Mellon Bank, NA
Cost Analysis Division

# Review Of Environmental Status

**Original Project #:** 2040115
**Current Task #:** 2040125

## Privileged And Confidential
## Attorney-Client Communication
## Legal/Cost Analysis Group

AUG 27 2004

| | | | |
|---|---|---|---|
| **Project Name:** | Desimone/Boeing East Marginal High | **Relationship Mgr.:** | Bill Kaull |
| **Borrower:** | Desimone Family Trust | **AIM #:** | 024-0074 |
| **Location:** | Tukwila, WA | **Company Number:** | 1 |
| **Date:** | August 26, 2004 | **Cost Code:** | 9510 |
| **Revision Date:** | | **Action:** | REP REV |

**The Following Document Has Been Reviewed For Completeness And Acceptability**

**ENVIRONMENTAL ASSESSMENT REPORT**

| | |
|---|---|
| **Type of Report:** | Summary Reprot Corrective Action |
| **Consultants Qualifications:** | Acceptable |
| **Quality of Assessment Report:** | Acceptable |
| **Consultant:** | Landau Associates |
| **Final Report Date:** | 3/1/2004 |

**Status Review History**

| Control | Consultant | Report Type | Report Date | Action | Issue Date |
|---|---|---|---|---|---|
| 2040115 | Landau Associates | Summary Report Corrective A | 2/27/2002 | Report Review | 8/26/2004 |

**Closing recommendation based on the documents listed above:**

____ **The site does not represent a significant environmental risk.**

____ **The site does not represent a significant environmental risk, if the recommendations listed in remarks are completed.**

X **The site evaluation requires a Phase II, further investigation or remediation of the items listed in remarks.**

Remarks: 1/ The Summary Report Corrective Action prepared by Landau Associates outlines 157 SWMUs and 5 AOCs. Nearly all of the issues have been resolved by Boeing between 2002 and 2004.
2/ The Evaluation Report prepared by Landau Associates provides the status of several remaining Solid Waste Management units (SWMU) and Area of Concern (AOC) located on the property. This report was prepared for The Boeing Company and Boeing is completing the work under the Washington State Department of Ecology Voluntary Cleanup Program. Continued remediation (SWMU 20) and monitoring (AOC-5) is recommended for several locations. Based on the efforts of Boeing, these issues do not represent a significant environmental risk.

Cost Analyst: Dolores H. Selby

cc: Jeffrey M. Parker, Esq..

No Further Action Required
by Cost Analysis Group
Date:
Initials: _____

**Boeing Realty Corporation**

BOEING

# TRANSMITTAL LETTER

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Re: Boeing Developmental Center

**COMMENTS:**

Please find enclosed the Summary Report of Corrective Action, dated February 27, 2002 and the Evaluation Report SWMU-17, SWMU-20 and AOC-05, dated March 10, 2004; both reports are for Boeing Developmental Center.

## Summary Report

# Corrective Action
# Boeing Developmental Center

February 27, 2002

Prepared for

**The Boeing Company**
**Seattle, Washington**

Prepared by


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# 1.0 INTRODUCTION

The Boeing Developmental Center (BDC) is a regulated facility under the Resource Conservation and Recovery Act (RCRA). The U.S. Environmental Protection Agency (EPA) identification number for the facility is WAD-09363-9946. Under its RCRA corrective action authority, EPA conducted a RCRA Facility Assessment (RFA) in 1994 to identify solid waste management units (SWMUs) and areas of concern (AOCs) at the site (SAIC 1994). The RFA identified 157 SWMUs and 5 AOCs and provided a preliminary assessment of the potential for release of hazardous constituents to the environment at each area (SAIC 1994). A summary of the SWMUs and AOCs is provided in Table 1.

The Washington State Department of Ecology (Ecology) has authority delegated from EPA to implement RCRA corrective action through the Model Toxics Control Act (MTCA) regulations (Washington Administrative Code [WAC] 173-340) and has assumed the oversight role of the corrective action activities at the BDC. The Boeing Company (Boeing) is addressing the SWMUs and AOCs through Ecology's voluntary cleanup program under MTCA.

## 1.1 STATEMENT OF PURPOSE

Corrective action investigation and remediation activities have been performed at a number of SWMUs and AOCs, primarily associated with former underground storage tanks (USTs) or sumps. In addition, several RCRA waste management areas have been clean-closed in accordance with RCRA requirements. The purpose of this document is to provide an overview of these activities and to document the current status of each SWMU and AOC.

## 1.2 REPORT ORGANIZATION

The remainder of this report consists of the following:

- Section 2.0 describes the physical characteristics of the facility, including the facility setting, facility background, and land use surrounding the site. Also included in this section is a discussion of geology and hydrogeology, both regional and site specific. Background water quality, surface water, and groundwater-surface water interaction are also described in this section.

- Section 3.0 presents a discussion of site screening standards. The selection of preliminary groundwater and soil screening levels and the points of compliance are described in this section.

- Section 4.0 is a summary of SWMUs and AOCs, including SWMUs-15, 16, 17, 20, 23-25, and 43 and AOCs-01 through 05. Within each summary of SWMU or AOC are a description of the SWMU or AOC, summary of corrective action, and current status.

- Section 5.0 – Summary of Corrective Action Status
- Section 6.0 – References
- Appendices
    - Appendix A contains summary tables of soil and groundwater data for the SWMUs and AOCs discussed in Section 4.0
    - Appendix B is a technical memorandum providing an evaluation of the pump and treat remedial system currently in operation at SWMU-20
    - Appendix C contains No Further Action notices from the Washington State Department of Ecology.

# 2.0 PHYSICAL CHARACTERISTICS OF THE FACILITY

## 2.1 FACILITY SETTING

The BDC is located at 9725 East Marginal Way South in Tukwila, Washington (Figure 1). The facility consists of approximately 60 buildings on 164.4 acres of property (Figure 2). Boeing owns 94.5 acres and leases the remaining 59.9 acres (SAIC 1994).

