0
NFPA Reactivity:	0

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Use personal protective equipment.
Environmental precautions: Prevent product from entering drains.
Methods for cleaning up: Sweep up and shovel into suitable containers for disposal.

7. HANDLING AND STORAGE

Storage:

ROOM TEMPERATURE

Handling: Use only in area provided with appropriate exhaust ventilation.
Safe handling advice: Wear personal protective equipment.
Incompatible products: Oxidising and spontaneously flammable products

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures: Ensure adequate ventilation.
PERSONAL PROTECTIVE EQUIPMENT
Respiratory protection: Breathing apparatus only if aerosol or dust is formed.
Hand protection: Pvc or other plastic material gloves
Skin and body protection: Usual safety precautions while handling the product will provide adequate protection against this potential effect.
Eye protection: Safety glasses with side-shields
Hygiene measures: Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state: Powder
Formula: Not applicable
Melting point/range: No data available at this time.
Boiling point/range: No Data available at this time.
Density: No data available
Vapor pressure: No data available
Evaporation rate: No data available

Vapor density:	No data available
Solubility (in water):	No data available
Flash point:	Not determined
Autoignition temperature:	Not determined

10. STABILITY AND REACTIVITY

Stability:	Stable under recommended storage conditions.
Polymerization:	None under normal processing.
Hazardous decomposition products:	Thermal decomposition can lead to release of irritating gases and vapours such as carbon oxides.
Materials to avoid:	Strong oxidising agents
Conditions to avoid:	Exposure to air or moisture over prolonged periods.

11. TOXICOLOGICAL INFORMATION

Product Information

Acute toxicity

Components	RTECS Number:	Selected LD50s and LC50s
YEAST HYDROLYSATE ENZYMATIC	Not Available	Not Determined

Chronic toxicity:	Chronic exposure may cause nausea and vomiting, higher exposure causes unconsciousness.
Local effects:	Symptoms of overexposure may be headache, dizziness, tiredness, nausea and vomiting.
Specific effects:	May include moderate to severe erythema (redness) and moderate edema (raised skin), nausea, vomiting, headache.
Primary irritation:	No data is available on the product itself.
Carcinogenic effects:	No data is available on the product itself.
Mutagenic effects:	No data is available on the product itself.
Reproductive toxicity:	No data is available on the product itself.

12. ECOLOGICAL INFORMATION

Mobility:	No data available
Bioaccumulation:	No data available
Ecotoxicity effects:	No data available
Aquatic toxicity:	May cause long-term adverse effects in the aquatic environment.

Components	U.S. DOT - Appendix B - Marine Pollutan	U.S. DOT - Appendix B - Severe Marine Pollutants	United Kingdom - The Red List:
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed

Components	Germany VCI (WGK)	World Health Organization (WHO) - Drinking Water	Ecotoxicity - Fish Species Data
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed

Components	Ecotoxicity - Freshwater Algae Data	Ecotoxicity - Microtox Data	Ecotoxicity - Water Flea Data
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed

Components	EPA - ATSDR Priority List	EPA - HPV Challenge Program Chemical List	California - Priority Toxic Pollutants
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed

Components	California - Priority Toxic Pollutants	California - Priority Toxic Pollutants
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Waste disposal must be in accordance with appropriate Federal, State, and local regulations. This product, if unaltered by use, may be disposed of by treatment at a permitted facility or as advised by your local hazardous waste regulatory authority. Residue from fires extinguished with this material may be hazardous.

Contaminated packaging: Do not re-use empty containers

14. TRANSPORT INFORMATION

UN/Id No: Not regulated

DOT:

Proper shipping name: Not Regulated

Components	U.S. DOT - Appendix A Table 1 - Reportable Quantities
YEAST HYDROLYSATE ENZYMATIC	Not Listed

TDG (Canada):

WHMIS hazard class: Non-controlled

IMDG/IMO

IMDG - Hazard Classifications Not Applicable

Components	U.S. DOT - Appendix B - Marine Pollutan	U.S. DOT - Appendix B - Severe Marine Pollutants
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed

IMO-labels:

15. REGULATORY INFORMATION

International Inventories

Components
YEAST HYDROLYSATE ENZYMATIC
Inventory - United States TSCA - Sect. 8(b) Not Listed

Canada DSL Inventory List - Not Listed

U.S. regulations:

Components	California Proposition 65 -	Massachusetts Right to Know List:	New Jersey Right to Know List:	Pennsylvania Right to Know List:
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed	Not Listed

Components	Florida substance List:	Rhode Island Right to Know List:	Illinois - Toxic Air Contaminants	Connecticut - Hazardous Air Pollutants
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	Not Listed	Not Listed

Components	SARA 313 Emission reporting/Toxic Release of Chemicals	CERCLA/SARA - Section 302 Extremely Haz	NTP:	IARC:
YEAST HYDROLYSATE ENZYMATIC	Not Listed	Not Listed	None	None

SARA 313 Notification: The above is your notification as to the SARA 313 listing for this product(s) pursuant to Section 313 of Title III of the Superfund Ammendments and Reauthorization Act of 1986 and 40 CFR Part 372.

If you are unsure if you are subject to the reporting requirements of Section 313, or need more information, please call the EPA Emergency Planning and Community Right-To-Know Information Hotline: (800) 535-0202 or (202) 479-2499 (in Washington, DC or Alaska).

State Notification: The above information is your notice as to the Right-to-Know listings of the stated product(s). Individual states will list chemicals for a variety of reasons including, but not limited to, the compounds toxicity; carcinogenic, tumorigenic and/or reproductive hazards; and the compounds environmental impact if accidentally released.

16. OTHER INFORMATION

Prepared by: Health & Safety
Disclaimer: The information and recommendations contained herein are based upon tests believed to be reliable. However, MP Biomedicals does not guarantee the accuracy or completeness NOR SHALL ANY OF THIS INFORMATION CONSTITUTE A WARRANTY, WHETHER EXPRESSED OR IMPLIED, AS TO THE SAFETY OF THE GOODS, THE MERCHANTABILITY OF THE GOODS, OR THE FITNESS OF THE GOODS FOR A PARTICULAR PURPOSE. Adjustment to conform to actual conditions of usage maybe required. MP Biomedicals assumes no responsibility for results obtained or for incidental or consequential damages, including lost profits arising from the use of these data. No warranty against infringement of any patent, copyright or trademark is made or implied.

End of Safety Data Sheet

SAFETY DATA SHEET: SODIUM THIOSULFATE, Pentahydrate

1. IDENTIFICATION

Product Name:	SODIUM THIOSULFATE, Pentahydrate
Synonyms:	Hypo; Sodium hyposulfite
Formula and Formula Weight:	Na2S2O3 5H2O 248.18
Integra numbers beginning with:	S624.10; S624.31; S624.50
Recommended Use:	Commercial/industrial use
Restrictions on Use:	No information available

INTEGRA Chemical Company
1216 6th Ave N
Kent WA 98032
Phone: 253-479-7000

24 Hour Emergency Response: CHEMTREC 800-424-9300 (Outside USA 703-527-3887)

2. HAZARDS IDENTIFICATION

OSHA Classification:	Hazard Category:	Hazard Statement:
None identified	Not applicable	Not applicable

Hazards Not Otherwise Classified: No information available

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	Synonyms	CAS #	% Weight
Sodium thiosulfate, pentahydrate	Hypo; Sodium hyposulfite	10102-17-7	100

4. FIRST AID MEASURES

Inhalation:	Remove person to fresh air.
Eye Contact:	Flush eyes with plenty of water. If irritation persists, seek medical attention.
Skin Contact:	Wash with soap and water. Seek medical attention if irritation develops.
Ingestion:	Rinse mouth and give victim large quantities of water. Never give anything by mouth to an unconscious person. Seek immediate medical attention.
Additional notes:	Symptoms and effects include irritation of skin, eyes, respiratory tract, gastrointestinal tract.

5. FIRE-FIGHTING MEASURES

Extinguishing Media:	Material is not flammable. Use extinguishing media suitable to surrounding materials.
Special Equipment and Precautions:	Use water to cool nearby containers and structures. Wear full protective equipment, including suitable respiratory protection.
Specific Hazards:	Fire conditions may liberate toxic and noxious fumes.
Hazardous combustion products:	Oxides of sulfur.

6. ACCIDENTAL RELEASE MEASURES

Spill Procedures:	Prevent spread of spill. Wear suitable protective equipment. Sweep or scoop into clean, dry disposal container. Flush spill area with water.

7. HANDLING AND STORAGE

Incompatible Materials:	Incompatible with strong acids and strong oxidizers. Iodine, silver salts, mercury, lead, sodium nitrate.
Storage and Handling:	Store in a cool, dry, well-ventilated area away from incompatible materials. Keep containers tightly closed and protect them from physical damage.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

OSHA & ACGIH Exposure Limits:

Sodium thiosulfate, pentahydrate None identified

Engineering Controls:	Use adequate general or local exhaust ventilation to keep fume and/or dust levels as low as possible.
Respiratory Protection:	If use generates annoying or irritating dusts, mists or vapors, use a NIOSH approved respirator with a particulate filter.
Skin/Eye Protective Equipment:	Safety glasses.
	Facilities storing or utilizing this material should have readily accessible eyewash stations and safety showers. Select respirators and other safety equipment in accordance with regulations and based upon the particular conditions of use and risk of exposure. Always use safe chemical-handling and good industrial hygiene practices.

9. PHYSICAL AND CHEMICAL PROPERTIES

Apearance:	Clear or white crystals
Odor:	No odor
Odor Threshold:	Not available
pH:	6.5 - 8.0 for aqueous solution
Melting/Freezing Point:	48 °C
Initial Boiling Point and Boiling Range:	Not available
Flash Point:	Not available

Evaporation Rate:	Not available
Flammability:	Not available
Flammable or Explosive	Upper: Not available
Limits (% by volume in air)	Lower: Not available
Vapor Pressure:	Not available
Vapor Density:	Not available
Relative Density:	1.69 g/cc
Solubility:	Soluble in water
Partition Coefficient: n-octanol/water	Not available
Auto-Ignition Temperature:	Not available
Decomposition Temperature:	Not available
Viscosity:	Not available

10. STABILITY AND REACTIVITY

Reactivity:	No information available
Stability:	Stable
Possibility of Hazardous Reactions:	Hazardous polymerization will not occur
Conditions to Avoid:	Excessive heat.
Incompatibles:	Incompatible with strong acids and strong oxidizers. Iodine, silver salts, mercury, lead, sodium nitrate.
Decomposition Products:	Oxides of sulfur.