The BDC is primarily an aircraft and aerospace research and development complex with most of the work supporting U. S. Department of Defense projects. Past projects at the BDC have included research on supersonic transportation and development of military aircraft (SAIC 1994).

## 2.2 FACILITY BACKGROUND

Boeing has been operating on portions of this site continuously since 1956. Figure 1 presents the site location map and Figure 2 presents the current facility boundary map.

Prior to about 1918, when the U.S. Army Corps of Engineers (USACE) channelized the Duwamish Waterway, the site was farmland. The earliest known commercial operations at the site began in 1927, when Prankratz Lumber Company (a sawmill), Washington Compressed Gas Company (a welding supply company), and Associated Packing Company (a stockyard and meat-packing plant) occupied portions of the site. Washington Compressed Gas Company occupied the northern portion of the site (generally in the area of Building 9-04), Associated Packing Company was southwest of the welding company, and Prankratz Lumber Company was southwest of the stockyard and adjacent to the Duwamish Waterway. By 1947, a warehouse of modular home components and an office building occupied the location of Washington Compressed Gas Company. Associated Packing Company closed in 1956 and Prankratz Lumber Company closed between 1958 and 1963. The only known waste associated with these businesses was a scrap wood pile that was in the southwestern corner of Prankratz Lumber Company's property (SAIC 1994).

By 1938, Monsanto Fund purchased the northern 38 acres of the BDC site. Monsanto Fund leased the property to tenants of a warehouse and office buildings, American Winegrower's Association, Dallas-Mavis, a granary, and Slip No. 6. In 1938, a winery owned by the American Winegrower's Association occupied the property south of Washington Compressed Gas and adjacent to East Marginal Way. The winery expanded in 1946 and again in 1968 until it occupied 60,000 $ft^2$. The winery closed in the mid-1970s. There were two 1,000 gal underground concrete settling tanks associated with the winery that were removed from the site (SAIC 1994). Dallas-Mavis, a commercial trucking operation, occupied the location of the 9-04 building and the adjacent parking lot areas (part of the former winery) until 1989.

A 77,000 ft² granary was located north and west of the winery. It ceased storing grain in 1973 and functioned as a warehouse until 1985 (SAIC 1994).

The Port of Seattle purchased the Monsanto property and took over the leases in 1976. They leased the northeastern 5 acres in two 2.5 acre parcels to Transport Pool International and Kenworth Truck Company for parking and storage. Isaacson Steel leased the former granary for storage. Terminal 128 Corporation leased Slip No. 6 and intended to develop the slip as a marina. However, the development of the marina did not occur and the Port of Seattle sold the property to Boeing in 1985. The only known waste associated with these businesses was from the Terminal 128 lease. In February 1984, the Port of Seattle notified Terminal 128 Corporation that three transformer vaults had illegal hook-ups and that the associated sumps contained debris that was making them inoperable. There were also oil and chemical leaks and spills. Terminal 128 Corporation hired a contractor to remediate the leased property to the Port of Seattle's satisfaction (SAIC 1994).

In the mid-1930s, the southeastern portion of the property was occupied by a grocery store and a gasoline station. The gas station only operated for a short time period. A portion of the grocery store building was leased and occupied by a tavern and a warehouse. The building was destroyed by a fire in the 1940s (SAIC 1994).

Pamco construction company owned and operated a construction yard and commercial parking lot in the area of the BDC south parking lot. The Pamco construction yard closed in 1955. Boeing has a long-term lease on the parking lot. Between 1958 and 1963, Pro Gas, a propane distributor, was located adjacent to East Marginal Way in the south half of the site.

Due to the nature of the aerospace industry, the BDC facility is a large complex facility with activities changing over time. Activities that have occurred at the BDC facility include manufacturing of airplanes and missiles, which involves machining metal aircraft hardware, electroplating, chemical milling, conversion coating, painting, parts cleaning, and assembly. The machining, assembly, painting, and cleaning processes have taken place since 1957. However, they have declined since the 1980s when graphite composite fabrication began. The electroplating, chemical milling, and conversion coating processes were used primarily during the 1960s and 1970s (SAIC 1994).

Research and development activities have been a part of the BDC operations, with a substantial emphasis placed on these activities between 1957 and the early 1970s. Experimental manufacturing shops and research laboratories were used to investigate production aspects of materials and processes for manufacturing. There were also laboratories to investigate metals technology and electronics sciences (SAIC 1994).

## 2.3 LAND USE

The land use surrounding the BDC is primarily industrial and commercial. The BDC is located within a large contiguous industrial land use area which extends from Harbor Island to near the head of navigation of the Duwamish Waterway. This zone represents one of the largest contiguous industrial areas within Washington state. The Military Flight Center and Museum of Flight are east of the BDC, immediately across East Marginal Way South, with Boeing Field King County Airport further east. The Duwamish Waterway forms the southern and western boundaries of the site, and also forms part of the northern boundary where Slip No. 6 separates the site from the former Rhone Poulenc Company chemical manufacturing facility to the north (SAIC 1994) (Figure 3).

## 2.4 GEOLOGY

This section provides a description of the regional geology for the area and the local geology underlying the site. The regional geology is based on the regional conceptual model of the Puget Sound lowland as documented in Dragovitch et. al (1994) and Galaster and Laprade (1991), among others. The local geology has been interpreted from lithologic descriptions of subsurface soil collected from logs of soil borings and monitoring wells drilled at the BDC or at adjacent properties between the years of 1967 -2001.