11. TOXICOLOGICAL INFORMATION

Effects of Over Exposure:

Inhalation:	Inhalation may irritate the nose, throat and upper respiratory tract.
Skin Contact:	No irritation is likely upon brief contact. May be irritating after prolonged or repeated contact.
Eye Contact:	Dusts may cause some eye irritation.
Ingestion:	Ingestion of large quantities may cause gastrointestinal irritation, nausea and vomiting.
Chronic Effects:	None identified
Target Organs:	None identified
Additional Effects:	None identified
Reproductive Effects:	None identified
Carcinogenicity:	None identified

Toxicity Data:

Sodium thiosulfate, pentahydrate	TDlo (oral, human)	300 mg/kg
	LDlo (intravenous, dog)	3000 mg/kg

12. ECOLOGICAL INFORMATION

	Aquatic Toxicity Data:	Terrestrial Toxicity Data:
Sodium thiosulfate, pentahydrate	No information available	No information available

Persistence and degradability:	No information available
Bioaccumulative potential:	No information available
Mobility in soil:	No information available
Other adverse effects:	No information available

13. DISPOSAL CONSIDERATIONS

Disposal Procedures: Dispose of material and containers in accordance with all local, state and federal regulations.

14. TRANSPORTATION INFORMATION

This product is not a regulated material for domestic ground transporation.

Environmental hazards:	No information available
Special precautions:	No information available
Bulk transport:	No information available

15. REGULATORY INFORMATION

Sodium thiosulfate, pentahydrate is listed in the TSCA inventory.

16. OTHER INFORMATION

OSHA SDS #: 26480 rev 101 3/27/2015

NE = Not established, NA = Not applicable or Not available

***** END OF SDS *****

APPENDIX B

Health and Safety Plan

Health and Safety Plan
Boeing Portland
Gresham, Oregon

March 28, 2008
Revised: January 4, 2017
Revised October 16, 2017

Prepared for

The Boeing Company

LANDAU ASSOCIATES

130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

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HEALTH AND SAFETY PLAN SUMMARY

SITE NAME:	Boeing of Portland: Troutdale Gravel Aquifer (TGA) and Troutdale Sandstone Aquifer (TSA) Remedies
LOCATION:	19000 NE Sandy Boulevard
CLIENT:	The Boeing Company (Boeing)
TYPE OF FACILITY:	Industrial/Aerospace Manufacturer
LAND USE OF AREA NEAR FACILITY:	Industrial, Commercial, and Residential
SITE ACTIVITIES:	Ongoing remediation of groundwater in two aquifers including: drilling, soil/vapor/groundwater sampling activities, construction oversight, and remedy system operation and maintenance (O&M).
POTENTIAL SITE HAZARDS:	Dermal exposure, incidental ingestion, and/or inhalation of contaminants; heat stress; slips, trips, and falls; work near heavy equipment and machinery; noise; storms; and work near pedestrians.
POTENTIAL SITE CONTAMINANTS:	Volatile organic compounds (VOCs) and diesel-range petroleum hydrocarbons (TPH-Dx).
ROUTES OF ENTRY:	Skin contact with or incidental ingestion of potentially contaminated soil, groundwater, solids; and inhalation of airborne droplets, dusts, or vapors.
PROTECTIVE MEASURES:	Protective clothing (including hard hat, steel-toed boots, safety glasses, nitrile gloves, coveralls); (stand-by) air purifying respirators, Tyvek suits; dust control; and ambient air monitoring equipment.
MONITORING EQUIPMENT:	Photoionization detector (PID) meter and chemical-specific detector tubes.

1.0 INTRODUCTION

This health and safety plan (HASP) presents requirements for remedial activities associated with both the Troutdale Gravel Aquifer (TGA) and the Troutdale Sandstone Aquifer (TSA) groundwater remedy and associated construction support activities. This HASP will be implemented for activities conducted on the Boeing Portland (Boeing) facility and in the local investigation and study areas, except for the Cascade Corporation (Cascade) facility, which will be addressed by separate Cascade health and safety plans.

Health and safety procedures to be used during these activities include descriptions of existing site conditions and organization, safety procedures, criteria for hazard and risk analysis, levels of personal protection and required equipment, air monitoring procedures, emergency response information, and requirements pertaining to training and medical monitoring of onsite personnel.

This HASP applies to Boeing personnel (associated with the site remedies) and Landau Associates (LAI) personnel. Contractors are required to submit a health and safety plan covering general safety for the contractors' specific work on the site, or adopt this plan as their own relative to potential exposure to volatile organic compounds (VOCs). The requirements outlined in this plan are considered the minimum health and safety requirements and are intended to be incorporated by each contractor into their respective health and safety plan. Contractors may choose to apply more stringent health and safety requirements. This plan does not address physical worker safety issues that may be associated with fall prevention, excavation trenching, shoring, hot work, and electrical work, as these activities are covered under the specific contractor HASP. Relevant federal, state, and local standards must be followed for all work related to the TGA corrective measures and TSA remedy implementation and associated construction support activities.

1.1 Site Description

The Boeing Portland facility is located in Gresham, Oregon at 19000 NE Sandy Boulevard as shown on Figure 1. The VOC plume in the TGA has been delineated and characterized through the Resource Conservation and Recovery Act (RCRA) facility investigations (RFI; LAI 1988, 1990, 1991, 1992, 1993, 1995a), and a corrective measures study (CMS; LAI 1995b, 1996) was performed to evaluate corrective measures alternatives and select a preferred corrective measure for remediation of the plume. Based on the CMS, the U.S. Environmental Protection Agency (EPA) issued a Statement of Basis (EPA 1997a) and a Final Decision (EPA 1997b) documenting the preferred corrective measure alternative. A corrective measure implementation was developed to describe the management strategy and present the conceptual design for conducting and implementing the design, construction, operation, maintenance, and monitoring of the selected corrective measure.

The TSA study area is located entirely in East Multnomah County and encompasses the TSA operable unit and surrounding area, including portions of Blue Lake, and Fairview Lake. The VOC plume has been delineated by investigations conducted separately by Boeing and Cascade and jointly as part of

the TSA remedial investigation and feasibility study (EMCON and LAI 1995; LAI and EMCON 1996). Based on these investigations, the boundaries of the TSA study area, established in the Oregon Department of Environmental Quality (ODEQ) Record of Decision (ROD) are: NE 181st Avenue to the west, NE 223rd Avenue to the east, NE Halsey Street to the south, and the Columbia River to the north.

For the purposes of this document, the terms "the site" and "onsite" include the Boeing facility, the TGA offsite investigation area, and the TSA study area.

1.2 Purpose, Applicability, and Adherence

Activities in this HASP include, but are not limited to, oversight of drilling activities (borehole drilling, installing, and decommissioning of wells and or sub-slab vapor pins); collection of groundwater and soil vapor in both wells and sub-slab vapor pins; collecting borehole soil and groundwater samples; oversight of construction related activities for underground piping from extraction wells to the existing groundwater treatment system (GWTS). Construction support may include borehole soil, surface water, groundwater, and air sampling and monitoring during well installation, as well as piping and treatment facilities construction. Monitoring, including periodic groundwater and borehole soil sampling and analysis, occur during the entire period of remediation to track constituent distributions. The health and safety requirements described in this HASP are directed at protecting workers from exposure to organic vapors and potentially contaminated soil, groundwater, and surface water during these activities. These health and safety requirements apply to all personnel, contractors, and others entering locations at the site where invasive remedial activities or sampling are being conducted.

All LAI, Boeing personnel, and visitors must read this plan prior to participation in remediation field activities or site visits of the remediation system. If information presented in this plan is unclear, the reader must contact the Boeing representative (see Section 1.3) for clarification before participating in field activity. Once the information has been read and understood, the individual will sign the health and safety acknowledgment form (Form 1); the signed form be kept in the LAI's project files. After each individual has read this HASP, but before participating in field activities, a training session will be conducted by the contractor to familiarize Boeing personnel and visitors with health and safety requirements at the site.

This HASP has been designed to be flexible to allow unanticipated location-specific problems to be addressed, while providing adequate and suitable worker protection. These requirements may be modified at any time by the Boeing project manager or the designated Boeing representative. Any modification will be presented to the onsite team during a safety briefing and documented.

1.3 Project Organization and Responsibilities

1.3.1 Boeing Project Manager

The current Boeing project manager is Mr. Mike Gleason. Mr. Gleason, or other future Boeing-designated project managers, will have responsibility for project planning and execution relative to environmental affairs and concerns. The project managers will be responsible for making project-level decisions regarding safety rules and operations in consultation with the Boeing Field Engineer and the LAI Project Manager. The project managers may suspend environmental investigations and remedial construction activities, and recommend suspension of other onsite construction activities to the Boeing Portland facility's manager if health and safety issues warrant. Specific responsibilities of the project manager or their designee include monitoring the contractors for compliance with their project-specific health and safety plans according to the terms of the contract.

1.3.2 Boeing Field Engineer

Ms. Jennifer Parsons is the current Boeing Field Engineer. In this capacity, she is the Boeing representative responsible for:

- Monitoring daily activities
- Conducting orientation training for all Boeing personnel before beginning their activities
- Communicating with the project manager regarding investigation and remediation activities and health and safety conditions
- Acting as the project manager's liaison with Boeing site facilities, construction, investigation, and remediation activities representatives.

The Boeing Field Engineer may also be designated as the project health and safety officer (HSO) for Boeing activities onsite. In this capacity, he/she may be assisted by a representative of Boeing's remediation consultant, LAI. The Boeing Field Engineer may not be available during onsite activities and may transfer safety oversight activities to Boeing’s remediation consultant, LAI.

1.3.3 Landau Associates Safety Manager

Safety monitoring during site remedial activities will be the responsibility of the Boeing Project Managers, and the designated LAI’s Health and Safety Manager. The Landau Associates’ Health and Safety Manager, Ms. Christine Kimmel, will prepare safety plans, review safety documentation prior to the start of field activities, and be the priory point of contact in the case of an incident. The LAI Safety Manger will also review contractor safety plans and provide comments, as needed. The Safety Manager will oversee any required safety investigation within 24 hours of an incident, and develop corrective actions (as needed).

1.3.4 Landau Associates Site Safety Officer

The LAI Site Safety Officer, Ms. Erin Waibel, or equivalent designee, will be present at the site at all times during intrusive site activities related to the monitoring well installation, soil boring completion,

and sampling activities. The LAI Site Safety Officer will review safety documents and conduct work in accordance with the plans. The LAI Site Safety Officer will oversee operation and maintenance (O&M) contractor activities and make observations on safety procedures, any safety concerns will be reported to the LAI Safety Manager.

1.3.5 Contractor Project Health and Safety Officer

Site O&M contractors will designate their own project HSO (CHSO) to be onsite at all times during intrusive and O&M activities. The CHSO be responsible to the Boeing Field Engineer and LAI for enforcing the provisions of their health and safety plan. He/she also monitors the implementation of contractor health and safety plans and notify the project manager, field engineer, and site facilities and contractor representatives of any conditions which may present a danger to personnel in the field or which may require modification of health and safety plans.

Contractor representatives will be present during all intrusive and O&M activities and audit health and safety conditions at the site. The Boeing representative, in coordination with the contractor and CHSO, will:

- Ensure that personnel are aware of health and safety requirements and the potential hazards associated with the work, instructed in safe work practices, and understand the planned procedures for dealing with emergencies.
- Ensure that all required forms are completed.
- Correct any work practices or conditions that may result in injury to personnel or exposure to hazardous substances.
- Require that appropriate personal protective equipment (PPE) is properly used by all onsite personnel.
- Report any deviations from the anticipated conditions described in this document to the project manager or his/her representative.
- Monitor decontamination procedures per Oregon Administrative Rule (OAR)-Occupational Safety and Health Administration (OSHA) 1910-132 and 134 (OSHA 1989a).

1.3.6 Work Area Security

Work areas where intrusive activities (i.e., drilling, excavating/trenching, extraction well cleaning, sampling, and pump replacement) are being conducted will be barricaded and separated from the general public. Ambient air quality monitoring will be conducted when personnel are located inside the secured work area to monitor for PPE protection/action levels. Work areas in and around groundwater extraction well and utility vaults will be barricaded and separated from the general public. Barricades consist of, but not be limited to, caution tape, flags, traffic cones, and traffic barricades. Only personnel who are familiar with the work procedures and have reviewed and signed the HASP acknowledgment form be allowed within the interior of the secured work area. Security in the contractor's work area will be the responsibility of the contractor with Boeing concurrence.

2.0 SAFETY PROCEDURES

Safety must be the concern of every individual involved in project activities. Whether in the office or onsite, properly followed procedures are essential for personal safety and to minimize lost time due to injuries or accidents involving equipment. Potential hazards in the work area include, but are not limited to:

- Exposure to toxic or hazardous chemicals
- Physical hazards from heavy equipment
- Fire and explosion caused by flammable or combustible materials
- Weather stress caused by PPE or weather conditions.

2.1 Chemical Hazards

Volatile organic compounds and diesel-range petroleum hydrocarbons (TPH-Dx) compounds may be present in soil, shallow soil vapor, surface water, and groundwater at the site. The presence of these compounds, some of which are known or suspected human carcinogens, requires the special considerations outlined within these health and safety requirements and each contractor's health and safety plan. This plan identifies the specific compounds of concern and action levels of these compounds at which personal protection must be taken.

2.2 Physical Hazards

Field work near heavy equipment and vehicle operations poses physical hazards. Workers need to be aware of all heavy equipment activity and be ready to avoid moving vehicles. Mobile construction equipment be equipped with backup alarms and all workers be made aware of their use. Only operators of heavy equipment will be allowed to ride and operate the equipment. Relevant federal, state, and local laws and regulations governing construction will be followed. Workers avoid working in areas where heavy machinery is operating in accordance with the Oregon Administrative Rules (OAR) Occupational Safety and Health Administration (OSHA). Safety glasses, ear protection, and highly visible safety vests will be used around operating machinery. Field work in and around groundwater extraction well and utility vaults also pose physical hazards. Workers need to be aware of pedestrians and moving vehicles while working in and around open vaults. Barricades will be placed around the open vault and consist of, but not be limited to, caution tape, flags, traffic cones, and traffic barricades.

2.3 General Safety Requirements

Boeing and contractor personnel have the responsibility for:

- Taking reasonable precautions to prevent injury to themselves and others.
- Performing only those tasks that they believe they can do safely, and immediately reporting the presence of unsafe conditions.

- Implementing the health and safety requirements, and reporting a deviation from the procedures to the project manager or the field engineer.
- Notifying the project manager of special medical problems and ensuring that appropriate onsite personnel are aware of these problems.

The following general safety rules apply:

- All federal and state OSHA regulations related to contaminated sites and construction-related activities including fall prevention, excavation, trenching, shoring, hot work, and electrical work.
- All personnel will conduct themselves in a professional manner at all times.
- All Boeing facilities are tobacco free zones. No smoking or chewing of tobacco will be conducted on Boeing property.
- Working while under the influence of intoxicants, narcotics, or controlled substances is prohibited. The use of any prescription drug will be reported to the project manager.
- Climbing or standing on machinery or equipment is prohibited unless authorized by the project manager or the field engineer and proper fall protection equipment is worn.
- Individuals required to wear respirators will have an updated respirator fit test and will not have beards.
- Contact with contaminated or potentially contaminated material should be avoided. Efforts will be made to stage site activity upwind of equipment, activities, and materials if dust is present.
- No use of phones while operating equipment, vehicles, or walking in areas of the site. Phone use is permitted in identified Safety Zones.
- Eating, drinking, or chewing gum, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited inside the designated secured work zones.
- Exchange of PPE will not be allowed.

2.4 Decontamination Procedures

In the case of an emergency, personal decontamination procedures will be speedily implemented, if possible. If a life-threatening injury occurs and the injured person cannot undergo decontamination procedures without incurring additional injuries or risk, he or she will be transported wrapped in plastic sheeting if time allows and if consistent with the injury. The medical facility will be: 1) informed that the injured person has not been decontaminated, and 2) given information regarding the most probable contaminants.

2.4.1 Personal Decontamination

A combination of disposable PPE and non-disposable PPE will be utilized to reduce exposure to contaminated soil, soil vapor, surface water, and groundwater. Disposable PPE will include nitrile

gloves, hearing protection, and Tyvek suits (if conditions warrant). Non-disposable PPE will include steel-toed boots, hard hats, and brightly colored vest or shirt. Disposable PPE be managed as solid waste and stored in a labeled 55-gallon drum. Non-disposable PPE will be routinely washed with hot water and detergent and any obvious signs of contamination be removed with paper toweling prior to conducting he appropriate decontamination process.

All personnel and equipment will undergo appropriate decontamination procedures before leaving the secured work zone. Personal decontamination will be as follows:

Step 1: Wash and rinse outer protective clothing (e.g., boots, and any rain gear).

Step 2: Remove disposable clothing (e.g., Tyvek and outer gloves). Place in marked receptacle.

Step 3: Remove, wash, rinse, and sanitize respirator (if used).

Step 4: Wash hands and face.

Certain parts of contaminated respirators such as the harness assembly or cloth components are difficult to decontaminate. If grossly contaminated, they will be discarded. Rubber components be soaked in soap and water and scrubbed with a brush. Respirators will be sanitized by rinsing in a detergent solution followed by a clear rinse, then hung to dry.

2.4.2 Heavy Equipment Decontamination

All heavy equipment must be thoroughly decontaminated before leaving the secured area or the designated decontamination area (i.e., decontamination pad located in the onsite Remediation Yard). Particular care be taken in decontaminating those parts of heavy equipment that have come into direct contact with soil, such as tracks, tires, shovels, grapples, and scoops.

For wet decontamination procedures, high-pressure water will be used (hot water if necessary). Physical scrubbing with disposable brushes will be used when necessary to loosen materials. Wet decontamination of heavy equipment will be conducted at the decontamination pad located in the remediation yard. Generated waste water will be cycled through the groundwater treatment system prior to discharge at the Storm Drain Creek, which discharges to the Columbia Slough. For dry decontamination procedures, the soil or groundwater will be brushed from the heavy equipment that has come into direct contact with potentially contaminated soil, such as tracts, tires, excavator bucket.

2.4.3 Sampling Equipment Decontamination

Disposable sampling equipment will be deposited in a labeled container and disposed as a solid waste. Non-disposable sampling equipment will be decontaminated between sampling intervals by a tap water and alconox soap mixture wash, followed by a tap water rinse, and a final distilled water rinse. If contamination is still observed, the process will be repeated.

2.5 Disposal of Contaminated Materials

Boeing Portland uses profiles to characterize hazardous waste streams for disposal purposes. These profiles are generated using a combination of process knowledge, manufacturers' safety data sheets (SDSs), and/or analytical test results. Waste is characterized in accordance with 40 CFR, parts 261 through 265, and 49 CFR, parts 78 through 215, and the Waste Characterization Manual maintained separately by Boeing Environmental Affairs. Initial laboratory analysis will be conducted whenever a hazardous waste is unknown. Unknown containerized wastes (label is missing or not legible) will be characterized in accordance with 40 CFR 261, sampled and analyzed per SW 846.

2.5.1 Hold for Analysis

"Hold for Analysis" labels (Boeing form X 24938) are used on containers of hazardous waste when the contents must be analyzed. Anytime a container has unknown contents, or if there are questions about compatibility, the Boeing Portland Environmental Affairs should be notified. Any container of hazardous waste bearing this label cannot be removed until its contents have been analyzed and identified by laboratory personnel or Environmental Affairs. In addition, no waste is to be added or removed from any container bearing this label. This container must also be stored for safe keeping at the hazardous waste storage facility.

2.5.2 Nonhazardous Waste

"Nonhazardous Waste" labels (Boeing form X-26893) are to be used on all containers that are legally defined as nonhazardous.

2.6 Housekeeping

Work areas will be kept clean and orderly at all times. Ordinary refuse will be placed in suitable rubbish or recycle bins. Extraneous materials will be minimized within the exclusion zone to reduce the decontamination load and possibilities for cross contamination. Contractors will not dispose of equipment maintenance waste materials at the site without prior approval of the Boeing project manager or designee.

2.7 Visitors

All visitors related to the ongoing remedy of the TGA and TSA must be cleared by the project manager or designee and will report to Boeing security to register their presence on the site and obtain an appropriate badge. Visitors must bring proof of citizenship to obtain access to the site. Visitors will only be allowed to observe operations and must obey all instructions of the project manager.

2.8 Spill Containment

It is not anticipated that bulk chemicals subject to spillage will be used by LAI's or Contractor personnel on this project with the exception of electron donor material. Donor material will be limited to the planned activities and will temporarily stored in the onsite Remediation Yard. Containers will be

closed to prevent rain water accumulation and will be labeled. Material will be stored either in a plastic lined berm or on the existing decontamination pad to eliminate potential runoff to stormwater system. When working near a storm drain, a protective storm drain cover will be installed to protect from spills or other unwanted material entering the stormwater system. Spill kits are stored onsite and will be delivered to the delineated work area for all intrusive activities to address small releases. Spill kits includes the following items:

- Absorbents – Universal spill pillow and absorbent pads.
- A 1:1:1 mixture of Flor-Dri (or unscented kitty litter), sodium bicarbonate, and sand.
- PPE – Nitrile gloves, heavy neoprene gloves, face shield, Tyvek coveralls and booties.
- Tools for Clean-up – Plastic dust pan and scoop, plastic bags for contaminated PPE, and paper towels.
- A shop vacuum to remove small volumes of liquid.