### 2.4.1 REGIONAL GEOLOGY

The BDC is located within the Duwamish Valley lowland along the floodplain of the Duwamish Waterway. The Duwamish/Green River Valley is a relict subglacial meltwater channel eroded during the retreat of the Puget lobe of the most recent glaciation (Vashon Stade of the Fraser Glaciation) about 14,000 years ago. With the retreat of the lobe, the Duwamish/Green River Valley was occupied by a deep embayment of Puget Sound that extended inland to near present day Sumner, Washington. Marine sedimentation occurred in the embayment until about 5,000 years ago when a large volcanic mudflow off of Mount Rainier, known as the Osceola Mudflow, swept down the Puyallup and Whiter River Valleys, partially spilling into the Duwamish/Green River valley and out into Puget Sound. The mudflow traveled northward down the ancestral Duwamish/Green River valley to near present day Tukwila and the location of the BDC. Subsequent channel incision and erosion resulted in increased sediment loads, river aggradation and delta progradation that eventually filled the valley with freshwater sediments. Within the last 100 years, the natural Duwamish Channel has been filled to create the present day morphology. The BDC is located adjacent to one of these channel fill structures (Bortleson et. al, 1980).

The general stratigraphic sequence within the Duwamish Valley lowland consists of recent Holocene (10,000 yrs to present) alluvial deposits overlying Pleistocene (10,000 to 2,000,000 years before present) glacial deposits. The Holocene alluvial deposits are typically over 250 ft thick in the valley; the thickness of the glacial deposits is unknown, but appears to be thin in places. Underlying the glacial deposits are deeper Tertiary sedimentary and volcanic rocks. In the vicinity of Tukwila and the BDC, Tertiary bedrock outcrops near the surface, associated with uplift along the Seattle fault (Yount et. al, 1985). In the vicinity of the BDC, the combined thickness of the marine sediments and freshwater Duwamish River alluvial sediments may be about 100 ft, but probably varies locally due to the buried bedrock topography.

### 2.4.2 SITE GEOLOGY

Prior to the construction of the Duwamish Waterway by the USACE in about 1918, the Duwamish River meandered through the site area. At that time, the BDC site was situated on the inner curve of an old meander loop of the Duwamish River. In about 1918, the loop was filled in with dredge spoils from the dredging of the current Duwamish Waterway (Bortleson et. al, 1980). The geologic units encountered beneath the site include fill, underlain by Duwamish River alluvium, underlain by marine sediment. Fill material has been encountered at the BDC in the upper 5 to 10 ft below ground surface (BGS) and generally consists of brown fine to medium sand with occasional gravel and silt.

Beneath the fill material is an approximately 30- to 40-ft thick layer of naturally deposited Duwamish River alluvium. The uppermost portion of this alluvium consists of brown and gray sand and silt with occasional red mottling. This portion of the alluvium is often difficult to distinguish from the overlying fill material. At approximately 10 to 20 ft BGS, the alluvium becomes a dark gray fine to medium sand characteristic of reworked Osceola Mudflow deposits. This sand becomes increasingly silty with depth. In the northern portion of the BDC (near Building 9-77) a 2- to 8-ft thick layer of black gravelly coarse sand is present beginning at approximately 20 ft BGS [about elevation –13 ft National Geodetic Vertical Datum (NGVD)]. At the northwest corner of Building 9-101 a 3 to 5 ft thick layer of silt and silty sand is present beginning at about 30 ft BGS (elevation –18 ft NGVD).

The freshwater (Duwamish River) alluvium is underlain by marine sediments consisting of a massive dark gray silt and silty clay overlying coarser sand deposits. The top of the silt/clay is generally encountered at approximately 50 ft BGS and is approximately 20- to 30-ft thick. The silt layer appears to be laterally contiguous across the site. The top of the marine sands is generally encountered at approximately 80 ft BGS. Underlying the sand deposit is a deeper marine layer of silty gravelly sand with shell fragments. A single onsite exploration (well MW-14E) penetrated through the silt/clay layer into the marine sand. No onsite explorations drilled into the deeper silty gravelly sand. Geologic cross

sections based on historical boring logs are provided on Figures 5 through 7. The location of each cross section is shown on Figure 4.

## 2.5 HYDROGEOLOGY

This section provides a description of the regional hydrogeology for the area and the local hydrogeology underlying the site. The site hydrogeology has been interpreted from monitoring wells drilled at the BDC or at adjacent properties between the years of 1967 – 2001.

### 2.5.1 REGIONAL HYDROGEOLOGY

The Duwamish River is a regional lowland stream that represents a regional groundwater discharge zone. In the vicinity of the BDC, the river is separated from Puget Sound to the west by the West Seattle and Des Moines Uplands, and from Lake Washington to the east by Beacon Hill and the Skyway Upland (Galaster and Laprade1991). Regional horizontal groundwater flow is from these upland areas towards the river and Elliot Bay. Regional vertical groundwater flow is upward from deep aquifers towards the river in the valley lowland reflecting groundwater discharge. However in the shallow aquifer, groundwater flow in the valley lowland is typically part of a local groundwater system with groundwater flow predominantly horizontal towards the river. The portion of the Duwamish River adjacent to the BDC is tidally influenced, which has a local, temporal effect on groundwater flow.

Two municipal supply wells are located approximately ¾ mile west and 1 mile south of the BDC, respectively, on the opposite side of the Duwamish River. Given their locations, neither well would be expected to be potentially impacted by any constituents in groundwater at the BDC. Water rights exist for domestic and/or irrigation wells in Sections east and south of the BDC; however, none of these are located within the two Sections occupied by the BDC (T23N, R4E, Section 4 and T24N, R4E, Section 33) and the locations are upgradient or cross-gradient from the BDC (groundwater from the BDC flows west and south to the Duwamish Waterway).

### 2.5.2 SITE HYDROGEOLOGY

Hydrogeology at the site consists of two identified aquifer units separated by an aquitard consisting of the silt/clay layer at the top of the marine sediment sequence. The shallow aquifer is typically characterized as unconfined saturated Duwamish alluvial sediments. Where Duwamish River alluvium grades silty, (i.e. the northwest corner of Building 9-101) the shallow aquifer exhibits more semiconfined characteristics. The deep confined aquifer consists of marine sand deposits beneath the silt/clay aquitard. The aquifer and aquitard units are discussed in greater detail below.