3.0 HAZARD/RISK ANALYSIS

Site remedy activities have aspects of risks associated with both physical and chemical exposure. Below is a summary of the most common identified risks; however, additional risks can be identified based on changing site conditions.

3.1 Physical Hazard Analysis

3.1.1 Slips/Trips/Falls

Keep work area clear of debris to minimize slips, trips, and falls. Keep engaged in site activities and awareness of body movement. Keep hands free of items to allow for bracing in the event of a slip/trip/fall by storing items in backpack or pockets of safety vest.

3.1.2 Arc Flash and Shock Hazard

Electrical work will be performed by certified electricians only. Arc flash and shock hazard warning labels exist on the GWTS electrical panels in the Control Room (85-118), GWTS building (85-124), and electrical panels located inside the individual extraction well vaults that will inform electricians of the necessary level of PPE required for working on a particular energized system. In 2014, a certified Electrical Engineer conducted a facility-wide Arc Flash Evaluation, which included the GWTS and remedial components.

3.1.3 Fire/Explosion

Although some of the chemical compounds can be explosive or flammable, they are found in relatively low concentrations, making the risk of fire or explosive conditions very unlikely during planned site activities. LAI vehicles will be stocked with an ABC fire extinguisher. If a fire or explosion becomes too large to easily resolve with the fire extinguisher than immediately call the Boeing Emergency Telephone (503) 676-1444).

3.1.4 Jib Crane Safety

The jib crane installed in the GWTS building (85-124) is used for air stripper tray maintenance. Use of the jib crane is an overhead hazard and shall only be operated by qualified contractors. When using the jib crane, proper PPE including a hard hat shall be worn at all times.

3.1.5 Confined Space Entry

A confined space is defined as an area that has limited work space and limited means of access and egress and is not designed for continuous employee occupancy. A permit-required confined space is a confined space that has the potential for any of the following characteristics:

- It contains or potentially contains a hazardous atmosphere.
- It contains a material that has the potential to engulf an entrant.
- It has an internal configuration that can trap or asphyxiate an entrant (such as tapering walls).
- It contains any other recognized serious safety or health hazards.

Due to the potential presence of VOC vapors at the site, extraction vaults are considered permitted confined space. Confined space work anticipated on this project involves work within groundwater extraction well vaults and utility vaults. Each extraction well vault has an exterior label to identify the location as a Confined Space.

Entering confined spaces requires specialized training and procedures outlined by the OSHA (1989b). OSHA issued a general industry standard (29 CFR 1910.146; the standard) to require protection for employees who enter permit-required confined spaces. Prior to each confined space entry, a safety plan and permit will be issued. The plan will identify roles, procedures, identify risks, and provide mitigation and monitoring procedures for each risk. In general, the confined space entry process will include the following steps:

1. Prepare work area (i.e., set up blowers and all ventilation, assess access/egress, and tripod, if necessary).
2. Ensure that all process piping, mechanical and electrical equipment, etc., have been disconnected, purged, blanked-off or tagged and locked, as necessary.
3. Ensure that hot work (e.g., welding, burning, open flames, or spark producing operation) that is to be performed in the confined space has been approved by the site HSO and is indicated on the confined space entry permit and coordinated with Boeing Security for a burn permit.
4. Test confined space atmosphere for oxygen (O2), lower explosive limit (LEL), carbon monoxide (CO), hydrogen sulfide (H2S), and VOCs using a calibrated multi-meter and photoionization detector (PID). Collect a 15-minute time-weighted average (TWA). In addition to the main space of occupancy, corners and pockets at both the top and bottom levels of the space should be tested as well.
5. Ventilate confined space for a minimum of 15 minutes while continuously monitoring for O2, LEL, CO, H2S, and VOCs. Ventilation will continue throughout confined space entry activities.
6. Fill out permit. Once the permit is complete, post it in a conspicuous location.
7. Don PPE (i.e., Tyvek, Tyvek booties, inner and outer gloves, respirator, rescue harness, etc., as necessary).
8. Conduct confined space entry while continuously monitoring for O2, LEL, CO, H2S, and VOCs. One PID and one multi-meter will be used in the immediate vicinity of the entrants. Both meters will be set with appropriate alarm levels, so that alarms are activated when action levels are met or exceeded.
9. If any action level is exceeded during entry, the entrant will immediately evacuate the confined space and the permit will be voided. A new permit will be issued once levels of all monitored constituents are below action levels.
10. Once the work is completed, void and file the permit.

The O&M contractor (Apollo Environmental) is trained in confined space rescue; however, in the event of an incident, Boeing Emergency Dispatch (503 676-1444) will be notified. The Emergency Dispatch will be notified prior to and upon completion of the confined space entry and will be

provided with information related to the type and timing of activities, to ensure proper preparedness for an emergency requiring rescue services.

3.1.5.1 Confined Space Entry General Requirements

General requirements for work in a confined space are listed below:

1. Confined spaces will be identified with a posted sign that reads "DANGER, PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER."
2. When entrance covers are removed from permit-required confined spaces, the opening will be promptly guarded by a railing, temporary cover, or other temporary barrier.
3. Only personnel trained and knowledgeable in permit-required confined space entry procedures and rescue will be authorized to enter a permit-required confined space or be an attendant.
4. Natural ventilation will be provided for the permit-required confined space prior to initial entry and for the duration of the confined space entry procedure. Positive/forced mechanical ventilation may be required. However, care will be taken to not spread contamination outside of the enclosed area.
5. The contents of any confined space will, where necessary, be removed prior to entry. All sources of ignition must be removed prior to entry.
6. A ladder is required in all confined spaces deeper than the employee's shoulders. The ladder will be secured and not removed until all employees have exited the space.
7. All equipment and hand tools used within permit-required confined space will be intrinsically safe and positively grounded if flammable liquids, gases, or vapors may be contained within the confined space. All power cords will be visually inspected.
8. Hand-held lights and other illumination utilized in permit-required confined spaces will be equipped with guards to prevent contact with the bulb and must be explosion proof.
9. Feed lines to confined spaces will be broken and blanked-out and sources of electrical or mechanical energy, which could activate any area of the confined space, must be identified, tagged, and locked out prior to anyone entering a confined space.
10. Compressed gas cylinders, except cylinders used for self-contained breathing apparatus, will not be taken into confined spaces. Gas hoses will be removed from the space and the supply turned off at the cylinder valve when personnel exit from the confined space.
11. If a permit-required confined space requires respiratory equipment or where rescue may be difficult, safety belts, body harnesses, and lifelines will be used. The outside observer will be provided with the same equipment as those working within the permit space.
12. Only self-contained breathing apparatus of National Institute for Occupational Safety and Health (NIOSH)-approved air line respirators equipped with a 5-minute emergency air supply (egress bottle) will be used in untested confined spaces or in any permit-required confined space with conditions determined to be immediately dangerous to life and health.
13. Where air-moving equipment is used to provide ventilation, chemicals will be removed from the vicinity to prevent introduction into the confined space.
14. Vehicles will not be left running near any confined work space or near air-moving equipment being used for any confined space ventilation.

15. Smoking in any confined space is prohibited.
16. Any deviation from these confined space entry procedures requires the prior permission of the project HSO or project manager.

3.2 Chemical Hazard Analysis

Previous investigations have identified the types and levels of constituents of concern at the site. Documents identified in the references (Section 8.0) were used in assessing site hazards/risks. Maximum reported concentrations and exposure limits are summarized in Table 1.

3.3 Suspected Hazardous Substances

Several VOCs have been detected at the site and are of concern because they may volatilize when exposed to the air column. Table 1 summarizes maximum concentrations of the various constituents found at the site in surface water, soil, soil vapor, and groundwater. The table also shows selected health and safety exposure limits for the identified constituents.

3.3.1 Electron Donor Injections

Currently, two TGA source areas are receiving electron donor material to reduce contaminant levels (Former Vapor Degreaser Source Area and the Coolant Release Area). Donor material for the Former Vapor Degreaser Source Area, located inside the 85-001 building, has consisted of a vegetable grade oil and surfactants to enhance biodegradation of VOCs. The Coolant Release Area, located inside the 85-105 building, has received injections of EHC-O™ oxygen-releasing compound in the 85-105 building to enhance the remediation of TPH-Dx-based coolant material. The potential hazards associated with injections are exposure to toxic or hazardous chemicals, physical hazards from slips and trips working in an active facility, and traffic from facility operations. Proper PPE must be worn at all times.

3.3.2 Exposure

The primary risk of exposure will be through handling potentially contaminated soil and from inhaling VOCs and TPH-Dx released from the soil, soil vapor, and/or groundwater. This risk will be greatly reduced by adherence to the minimum level of protection required by this HASP. Some inhalation and ingestion risk from exposure to contaminants as airborne particulates may exist. Good ventilation, including the possible use of soil wetting techniques, will reduce the exposure risk. Low to moderate exposure hazard is expected during TGA and TSA remedial activities.

3.4 Action Levels for Required Protection

Monitoring ambient air quality using real time instruments will be conducted to identify if action levels have been reached that will require upgrading PPE requirements. Action level are shown on Figure 2. The action levels listed assume sustained readings of 1 minute or more in the breathing zone. The PPE requirement applies to the area within a 30 ft radius of where measured. Justification for the action levels is presented in Section 3.3.

Air monitoring will be performed by the CHSO or their designee to determine necessary levels of respiratory protection. Background readings will be taken 50 ft upwind of site activities. Monitoring for organic vapors will be accomplished using a PID meter.

Monitoring will be conducted in the worker breathing zone at regular intervals during all site work in which airborne contamination may be present. During intrusive activities in these areas, breathing space monitoring will be conducted at least every 15 minutes.

3.5 Justification for Exposure Limits

It is anticipated that most of the project activities will be performed at Level D (modified), and supplemented with air purifying respirators if the action levels identified for Level C are reached.

Action levels for donning respiratory protection will be based on readings taken with a PID supplemented, as appropriate, with chemical-specific detector tubes. The PID detects all ionizable volatile constituents and does not provide reliable readings below 10 parts per million (ppm); therefore, for constituents with permissible exposure limits (PEL) less than 10 ppm, chemical-specific detector tubes must be used to determine if these constituents are present at concentrations below 10 ppm, but above their respective PELs. Exposure to volatile ionizable constituents with PELs greater than 10 ppm will be monitored using the PID; action levels based on this monitoring are specified on Figure 2.