#### 2.5.2.1 Shallow Unconfined Aquifer

A shallow unconfined aquifer is encountered beneath the site at a depth of approximately 10 to 12 ft BGS (approximately elevation 3 to 5 ft NGVD). The shallow unconfined aquifer is about 40 ft thick and is segregated into three depth intervals (A, B, and C horizons) (Landau Associates 1992) (Tetra Tech 1996). Groundwater level elevation contours, shown on Figure 8, indicate west to northwest horizontal groundwater flow toward the Duwamish Waterway in the shallow aquifer. The horizontal gradient is approximately 0.0004 to 0.0008 based on June 2001 water level data (Figure 8).

A distinct discontinuous silt layer is present at approximately 25 ft BGS in the vicinity of the northwest corner of Building 9-101. Underlying the silt layer is approximately 8 ft of Duwamish River alluvium. This specific area and depth interval was termed the D horizon of the shallow aquifer (Landau Associates 1992, Tetra Tech 1996). D horizon water levels have larger tidal fluctuations then other portions of the shallow aquifer indicating the presence of semi confined conditions.

Groundwater level elevations in the shallow aquifer appear to vary approximately 1 to 2 ft in response to tides and seasonal precipitation changes (Landau Associates 1987). Tidal influence on the groundwater levels (approximately 0.4 ft) was observed in the shallow unconfined aquifer (A through C horizon) in the area of Building 9-101 and SWMU-20 during a 45 hour period (Tetra Tech 1996). However only a minimal (up to 0.04 ft) groundwater level change was observed in wells at SWMU-17 during a 12-hour period (Landau Associates 1987). It appears that the tidal influence on groundwater levels does not extend appreciably east of SWMU-20 and AOC-03/04. At the north end of the site, tidally influenced groundwater level fluctuations have been observed in monitoring wells in the vicinity of Slip No. 6 but this affect does not appear to extend south to AOC-01/02 (Landau Associates 1986). In the D horizon, a tidally influenced groundwater elevation change of approximately 0.75 ft was observed in the vicinity of SWMU-20 during a 45 hour period (Tetra Tech 1996).

Water levels in adjacent wells, which are screened at different depths within the unconfined aquifer, show minor head differences with no consistent trend. This indicates there are no strong vertical gradients within the unconfined aquifer in the vicinity of the site and groundwater flow can be expected to be primarily horizontal. Aquifer transmissivity of 1.91 to 2.28 $ft^2$/min and hydraulic conductivity of $7.5 \times 10^{-2}$ to $9.0 \times 10^{-2}$ ft/min (110 to 130 ft/day) was calculated from pumping test data (Tetra Tech 1996).

Horizontal groundwater velocity measurements were calculated from hydraulic gradient, hydraulic conductivity and porosity estimates using Darcy's law. The hydraulic gradient at the site is approximately 0.0004 to 0.0008 ft/ft; the hydraulic conductivity has been estimated to be approximately

is typically in contact with the salt wedge except when very low tides and very high stream discharges co-occur. During these infrequent events of co-occurrence, the groundwater flow from BDC is expected to have minimal contribution to total Duwamish Waterway stream flow. The Duwamish Waterway water column adjacent to the BDC, at zero tide, consists of an approximately upper 10 ft of brackish water and a lower 20 ft of salt water (Landau Associates 1986). The Duwamish Waterway discharges at an annual average rate of 1660 $ft^3$ per second into Elliott Bay (SAIC 1994). The lowest flows typically occur in August and the highest flows in December and January.

## 2.7 GROUNDWATER-SURFACE WATER INTERACTION

The Duwamish Waterway is a point of discharge for groundwater from the unconfined aquifer. As discussed in Section 2.5, groundwater in the unconfined aquifer flows toward the waterway and groundwater levels are affected by tidal fluctuations in the surface water.

# 3.0 SITE SCREENING STANDARDS

This section presents the development of screening standards for groundwater and soil at the BDC, based on requirements under Ecology's revised MTCA regulations that became effective August 15, 2001. Preliminary screening levels are discussed in Section 3.1. Points of compliance for the preliminary screening levels are discussed in Section 3.2.

## 3.1 SELECTION OF PRELIMINARY SCREENING LEVELS

Preliminary groundwater screening levels were developed based on protection of surface water. Preliminary soil screening levels were developed for protection of human health assuming direct contact with the soil and protection of groundwater using the fixed parameter three-phase leaching model described in WAC 173-340-747(4) (Ecology 2001a).

### 3.1.1 PRELIMINARY GROUNDWATER SCREENING LEVELS

Groundwater at the BDC meets the criteria listed in WAC 173-340-720(2)(d) for classification as nonpotable water for purposes of preliminary screening level development. Each of the criteria is discussed below.

- **The groundwater does not serve as a current source of drinking water and it is unlikely that hazardous substances will be transported from the contaminated groundwater to groundwater that is a current or potential future source of drinking water.** As described in Section 2.5.1, there are no known municipal or domestic water wells either at or within at least ½ mile of the BDC. Two municipal supply wells are located approximately ¾ mile west and 1 mile south of the BDC, respectively, on the opposite side of the Duwamish River. Given their locations, neither well would be expected to be potentially impacted by any constituents in groundwater at the BDC. Water rights exist for domestic and/or irrigation wells in Sections east and south of the BDC; however, none of these are located within the two Sections occupied by the BDC (T23N, R4E, Section 4 and T24N, R4E, Section 33) and the locations are upgradient or cross-gradient from the BDC (groundwater from the BDC flows west and south to the Duwamish Waterway). As described in Section 4, areas of impacted groundwater are limited in areal extent, are decreasing over time through active remediation and natural attenuation, and are contained within the site boundaries.

- **There are known or projected points of entry of the groundwater into the surface water.** The BDC is adjacent to the Duwamish Waterway and shallow groundwater at the site flows southwest or west and discharges to the waterway.

- **The surface water is not classified as a suitable domestic water supply source.** The Duwamish Waterway adjacent to the site typically consists of brackish water overlying salt water. The Duwamish Waterway adjacent to the site and downstream of the site is not considered a suitable domestic water supply source due to the salinity of the water.