Six potential TGA contaminant source areas were identified based on earlier investigations and current or past facility uses, as shown on Figure 3. Investigations have been conducted within all the source areas, based on these results and with ODEQ approval only the Former Degreaser Source Control Area remains in the Institutional Controls Plan (ICP; LAI 2005).

The ICP provides measures to restrict the potential ingestion of TGA groundwater exceeding the maximum cleanup levels; provides a work protection institutional control to restrict the potential exposure of workers during surface/subsurface disturbances within the Former Degreaser Source Control Area; and provides a restrictive covenant for the facility. The groundwater use institutional control regulates groundwater use in the area by granting the lead agency the authority to review any proposed actions involving the installation of wells or modifications of existing well water use within the dissolved-VOC plume. The worker protection institutional control provides procedures for notification to the lead agency of proposed worker activities within the source areas. Workers shall conduct activities under guidance of an approved health and safety plan, and disposal criteria will be coordinated with the lead agency. Personal protection equipment will be worn according to the action levels designated on Figure 2.

3.6 Level C (Modified) Action Levels

A half-face respirator, equipped with organic vapor and high efficiency particulate cartridges, provides a protection factor of 50 (NIOSH recommendation). Therefore, a half-face respirator may be worn in

concentrations up to 50 times the threshold limit value (TLV) values noted in Table 1. Based on previous investigations, it is not expected that Level C action levels will be exceeded. However, if they are, half-face respirators will be worn.

Normal field conditions (e.g., drilling operations, groundwater sampling) are not expected to exceed the 50 protection factor level, such that Level B protection would be required. However, such conditions may be encountered during large-scale invasive activities such as piping construction excavation (see Section 3.4 above). If conditions are encountered that warrant Level B protection, safety procedures will be revised before beginning or continuing invasive activity.

4.0 PERSONAL SAFETY EQUIPMENT

Equipment required for the various levels of protection expected onsite is listed below.

Level D (Modified):

- Nitrile gloves
- Hard hat
- Safety glasses
- Steel-toe and steel-shank neoprene or rubber boots.

Level C (Modified):

- Level D (modified) equipment.
- Tyvek suit (Saranex or equivalent), water resistant coveralls, or rain gear when direct contact with wet soil and water is encountered.
- Half-face air-purifying respirator equipped with high efficiency air purifying organic vapor and HEPA cartridges. Respirators must be NIOSH approved. Cartridges will be changed daily (if used) or more frequently if directed by the project HSO.

5.0 EMERGENCY RESPONSE PLAN

This emergency response plan outlines the steps necessary for appropriate response to emergency situations. The following summarizes the key emergency response plan procedures for this project. Each Contractor vehicle associated with well installation and soil boring activities will be provided with a Boeing-supplied Dash-Board Safety Card (Form 3), which will summarize the emergency procedures described below.

5.1 Notification and Reporting

The LAI's Health and Safety Manager is to be notified immediately of any emergency situation. If the situation is life-threatening and notification of the LAI's Health and Safety Manager would delay emergency response, site personnel may initiate the appropriate emergency contacts as noted below prior to notifying the LAI's Health and Safety Manager. The LAI's Health and Safety Manager will initiate contacts as follows:

1. Call Boeing Emergency Dispatch (Form 3) and provide the following information:
   - Name and location of person reporting
   - Location of accident/incident
   - Name and affiliation of injured party
   - Description of injuries
   - Status of medical aid effort
   - Details of any chemicals involved
   - Summary of the accident, including the suspected cause and the time it occurred
   - Temporary control measures taken to minimize further risk.

   Note: This information is not to be released to parties other than the Landau Associates' Health and Safety Manager, Boeing and City personnel, Contractor personnel, and bona fide emergency response team members.
2. Call the Boeing Project Manager and provide information noted in Item 1 above.
3. Call Landau Associates' Corporate Health and Safety Manager and the Landau Associates' Project Manager with information in Item 1 above.
4. The Landau Associates' Health and Safety Manager will complete a written accident/incident report, using Form 4, within 24 hours, sending copies to Boeing's Project Manager.

Resources to be used in cases of emergency include:

- List of Emergency Contacts: Table 3 includes both the appropriate emergency services and the appropriate project contacts.
- Nearest Phone: Telephones are located inside buildings. Boeing and Landau Associates' site personnel also possess cellular phones.

- Onsite Emergency Equipment: An industrial first-aid kit, an ABC type portable fire extinguisher, and an eyewash kit accompany each site vehicle operated by Landau Associates.
- Offsite Emergency Services: Phone numbers for offsite emergency services are listed in Table 3. Copies of this table must be located in each vehicle.

5.2 Emergency Facilities and Numbers

Hospital: Legacy Mt. Hood Medical Center
24800 SE Stark Street
Gresham, OR 97030

Emergency: (503) 667-1122

Emergency Route: See Figure 4

Directions: Travel east on Sandy Boulevard to NE 223rd Ave. Turn south (right) onto NE 223rd Ave., and proceed to Stark Street. Turn east (left) onto Stark Street and proceed for approximately 1 mi to Legacy Mt. Hood Medical Center.

Boeing Emergency Telephone: (503) 676-1444 (Fire, ambulance, police, spill reporting)

Boeing Non-Emergency Security: (503) 676-1800

Emergency Contacts:

Boeing Security	(503) 676-1800
Mike Gleason (Boeing Project Manager)	Cell (206) 290-6576
Jennifer Parson (Boeing Field Engineer)	Cell (206) 715-7981
Christine Kimmel (LAI Project Manager)	Cell (206) 786-3801

In the event of an emergency, do the following:

1. Call Boeing Emergency number for help as soon as possible. Give the following information:
    - WHERE the emergency is - use cross streets or landmarks
    - PHONE NUMBER you are calling from
    - WHAT HAPPENED - type of injury
    - HOW MANY persons need help
    - WHAT is being done for the victim(s)
    - YOU HANG UP LAST - let the person you called hang up first.

2. Transport to the hospital will be performed by local emergency response professionals in all cases. If the injury or exposure is not life threatening, decontaminate the individual first. If decontamination is not feasible, wrap the individual in a sheet of plastic prior to transport.

3. Notify the project manager or representative.

5.3 Onsite Emergency Equipment

An industrial first aid kit, a 20-pound type ABC portable fire extinguisher, and an eyewash kit will be maintained by the contractor.

5.4 Offsite Emergency Services

A copy of EMERGENCY FACILITIES AND NUMBERS will be posted next to the contractor telephone identified for emergency use.

5.4.1 Weather-Related Illnesses

Weather-related (hot or cold weather conditions) illnesses can occur at any time when protective clothing is worn. For heat-related illnesses, workers wearing semipermeable or impermeable encapsulating clothing should be monitored when the temperature in the work area is above 70°F (21°C). Heat stress monitoring includes regular checks of heart rate.

Each employee should check his/her pulse rate at the beginning of each break period. The pulse rate should be taken at the wrist for 30 seconds, and multiplied by 2. If the pulse rate exceeds 110 beats per minute, the length of the next work period should be reduced by one-third (the rest period need not be lengthened). A pulse rate in excess of 150 beats per minute may indicate heat exhaustion, although this rate will vary among workers. All personnel will know what their baseline pulse rate is before working in elevated temperatures, so as to monitor themselves. Personnel should follow appropriate guidelines if any personnel exhibit these symptoms:

- Heat Rash – Redness of skin. Frequent rest and change of clothing.
- Heat Cramps – Painful muscle spasms in hands, feet, and/or abdomen. Administer lightly-salted water by mouth, unless there are medical restrictions.
- Heat Exhaustion – Clammy, moist, pale skin, along with dizziness, nausea, rapid pulse, fainting. Remove to cooler area and administer fluids.
- Heat Stroke – Hot dry skin; red, spotted, or bluish; high body temperature of 104° F; mental confusion; loss of consciousness; convulsions; or coma. Immediately cool victim by immersion in cool water. Wrap with wet sheet while fanning; sponge with cool liquid while fanning; treat for shock. DO NOT DELAY TREATMENT. COOL BODY WHILE AWAITING AMBULANCE.

For cold-related illnesses site personnel may be subject to low temperatures, rain, and winds; therefore, proper protective clothing must be worn. Cold stress can be manifested as both hypothermia and frostbite:

- Hypothermia is a cold-induced decrease in the core body temperature that can increase the safety hazards associated with field work activities that require maximum attentiveness and manual dexterity. Hypothermia produces shivering, numbness, drowsiness, muscular weakness, and, if severe enough, death.
- Frostbite results from the constriction of blood vessels in the extremities, and decreasing the supply of warming blood to these areas. This drop in blood supply may result in the formation of ice crystals in the tissues, causing tissue damage. The symptoms of frostbite are white or grayish skin, blisters, or numbness.

If such conditions exist, the following procedures will be carried out to reduce weather-related stress:

- Acclimatization
- Work/rest cycles
- Heat stress monitoring
- Liquids that replace electrolytes/salty foods available during rest
- Use of buddy system.

The LAI's Health and Safety Manger and the CHSO will be trained in monitoring, treating, and recognizing the signs of heat stress. Unless the victim is obviously contaminated, decontamination should be minimized and treatment begun immediately.

5.5 Site Evaluation and Evacuation

The Landau Associates Health and Safety Manager in cooperation with the Boeing representative will be responsible for determining if circumstances exist that require re-evaluation or evacuation.

5.5.1 Withdraw from Work Area

Withdrawal to a safe upwind location will be required under the following circumstances:

- Detection of VOCs or toxic gases at concentrations above action levels for the level of protection being worn.
- Occurrence of a minor accident - field operations resume after first-aid and decontamination procedures have been administered.
- Malfunction or failure of protective equipment, clothing, or respirator.

6.0 TRAINING

Orientation training will be held before beginning work. If appropriate, based on observation of the work area and air monitoring results, the Boeing project manager or the LAI site safety officer may require site personnel to have additional safety training. The initial training will be supplemented, as necessary, in subsequent safety meetings. Orientation training will include:

- Health effects and hazards of the chemicals identified or suspected to be at the site and in the work area.
- Personal protection requirements.
- Personal hygiene (beards, etc.).
- Use, care, maintenance, and fitting of PPE. Training in respiratory equipment use will conform to ANSI Z88.2 and 29 CFR 1910.134 (OSHA 1989a), which establishes the necessity, effectiveness, and limitations of respiratory equipment. Workers with limiting physical disabilities such as respiratory ailments will not be assigned to tasks requiring the use of respirators. Fit testing for respirators will have taken place prior to entry to the project site.
- Decontamination procedures.
- Accepted practices for entry, exit, and activities within specific areas of the site.
- Emergency response procedures.
- Review and assessment of equipment.