- **The groundwater is sufficiently hydraulically connected to the surface water that the groundwater is not practicable to use as a drinking water source.** The unconfined aquifer at the site is hydraulically connected to the Duwamish Waterway as evidenced by the tidal response observed in site monitoring wells.

The groundwater at the BDC meets the criteria for considering the groundwater to be nonpotable; therefore preliminary groundwater screening levels were developed that are protective of beneficial use of surface water. The MTCA Method B marine surface water and fresh water screening levels were selected as the preliminary groundwater screening levels for the site.

Preliminary screening levels for marine and fresh surface water were developed for detected constituents using standard Method B in accordance with WAC 173-340-730 (3)(b) (Ecology 2001a). Preliminary groundwater screening levels were based on the most stringent of federal and state water quality criteria for protection of marine and fresh water aquatic organisms and human health, if available. If no federal or state criteria were available, preliminary groundwater screening levels were determined using the equations in WAC 173-340-730 (3)(b)(iii). MTCA Method A groundwater levels were used for total petroleum hydrocarbon (TPH) diesel-range and gasoline-range petroleum hydrocarbons as there are no marine surface water values. Where analytical methods prevent the reliable detection of a constituent at the concentration defined as the preliminary screening level, the preliminary screening level was adjusted upward to the practical quantitation limit (PQL) in accordance with 173-340-730 (5)(c) (Ecology 1995). Preliminary groundwater screening levels protective of marine and fresh water surface water are shown in Table 2.

### 3.1.2 PRELIMINARY SOIL SCREENING LEVELS

Preliminary soil screening levels were developed using standard Method C for industrial properties in accordance with WAC 173-340-745. The BDC meets the industrial land use criteria in WAC 173-340-745 (1)(a). The BDC is zoned for industrial land use. The BDC has been used in the past and is currently used for industrial purposes. It is expected that the BDC will be used for industrial purposes in the future. The land use surrounding the BDC is primarily industrial and commercial. The BDC is located within a large contiguous industrial land use area which extends from Harbor Island to near the head of navigation of the Duwamish Waterway. This zone represents one of the largest contiguous industrial areas within Washington state.

The BDC meets the exclusion from a terrestrial ecological evaluation requirement based on WAC 173-340-7491(1). Impacted soil at the site is covered by buildings and pavement that prevent plants or wildlife from being exposed to the soil.

Soil screening levels protective of groundwater and direct contact were evaluated in the selection of preliminary soil screening levels. Preliminary soil screening levels protective of groundwater were calculated in accordance with Ecology's fixed parameter three-phase partitioning model, WAC 173-340-747(4). Preliminary soil screening levels protective of direct contact (MTCA Method C industrial soil screening levels) were also evaluated. The levels protective of groundwater and protective of direct human contact were compared and the more stringent values were selected as the preliminary soil screening levels. Where analytical methods prevent the reliable detection of a constituent at the concentration defined as the preliminary soil screening level, the preliminary screening level was adjusted upward to the PQL in accordance with WAC 173-340-745 (6)(c) (Ecology 1995). For metals, the Puget Sound Basin natural background 90$^{th}$ percentile values were compared to the preliminary soil screening levels (Ecology 1994). The preliminary soil screening levels were adjusted upward to the natural background values if the background value was greater than the Method C values. The MTCA Method A industrial soil cleanup level was used for arsenic, which includes an adjustment for natural background. The MTCA Method A industrial value was also used for "polychlorinated biphenyls (PCBs) and mixtures" and for TPH. The preliminary soil screening levels are shown on Table 3.

## 3.2 POINTS OF COMPLIANCE

The points of compliance for groundwater at the BDC are throughout groundwater at the site unless the groundwater screening levels cannot be met at these standard points of compliance within a reasonable restoration time frame. In the event that it is determined that the groundwater screening levels cannot be met at the standard points of compliance, Boeing reserves the right to use conditional points of compliance, in accordance with WAC-173-340-720(8). The point of compliance for soil at the BDC is established in soil throughout the site, in accordance with WAC 173-340-745 (7).

# 4.0 SUMMARY OF SWMUs/AOCs

## 4.1 OVERVIEW

In 1994, a RFA was performed to evaluate SWMUs and AOCs at the BDC. The RFA identified 157 SWMUs and 5 AOCs, which are described in detail in the RFA (SAIC 1994). The majority of the SWMUs have been excluded from further investigation based on a determination that they do not pose a threat to human health or the environment (Table 1). As shown in Table 1, all of the original 157 SWMUs and 5 AOCs except the following have been identified as requiring no further action:

- SWMU-15, paper shredder, Building 9-67
- SWMU-16, former regulated materials storage area, Buildings 9-69/70
- SWMU-17, former sump and USTs, Building 9-75
- SWMU-20, former degreaser pit, Building 9-101
- SWMUs-23 through 25, former waste water above ground storage tanks (ASTs), Building 9-101
- SWMU-43, storm water sewer system
- AOC-01/02, former unleaded gasoline USTs, Building 9-52
- AOC-03/04, former No. 5 fuel oil USTs, Buildings 9-50 and 9-72
- AOC-05, former unleaded gasoline UST, Buildings 9-60 and 9-61.

The locations of these SWMUs and AOCs are presented on Figure 9. Further detail of these SWMUs and AOCs, including description of SWMU or AOC, summary of corrective action, and current status of the SWMU or AOC, are presented below.

## 4.2 SWMU-15: PAPER SHREDDER (BLDG 9-67)

### 4.2.1 DESCRIPTION OF SWMU

SWMU-15, near Building 9-67, consists of two adjacent paper shredders used to destroy classified and "Boeing Limited" documents (Figure 9). Papers are ground into fine particles in one of two shredders that each have an associated baghouse (cyclone). The particles are then sent to another baghouse where water is added to produce a slurry. The paper slurry passes through a screw press where excess water is removed. The wetted paper is then loaded into a 13 $yd^3$ box and sent offsite to be blended

with compost. Approximately one box of paper is generated each day. The paper shredders have been in operation since 1984; the baghouses were added in 1988 (SAIC 1994).