Written documentation of training will be maintained and will be available for Boeing review, if necessary.

7.0 ROUTINE HEALTH CARE AND MONITORING

A baseline medical evaluation will be required for all employees, contractors, and subcontractors performing intrusive activities. An annual update exam will be required for employees, contractors, and subcontractors performing intrusive activities regarding the use of respirators for more than 30 days per year or are exposed to air concentrations greater than permissible exposure limits. Follow-up examinations are appropriate if exposures are known or suspected to have occurred. Documentation of medical evaluations (including medical clearance for respirator use) will be maintained by the contractor and will be available to Boeing for inspection for all workers performing intrusive activities.

8.0 REFERENCES

American Conference of Governmental Industrial Hygienists. 1996. Threshold Limit Values and Biological Exposure Indices for 1995-1996.

EMCON and LAI. 1995. Remedial Investigation and Feasibility Study, Troutdale Sandstone Aquifer. Prepared for the Boeing Company. October 6.

EPA. 1997a. Statement of Basis for the Boeing Portland Facility Troutdale Gravel Aquifer. ORD 054964481. U.S. Environmental Protection Agency.

EPA. 1997b. Final Decision and Response to Comments f or The Boeing Portland Facility, Troutdale Gravel Aquifer. ORD 054964481. U.S. Environmental Protection Agency.

LAI. 2005. Institutional Controls Plan, Troutdale Gravel Aquifer, Boeing Portland, Gresham, Oregon. Prepared for The Boeing Company. December 20.

LAI. 1996. Phase 2 Corrective Measures Study. September 13.

LAI. 1995a. Phase III RCRA Facility Investigation Report. (Includes health and environmental assessment.) Prepared for The Boeing Company. July 31.

LAI. 1995b. Phase 1 Corrective Measures Study Report. Prepared for The Boeing Company. July 17.

LAI. 1993. Final Report, Phase II Investigation, Boeing Portland. Prepared for The Boeing Company. June 21.

LAI. 1992. Building 85-105 Expansion, Final Report, Gresham, Oregon. April 24.

LAI. 1991. Final Report, Hydrogeology Investigation, Southeast Corner, Boeing Portland. Prepared for The Boeing Company. June 17.

LAI. 1990. Final Report, Investigation of Troutdale Sandstone Aquifer, Boeing Portland, Gresham, Oregon. Prepared for The Boeing Company. February 26.

LAI. 1988. Boeing Portland Phase I Investigation, Final Report. March 17.

LAI and EMCON. 1996. Feasibility Study, Troutdale Sandstone Aquifer. Prepared for the Cascade Corporation and The Boeing Company. March 4.

OSHA. 1989a. Federal Register 29 CFR Part 1910, Hazardous Waste Operations and Emergency Response; Final Rule. U.S. Department of Labor Occupational Safety and Health Administration. March.

OSHA. 1989b. Federal Register 29 CFR Part 1910, Permit-Required Confined Spaces for General Industry; Final Rule. U.S. Department of Labor Occupational Safety and Health Administration.

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N

Legend

- TGA Extraction Well
- TGA Injection Well
- TGA Monitoring Well
- TGA Multiple-Purpose Well
- TSA Monitoring Well
- TSA Extraction Well

Notes

1. Corrective Action Areas defined in Phase 2 Corrective Measures Study (1996).
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

NE 185th

Approximate Limit of the TGA

D-2(i)

Columbia Slough

D-7(i) D-8(i) D-12(i) E-13

Downgradient Area

Storm Drain Creek

D-11(i)

NE SANDY BLVD

E-12 BOP-7(d) BOP-7(i) BOP-22R(ds) E-4 BOP-21(ds) E-3 E-2 BOP-83(i) BOP-82(i) BOP-80(i) BOP-81(i) BOP-16(i) BOP-74(i) BOP-84(i) BOP-77(i) BOP-79(i) BOP-78(i) BOP-88(i) BOP-76(i) BOP-87(i) BOP-86(i) BOP-85(i) BOP-75(i) BOP-72(i) BOP-73(i) BOP-20(dg) BOP-20(ds) BOP-23(dg)

East Yard Area

E-15 BOP-60R(ds)

West Area

E-16 E-11 BOP-57(i) EW-3 E-5 BOP-56(i) E-9 BOP-48(i) E-8 BOP-61(ds)

Southwest Area

BOP-65(ds) LAI-2 LAI-1 EW-13 BOP-66(ds) BOP-31(dg) BOP-31(ds)

BOP-10(i) E-7 LAI-3 BOP-9(i) E-6 LAI-7 LAI-4 IW-2 LAI-8 DP-1 LAI-6 IW-3 BOP-59(i) LAI-5 IW-5 IW-1 IW-4 BOP-62(ds)

THE BOEING COMPANY

BOP-11(i)

Central Area

East Area

BOP-42(dg) BOP-42(ds)

BOP-13(ds) BOP-13(dg)

INTERSTATE 84

0 350 700

Scale in Feet

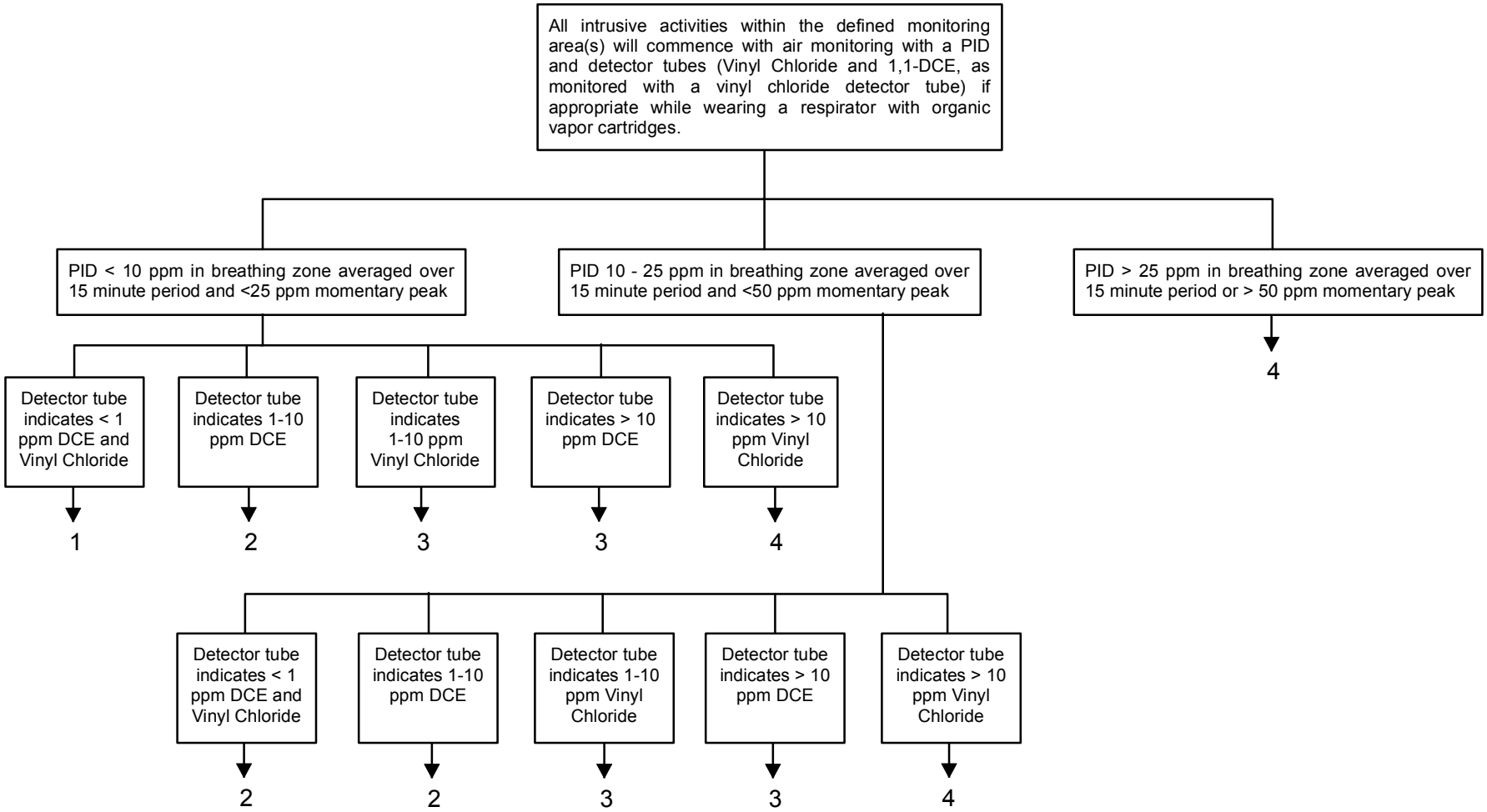
LANDAU ASSOCIATES

Boeing Portland
Gresham, Oregon

Boeing Facility and Corrective Action Areas

Figure 1

G:\Projects\025\116\116\410\2017 HASP\F02 PPE Action Levels.mxd 1/4/2017



1 = Level D and continued monitoring
2 = Level C (full-face respirator with organic vapor cartridges) and continued monitoring
3 = Level B revise safety procedures prior to commencing or continuing invasive activity
4 = Evacuate work area

Notes
1. 1 ppm 1,1-dichloroethylene = 2 ppm on a vinyl chloride detector tube.
2. Vinyl chloride detector tubes will only be used in some work areas.