There has been one documented release of paper slurry waste from SWMU-15. Approximately 200 gal of paper slurry wastewater were released to a storm drain in 1994. The material was captured in the oil/water separator (SAIC 1994).

### 4.2.2 SUMMARY OF CORRECTIVE ACTION

Since the release of process water in 1994, three boxes were purchased for use at Building 9-67. The BDC best management practices (BMPs), with respect to the paper shredder, have been modified as follows. The boxes are lined and covered when not in use to help prevent leakage of debris to pavement. In addition, the area around the paper shredder is swept nightly to remove any accumulated debris. Debris from Building 9-67 that cannot be removed by street sweeping, and which enters site catch basins, is captured by the storm sewer system oil/water separators. The site has several oil/water separators in the storm sewer system which are inspected quarterly and cleaned out at least annually.

### 4.2.3 CURRENT STATUS

The release of paper slurry waste noted was a one-time release of a non-hazardous material. Modifications to the BMPs have been implemented to prevent future releases. No additional corrective actions are planned for this unit. No further action is recommended for SWMU-15.

## 4.3 SWMU-16: FORMER REGULATED MATERIALS STORAGE AREA

### 4.3.1 DESCRIPTION OF SWMU

SWMU-16 is a former regulated materials storage area located in and adjacent to Building 9-69/70 (Figures 9 and 10). This unit was used to manage regulated waste generated throughout the BDC facility. The unit operated from 1979 to 1992. Building 9-69/70 consisted of six container storage bays that were used to segregate flammables, corrosives, and other wastes. Lead acid batteries were also stored in this area.

The six curb-enclosed container storage bays were each 18 ft wide by 16 ft deep with 6-inch to 8-inch high curbs on two sides, and walls on top of the curbs (Figure 11). The bays were enclosed with metal walls and a post-supported canopy roof. A strip drain ran across the front of each bay, and the inside wall of Building 9-69/70 formed the back side of the bays. The bays were arranged such that three bays faced each other with a 15-ft corridor down the center. The corridor sloped toward a catch basin in

the center. The strip drains emptied into a 1,000 gal oil/water separator (SWMU-35) with a shut-off valve. An asphalt paved container storage area behind the building was surrounded by a chainlink fence on three sides and the building on the fourth side. The area inside the fence did not have curbing or containment structures around its perimeter (SAIC 1994, Weston 1997).

### 4.3.2 Summary of Corrective Action

Ecology approved the RCRA Closure Plan for Building 9-69/70 Container Storage Area (Weston 1993 and Ecology 1993). During June 1996, the building structure was removed. Samples of the concrete slab and surface and subsurface soil beneath the concrete slab and asphalt area were collected and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), total PCBs, and priority pollutant metals. The soil samples contained VOCs, SVOCs, total PCBs, and metals. Soil underneath the concrete slab contained concentrations of total PCBs above the MTCA Method A industrial cleanup level. Soil underneath the asphalt contained elevated concentrations of lead. Approximately 800 $yd^3$ of soil were excavated from SWMU-16 and disposed of at an approved facility.

After excavation, 11 soil samples from the bottom of the excavation and 8 sidewall samples were collected and analyzed for VOCs, SVOCs, total PCBs, and priority pollutant metals. In accordance with the Closure Plan, the screening criteria for the soil samples was 100 times MTCA Method B groundwater criteria. Concentrations of VOCs in the soil samples did not exceed the screening criteria. One soil sample contained concentrations of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) above the screening criteria but the elevated concentration appears to be residue from a buried treated wood bulkhead near the sampling location (Weston 1997). Concentrations of arsenic, beryllium, and chromium were above the screening criteria but within natural background concentrations for the area (Ecology 1994). The concentrations of these metals in the site soil appeared to result from natural background and not from contamination. Three soil samples contained concentrations of total PCBs above the screening criteria.

Additional soil was excavated from the three sample locations that contained total PCB exceedances. The locations were sampled after the excavation. One of the three locations did not contain detectable concentrations of total PCBs (0.036 mg/kg detection limit). The mean total PCB soil concentration in the remaining two locations (0.33 mg/kg) was below the screening criteria of 1 mg/kg established in the Closure Plan.

In summary, the Building 9-69/70 Container Storage Area was closed in accordance with the requirements of the Closure Plan. All concrete underlying the facility was removed and disposed of offsite. Residual PCB concentrations satisfied the Closure Plan requirements. Arsenic, beryllium, and chromium were not present in concentrations exceeding background concentrations (Weston 1997).

Ecology approved the closure of Building 9-69/70 (Ecology 1997). A copy of Ecology's approval letter is included in Appendix C.

During closure of the Building 9-69/70 Container Storage Area, soil was excavated beyond the boundaries of the storage unit. At the easternmost edge of the excavation, a sample was collected that contained 7.1 mg/kg PCB. Because this sample was collected beyond the boundaries of the container storage unit, the unit was certified clean-closed and Ecology approved the closure. The observed concentration of 7.1 mg/kg is below the MTCA Method A industrial cleanup level of 10 mg/kg; however, Ecology requested that additional investigation be performed to evaluate whether the PCB detected in soil was impacting groundwater. Boeing submitted a work plan on July 25, 2000 outlining a scope of work for the requested investigation (Boeing 2000). Ecology approved the plan on February 8, 2001.

The additional investigation of SWMU-16 included the drilling and sampling of six Geoprobe™ borings in January 2001. The soil boring locations are shown on Figure 12. Two groundwater samples were collected from each boring. The initial groundwater sample from each boring was collected from 0.5 to 3.5 ft below the top of the water table. The second groundwater sample from each boring was collected from a depth of 10.5 to 13.5 ft below the top of the water table (IT Corporation 2001).