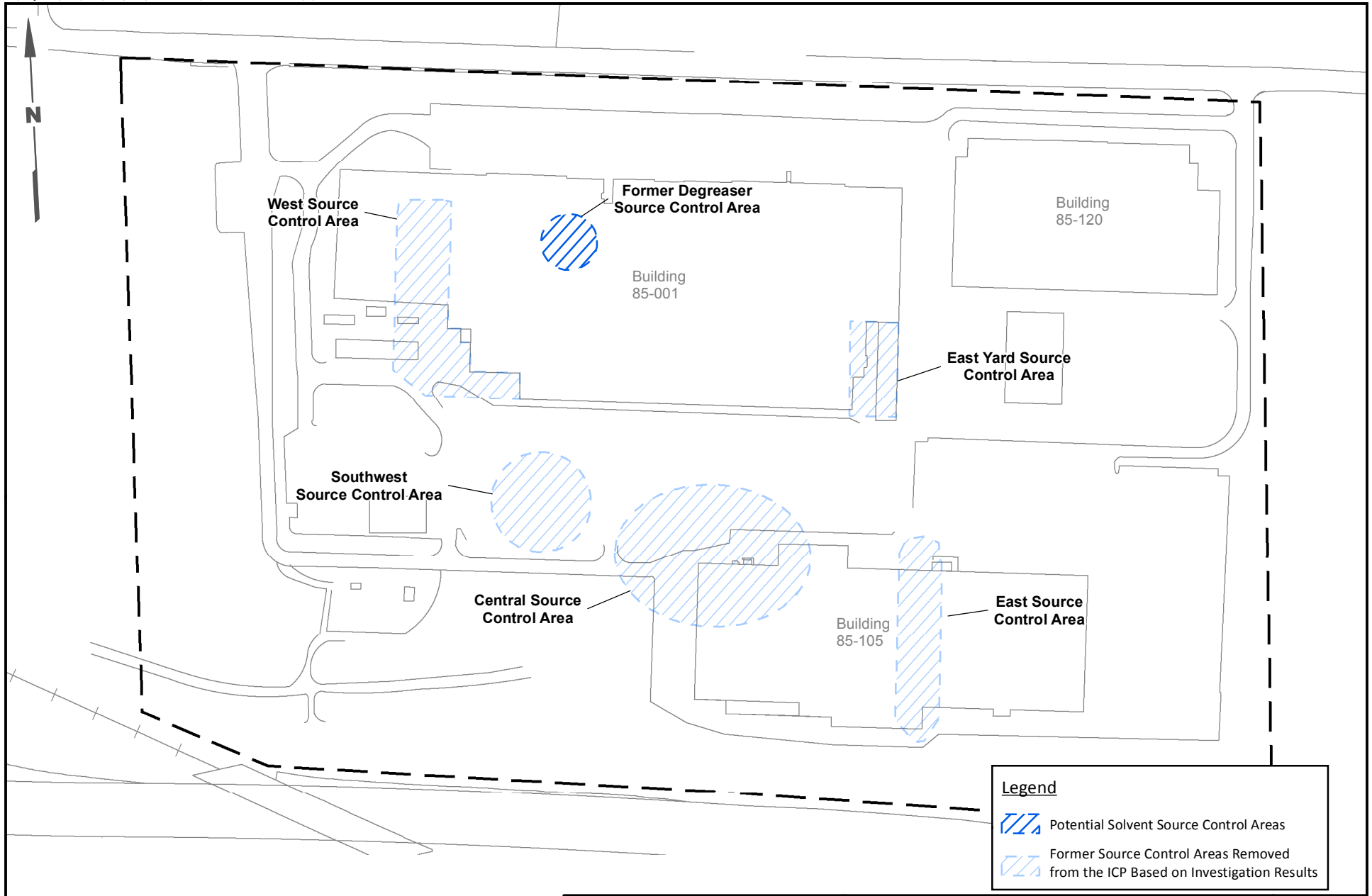
LANDAU ASSOCIATES

Boeing Portland
Gresham, Oregon

PPE Action Levels for Intrusive Activity

Figure 2

G:\Projects\025\116\116\410\2017 HASP\F03 ICP Source.mxd 1/4/2017

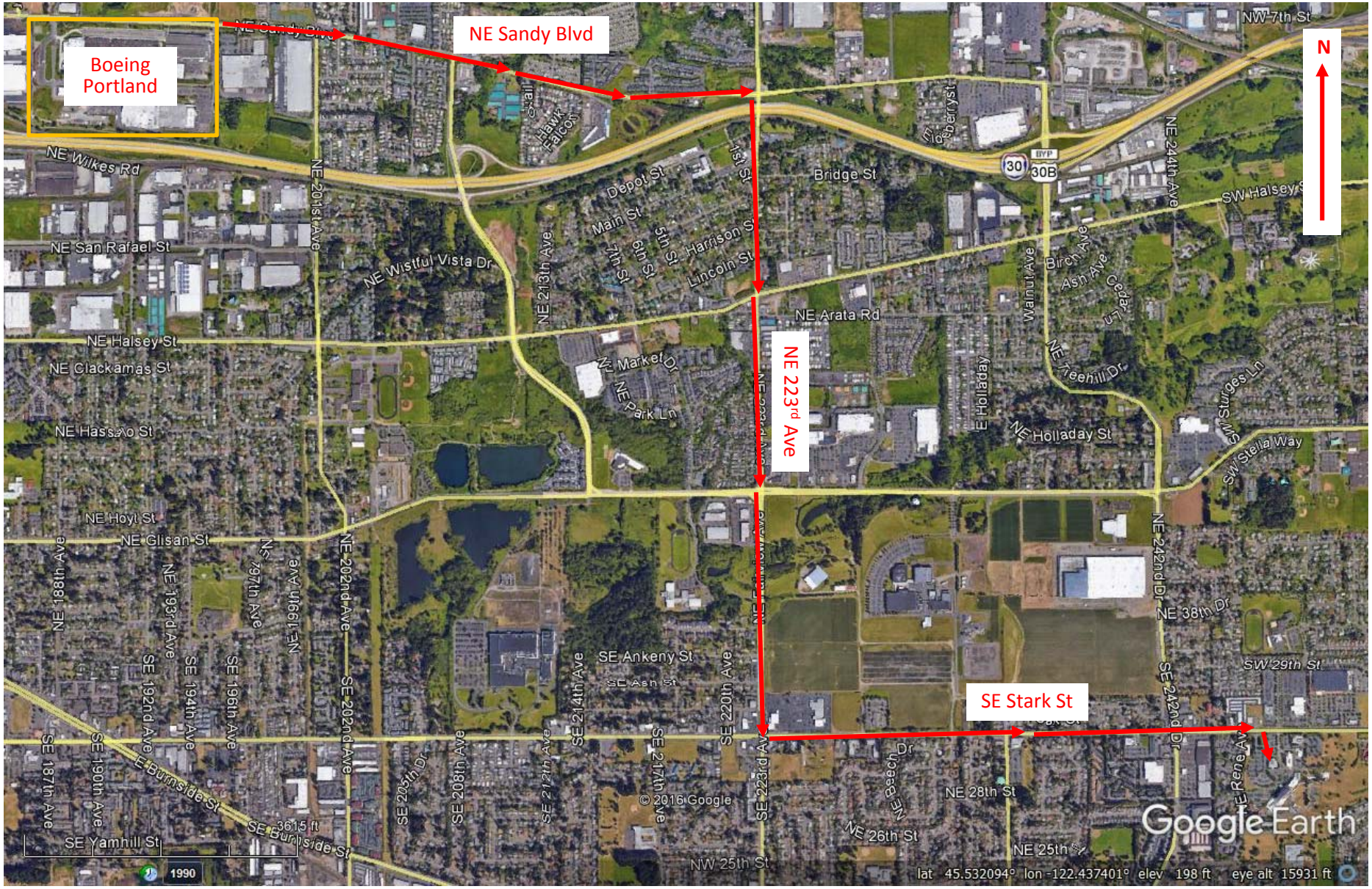


LANDAU ASSOCIATES

Boeing Portland
Gresham, Oregon

ICP: Source Control Areas

Figure
3



Source: GoogleEarth 2016

Boeing Portland Gresham, Oregon	**Emergency Route to Hospital**	Figure 4

LANDAU ASSOCIATES

TABLE 1
SURFACE WATER, SOIL, AND GROUNDWATER QUALITY AND SITE EXPOSURE ASSESSMENT

Chemical Constituent	Maximum Concentration Detected in Environmental Samples (1986 to Present)				Threshold Limit Values (a) Time-Weighted Average	Permissible Exposure Limit (b) Time-Weighted Average	Immediately Dangerous to Life and Health Concentrations (c)	Routes (d)
	Surface Water (ppb)	Soil (ppb)	Soil Vapor (ppbV)	Groundwater (ppb)	(ppm)	(ppm)	(ppm)	
Acetone	23	130		1,100	250	1000	2500	Inh, Ing, Con
Benzene	0.8			32	0.1	1	Ca (e) (500)	Inh, Abs, Ing, Con
Carbon disulfide				110	1 (f)	20 (f)	500	Inh, Abs, Ing, Con
Chloroethane (ethyl chloride)				1,600	1,000	1,000	3,800	Inh, Abs, Ing, Con
Chloroform	1			130	50	50 (g)	Ca (e) (500)	Inh, Abs, Ing, Con
Chloromethane (methyl chloride)				13	25 (f)	25	Ca (e) (2,300)	Inh, Con
1,1-Dichloroethane		780		5,100	100	100	3,000	Inh, Ing, Con
1,1-Dichloroethene		11	3,600	1,800	5	--	--	Inh
1,2-Dichloroethane				10	1	50	Ca (e) (50)	Inh, Ing, Abs, Con
1,2-Dichloroethene (total)	440	20	1,870 (h)	7,187	200	200	1,000	Inh, Ing, Con
1,2-Dichloropropane				17	75	75	Ca (e) (400)	Inh, Abs, Inc, Con
Ethyl benzene		1520		17	100	100	800	Inh, Ing, Con
Freon TF		0.5		890	1,000	1,000	2,000	Inh, Ing, Con
2-Hexanone				10	1 (f)	100	1,600	Inh, Abs, Ing, Con
Methyl ethyl ketone (2-butanone)		47		79	200	200	3,000	Inh, Ing, Con
Methylene chloride	8.2	13		330	25	25	Ca (e) (2,300)	Inh, Abs, Ing, Con
1,1,2,2-Tetrachloroethane				75	1 (f)	5 (f)	Ca (e) (100)	Inh, Abs, Ing, Con
Tetrachloroethene		19	1,300	500	25	100	Ca (e) (150)	Inh, Abs, Ing, Con
Toluene	6.1	1,730		56	100 (f)	200	500	Inh, Abs, Ing, Con
Trichloroethene	440	91	160,000	10,000	50	100	Ca (e) (1,000)	Inh, Abs, Ing, Con
1,1,1-Trichloroethane	1.8	4,670	35,000	39,000	350	350	700	Inh, Abs, Ing, Con
1,1,2-Trichloroethane				17	10 (f)	10 (f)	Ca (e) (100)	Inh, Abs, Ing, Con
Trichlorofluoromethane		44		2.7	1,000 (g)	1,000	2000	Inh, Ing, Con
Vinyl chloride		1,300	440	13	1	1	Ca (e) (ND)	Inh, Con
Xylenes (total)	0.4			250	100	100	900	Inh, Abs, Ing, Con
Diesel		45,600		16,600,000	444 (g)	500	1,100	Inh, Ing, Con
Motor Oil		5,100		15,200,000	444 (g)	500	1,100	Inh, Ing, Con
Total TPH-Dx		45,600		31,800,000	444 (g)	500	1,100	Inh, Ing, Con

ND = Not Determined.
ppb = parts per billion
ppm = parts per million

(a) Threshold Limit Values and Biological Exposure indices for 1996-1997 (ACGIH 1996).
(b) Oregon Adminstrative Rules (OAR 437-02, Subdivision Z, Air Contaminants [State of Oregon 1993]).
(c) Comptons Concise Chemical Contaminant Services 1997.
(d) Ing = Ingestion; Inh = Inhalation; Abs = Absorption; Con = Dermal Contact.
(e) Ca = National Institute of Occupational Safety and Health (NIOSH)-designated potential carcinogen.
(f) "Skin" = Potential significant contribution to the overall exposure by the cutaneous route.
(g) Ceiling limit that should not be exceeded.
(h) Value shown is for cis-1,2-Dichloroethene only

References:

ACGIH. 1996. Threshold Limit Values and Biological Exposure Indices for 1995-1996. American Conference of Governmental Industrial Hygienists.

State of Oregon. 1993. OAR 437, Division 2, General Occupational Safety and Health Rules, Subdivision Z - Toxic and Hazardous Substances. Oregon Administrative Rules, Oregon Occupational Safety and health Division.

FORM 1

HEALTH AND SAFETY PLAN
APPROVAL/SIGN OFF FORMAT

I have read, understood, and agreed with the information set forth in this Health and Safety Plan (and attachments) and discussed in the Personnel Health and Safety briefing.

Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Site Safety Coordinator	Signature	Date
Landau Health and Safety Manager	Signature	Date
Project Manager	Signature	Date

Personnel Health and Safety Briefing Conducted By:

Name	Signature	Date

FORM 2
Confined Space Entry Permit

Facility:

Date and time

Permit Valid From: _____ To: _____

Specific Entry Location: _____

Purpose of Entry: _____

(specify any additional) _____

_____

Entry Supervisor: _____ Date: _____ Time: _____

Entry Attendant: _____ Date: _____ Time: _____

(entrant may change, use personnel list on following page) _____

Facility/Proj Manager(s): _____ Date: _____ Time: _____

_____

Emergency Contact Information: (In case of emergency, call in the order listed)

911 911

Potential Chemicals of Concern: (see HASP for more details)

Potential Physical Hazards: (see HASP for more details)
Equipment hazards (piping and pumps)
Slips, trips, and falls
Atmospheric conditions in work area
Energy sources
Drowing (if vaults fill with water)

REVIEW THE PLAN, CHECK FOR THE FOLLOWING:	YES	NO
Entry Plan Attached and Reviewed	☐	☐
Area Secured (barricades, cones, other)	☐	☐
Ventilation Equip. in Place, Operating and Grounded	☐	☐
Communication Equipment Tested (Voice and Visual)	☐	☐
Rescue Equipment In Place	☐	☐
Required PPE Equipment in Place & Available	☐	☐
(Half Face Respirators, PIDs, Hardhat, Steel Toe Boots, Hearing Protection,	☐	☐
Gloves, Eye Protection)	☐	☐
Fire Protection Equipment Available	☐	☐
Standby Personnel Available	☐	☐
Pre-Entry Atmospheric Conditions Within Acceptable Levels	☐	☐
All Personnel Understand PID Action Levels	☐	☐
Entry Conditions Acceptable	☐	☐

LANDAU ASSOCIATES
ENVIRONMENTAL | GEOTECHNICAL | NATURAL RESOURCES

CONFINED SPACE ENTRY FORM

Atmospheric Hazards to be Monitored, and Acceptable Levels:

Oxygen	L.E.L	PID*	H2S	Other	Other	Other
>19.5%	<10%	<15ppm	10 ppm			
<23.5%						

* For PID Readings:			Then:
< 15 ppm			No Action Required
> 15 ppm	but	< 75 ppm	Evacuate Work Area or Establish Exclusion Zone Around Work Area and Upgrade to Level C Half Face Respirator with Organic Vapor/HEPA
>75 ppm			Evacuate Work Area

Types and Quantities of Monitoring Equipment:
MultiRAE Plus multi-gas meter w/ 10.6 ev PID lamp and O2, H2S, & LEL

Monitoring Instrument Calibration Data Log:

	Oxygen (%)	L.E.L (%)	H2S (ppm)	PID (ppm)
Calibration levels				
MultiRAE Plus multi-gas meter readings				

Monitoring Schedule:

Prior to entry, monitors & equipment will be run & watched continuously with readings documented every 5 minutes for 2 consecutive readings. During CSE work, document results every 30 minutes. Double check that PID alarm levels have been set at lowest setting (15 ppm - action Level for half face respirators)

Gas Testing Logsheet

Location	Time	Oxygen	L.E.L.	H2S	PID	Other

Entry/Attendant Personnel: All entrants & attendants listed below have completed confined space entry training.

Name	Entrant / Attendant	Entry Time	Exit Time	Entry Time	Exit Time	Entry Time	Exit Time	Entry Time	Exit Time	Entry Time	Exit Time

Signature (sign at end of each shift and save permit in project file for 1 year)

Entrant Name (Print)	Entrant Name (sign)	Date
Attendant Name (Print)	Attendant Name (sign)	Date
Supervisor Name (Print)	Supervisor Name (sign)	Date

BOEING PORTLAND
19000 NORTHEAST SANDY BLVD., PORTLAND, OREGON
STANDARD WORK PRACTICES

Health and Safety is **EVERYONE'S** responsibility and **NUMBER ONE PRIORITY**

- Regulatory compliance is **MANDATORY** – No work will begin and/or work will immediately stop unless the answer to the following question is a positive **"YES"** – AM I IN COMPLIANCE WITH ALL REGULATORY, FACILITY, PROJECT, AND HEALTH AND SAFETY REQUIREMENTS?

- All incidents and regulatory inspections must be reported immediately

    - **Incident definition**: Any event condition, or action (including near misses) that affects the safety of personnel, does not follow rules and guidelines for work implementation and regulatory compliance onsite
- Incident examples:
    - Spilled liquid in an uncontrolled environment
    - Working without correct/complete permit in place
    - Performing hot works without a "Hot Works Permit"

Before starting work, **HAVE YOU?** :

1. Reviewed the Health and Safety Plan prior to performing work?
2. Performed a Health and Safety "Tail Gate Meeting" and filled out the sign-in form prior to starting work?
3. Reviewed scope of work documents, permits, and other related items prior to performing work?
4. Provided correct Personal Protective Equipment (PPE) for the work to be performed?

IF YOU ARE UNSURE OF SAFETY PRACTICES FOR THE PARTICULAR WORK INVOLVED – GET CLARIFICATION PRIOR TO STARTING WORK

Working with subcontractors:

- Review Health and Safety Plan with subcontractor
- Review site "Incident Reporting Procedures"
- Perform "Tail Gate Safety Meeting" with subcontractor

SAFETY AND REGULATORY COMPLIANCE IS MY PRIORITY AND I MUST TAKE THE NECESSARY STEPS TO PROVIDE THIS SERVICE

I AM RESPONSIBLE AND I HAVE THE AUTHORITY TO STOP WORK IF THE TASK DOES NOT MEET THE SAFETY AND REGULATORY REQUIREMENTS

SAFETY DASHBOARD CARD
EMERGENCY AND INCIDENT REPORTING PROCEDURES

EMERGENCY PHONE NUMBER:
(503) 676-1444 Fire, Ambulance, Police, Spill Reporting
Non Emergency Security Phone Number:
(503) 676-1800 Non emergency security guard house
SITE ADDRESS:
19000 NE SANDY BLVD., PORTLAND, OREGON 97230
WORK LOCATION:
WEST SIDE OF 85-001
IN THE EVENT OF FIRE LINE BREACH:

- **REPORT WEST END FIRE LINE BREACH TO BOEING SECURITY**
- **SECURITY WILL CLOSE**
    1) **SECTIONAL VALVE 7 (EAST END OF 85-104)**
    2) **SECTIONAL VALVE 8 (NORTH SIDE 85-001 OUTSIDE CAFÉ)**

AN EMERGENCY IS AN UNCONTROLLED SITUATION, AN INJURY THAT IS MAJOR OR LIFE THREATENING, FIRE, OR ANYTHING THAT REQUIRES IMMEDIATE ASSISTANCE.

EMERGENCY REPORTING:

1. Contact the **BOEING PORTLAND** Emergency Response (fire, ambulance, police) at **(503) 676-1444**
2. Follow Incident Reporting procedures listed below

INCIDENT REPORTING:
Respond to the incident and get it under control. Contact the following by e-mail and brief phone message (**MUST DO BOTH**):

Name	Email Address	Phone Number	Position
Michael Gleason	michael.j.gleason@boeing.com	(206) 290-6576 Cell	Boeing Project Manager
Jennifer Parsons	jennifer.a.parsons@boeing.com	(206) 715-7981 Cell	Boeing Field Engineer
John Rusoff	john.w.rusoff@boeing.com	(971) 563-0257 Cell	Boeing Site Focal
Chris Kimmel	ckimmel@landauinc.com	(206) 786-3801 Cell	Consultant Contact
Mark Vealey	Mark.Vealey@ApolloMech.com	(503) 313-9438 Cell	O&M Contractor Contact

When leaving the message state the following:

1. **Date:** The date the incident occurred
2. **Time:** The approximate time the incident occurred
3. **Location:** Where the incident occurred, i.e.; Admin Compound…

When send the email include the following:

1. **Description:** Describe briefly what happened and what it may affect
2. **Time:** The approximate time the incident occurred
3. **Location:** Where the incident occurred, i.e.; Admin Compound…
4. **Description:** Describe briefly what happened and what it may affect

After the incident is under control, the sequence of events will be recorded, including probable cause, people who responded to the incident, the extents of the incident, and relevant dates and times

FROM SITE: 19000 N.E. Sandy Blvd., Gresham, Oregon 97230

TO HOSP: Mt. Hood Medical Center
24800 S.E. Stark Street
Gresham, OR 97030
503-667-1122

1. Go EAST on NE Sandy (US-30 Bypass)
2. Turn RIGHT (south) on NE 207th Avenue
3. Take ramp (left) onto I-84 (US-30) toward I-84/The Dalles
4. Take EXIT 16 and turn RIGHT onto ramp toward 238th Drive/Wood Village
5. Turn RIGHT onto NE 238th Drive
6. 238th Drive becomes NE 242nd Drive
7. Turn LEFT on SE Stark
8. End Mt. Hood Medical Center