The groundwater samples were analyzed for PCBs, which were not detected at the 1 to 2 μg/L method reporting limit (IT Corporation 2001). The results are summarized in Table 4. Based on the groundwater sample analytical results, it does not appear that PCBs previously detected in the soil have impacted the groundwater.

### 4.3.3 CURRENT STATUS

Ecology approved the RCRA closure of the former Building 9-69/70 Container Storage Area. Boeing performed a supplemental investigation to verify that residual PCB concentrations in soil in the area beyond the boundaries of the former storage area are protective of groundwater. PCBs were not detected in groundwater samples collected during this investigation. Based on these results, no further actions are recommended for SWMU-16.

## 4.4 SWMU-17: FORMER UNDERGROUND STORAGE TANK

### 4.4.1 DESCRIPTION OF SWMU

SWMU-17 consists of a former 67-gal sump and associated 4,000-gal steel UST, which were used to store waste hydraulic and engine oil. The sump/UST system is designated DC-05. It was installed in 1957 and was located east of the Building 9-75 water tank. The location of SWMU-17 is shown on Figures 9 and 10, and groundwater contours for SWMU-17 are presented on Figure 8. Waste oil

generated by hydraulic testing shops, automotive maintenance shops, and various other locations throughout the BDC was poured into the sump and then flowed into the UST. Periodically, the waste oil was pumped from the UST and shipped offsite for treatment and disposal (SAIC 1994). The sump and UST were closed and removed in late March or early April 1986 (Landau Associates 1987).

### 4.4.2 SUMMARY OF CORRECTIVE ACTION

Soil samples collected in 1985 in the vicinity of the UST indicated the soil was impacted with hydrocarbons (Norton Corrosion Limited, Inc. 1985). Visual contamination was not observed in the soil during the UST removal. Soil samples collected after the UST removal indicated minor amounts of hydrocarbon present in the soil (Landau Associates 1987).

As a result of identifying the presence of contaminated soil, three monitoring wells (BDC-05-1, BDC-05-2, and BDC-05-3) were installed in May or June 1986 (Figure 13) (Landau Associates 1987). One soil sample, from a depth of approximately 10 ft BGS in the boring for well BDC-05-2, was analyzed for VOCs and priority pollutant metals. Analytical results for detected constituents are presented in Table 5. The soil sample contained methylene chloride, acetone, toluene, total xylenes, and metals. However, the concentrations of all detected constituents were below the preliminary soil screening levels, with the exception of copper. The maximum concentration of copper (41 mg/kg) was above the preliminary soil screening level of 36 mg/kg, which is based on the 90$^{th}$ percentile concentration in soil for Puget Sound basin (Table 3). However, the measured concentration is less than two times the preliminary soil screening level and is also within the Puget Sound Basin natural background range of 4 to 243.5 mg/kg (Ecology 1994). Methylene chloride in the soil sample appears to be a result of laboratory contamination as it was detected in the lab blank at similar concentrations as the soil sample (Landau Associates 1987). The presence of trace levels of toluene and total xylenes with the absence of benzene and the detection of acetone may suggest low levels of non-chlorinated solvent contamination rather than hydrocarbon contamination (Landau Associates 1987).

Following installation of the groundwater monitoring wells, one groundwater sample was collected from each well and submitted for analysis of VOCs and priority pollutant metals. Additional groundwater samples were obtained from monitoring wells BDC-05-2 and BDC-05-3 in November 1986. Shortly thereafter, monitoring well BDC-05-2 was inadvertently destroyed during construction of Building 9-64. Boeing replaced the destroyed well and installed several additional monitoring wells to further define the extent and probable source of contamination associated with tank DC-05 (Landau Associates 1987). Monitoring wells BDC-05-2A, BDC-05-4, BDC-05-5, and BDC-05-6 (Figure 13) were installed in January 1987 and sampled in early February 1987. In March 1987 an additional monitoring well (BDC-05-7) was installed adjacent to and downgradient of the former tank

location (Figure 13). In December 1987, Ecology requested that additional groundwater sampling be conducted. Monitoring wells BDC-05-1, BDC-05-2A, BDC-05-3, and BDC-05-7 were sampled in February 1988 and the samples were analyzed for VOCs, bis(2-ethylhexyl)phthalate, and metals (chromium, copper, nickel, and zinc). In August 1988, Ecology stated that no further work was required at this site and that the monitoring wells could be abandoned (Ecology 1988). In January 1995, monitoring well BDC-05-01 was abandoned during a storm sewer relocation project. Monitoring well BDC-05-06 was abandoned prior to soil excavation activities related to closure of SWMU-16. From 1996 to 2001, groundwater samples from the five wells (BDC-05-2A, BDC-05-3, BDC-05-4, BDC-05-5, and BDC-05-7) were collected approximately annually and analyzed for VOCs, TPH, and metals.

Detected metals concentrations for groundwater samples collected since January 1998 are summarized in Table 6. Arsenic, cadmium, copper, and lead were detected at concentrations exceeding the preliminary screening levels. In general, the exceedances of preliminary screening levels for metals were infrequent with the exception of copper. Copper was detected at a maximum concentration of 44 µg/L, compared with the preliminary screening level of 3.4 µg/L for marine water and 8.9 µg/L for fresh water. TPH was not detected above the detection limit, 250 µg/L. Detected VOCs for samples collected since January 1998 are summarized in Table 7. Tetrachloroethene (PCE) is the only VOC detected at concentrations exceeding the preliminary screening level. During the most recent sampling event (December 2001), the maximum observed concentration of PCE was 8.2 µg/L, which is below the preliminary screening level of 9 µg/L. A complete summary of groundwater data for SWMU-17 is provided on digital media (compact disc) in Appendix A.

In the December 2001 groundwater monitoring event, split samples were sent to Analytical Resources, Inc. (ARI) of Seattle, Washington to confirm the concentrations of metals that had been observed in previous samples. Metals concentrations in the ARI samples were significantly lower, indicating that the elevated concentrations of metals in previous samples may be inaccurate. Semi-annual groundwater sampling will continue to monitor metals to confirm the lower concentrations. Analytical results for the original and split samples are presented in Appendix A.

### 4.4.3 CURRENT STATUS

Under the groundwater monitoring program, the monitoring wells (BDC-05-2A, BDC-05-3, BDC-05-4, BDC-05-5, and BDC-05-7) are currently sampled semi-annually for VOCs, diesel-range petroleum hydrocarbons, and metals (Boeing 2001).

## 4.5 SWMU-20: FORMER DEGREASER PIT (BLDG 9-101)

### 4.5.1 DESCRIPTION OF SWMU

SWMUs-20 through 22, the former degreaser pit (SWMU-20) and sumps [Sump No. 2 (SWMU-21) and Sump No. 3 (SWMU-22)] in the tank line, were associated with the vapor degreaser and the anodizing tank line, respectively, and were located in the northwest corner of Building 9-101 (Figure 14). Originally, there was an 8.5-ft deep degreaser pit that was 9 ft wide by 22.3 ft long with an adjacent plating line sump (Sump #1) that was 6.6 ft deep, 6.3 ft long, and 7.3 ft wide. The degreaser pit and sumps were used from about 1956 to 1984 (Landau 1990a). In 1967, a new sump pit was added that was 6.3 ft deep, 8 ft long, and 6 ft wide. The former degreaser pit and sumps were concrete lined. The degreaser pit was used as containment for solvents [reportedly PCE and trichloroethene (TCE)] used in the degreaser. The base of the degreaser pit was about 10 ft BGS and sloped toward Sump No. 2, which was about 13 ft BGS. Sump No. 2 drained into Sump No. 3. The two sumps were used to contain and accumulate wastewater contaminated with acid, alkaline, and metals from the anodizing plating line. After chemical testing, liquid waste was pumped from Sump No. 3 to either a tank truck for disposal by a waste hauler or to the METRO Sewer System. Elementary neutralization was performed on the wastewater prior to discharge to the sanitary sewer (SAIC 1994).

The degreaser pit and sumps were closed in 1984. All tanks, piping, and other equipment were removed. The degreaser pit and sumps were backfilled with compacted sand backfill material and capped with a 10-inch thick concrete slab. All openings through the walls and floor were plugged (Landau Associates 1990a).

### 4.5.2 SUMMARY OF CORRECTIVE ACTION

In 1989, approximately 1,400 tons of soil contaminated with PCE and TCE were removed from the area of the former degreaser pit and sump area during a structural upgrade project of Building 9-101. Six soil samples were collected from test pits in a Phase I investigation during June 1989. Water was observed at the base of the excavation, in two test pits 2 to 29 inches above the depth of the concrete floor of the degreaser pit. Soil and water samples were analyzed for VOCs, SVOCs, metals, and cyanide. Soil samples were collected from the area of subsequent excavation and therefore analytical results for VOCs and SVOCs are not presented in this report. The soil metals results from Phase I are presented in Table 8a. Although most or all of the soil represented by these samples was excavated, the results are included to document that metals were not present at concentrations above preliminary screening levels. A Phase II investigation was performed in August 1989; 65 soil samples were collected from borings and 24 monitoring wells were installed in the vicinity of the former degreaser pit/sump area. Soil samples

were submitted for analysis of VOCs, SVOCs, TPH, and PCBs. Groundwater samples were collected and analyzed for VOCs and TPH. A Phase III investigation was completed in February 1991, which included soil sampling and installation of 13 monitoring wells. Soil samples were analyzed for VOCs. Groundwater samples from the 24 existing monitoring wells and 13 additional monitoring wells were collected and analyzed for VOCs. Subsequent investigations confirmed the presence of chlorinated VOCs in the groundwater (Boeing 2001). The solvent release was interpreted to be from the former degreaser pit (SAIC 1994).

The detected analytical results for soil samples collected from the monitoring well borings during the Phases II and III investigations are presented in Table 8b. The most frequently detected constituents were chlorinated VOCs: PCE, TCE, cis-1,2-dichloroethene (DCE), and vinyl chloride (VC). Concentrations of PCE and TCE were above the preliminary soil screening levels at two depth intervals. The shallowest interval included soil from the vadose zone, from approximately 0 to 10 ft BGS. This zone contained the highest concentration of chlorinated VOCs. The deeper zone was observed from approximately 32 to 40 ft BGS (Landau Associates, 1992). Soil sample 8C-12 contained polycyclic aromatic hydrocarbons (PAHs) and other creosote-associated compounds at concentrations below the preliminary screening levels. These compounds appear to be associated with treated timber piles used to support Building 9-101 (Landau Associates 1990a). TPH was also detected at concentrations below the preliminary soil screening level in some of the samples.

The groundwater monitoring wells installed at the facility were constructed to allow evaluation of layers (horizons) of the aquifer system beneath the site. The range of depths of the monitoring well screens relative to the horizon of groundwater targeted for assessment were as follows:

A Horizon Wells – screen depths ranging from 6.5 to 21.5 ft BGS
B Horizon Wells – screen depths ranging from 22.0 to 27.5 ft BGS
C Horizon Wells – screen depths ranging from 23.5 to 40.5 ft BGS
D Horizon Wells – screen depths ranging from 40.0 to 56.0 ft BGS
E Horizon Wells – screen depths ranging from 77.0 to 82.0 ft BGS

As described in Section 2.5.2, the A, B, and C Horizon wells were intended to monitor three distinct layers of groundwater located in the shallow, unconfined aquifer located beneath the site. The D Horizon wells were intended to evaluate the semi-confined layer of groundwater present beneath a discontinuous silt aquitard underlying the unconfined aquifer. The E Horizon well (MW-14E) was intended to monitor the water quality in the fully confined aquifer present beneath a massive marine silt deposit located beneath the site.

SVOCs were not detected above EPA Contract Laboratory Program (CLP) quantitation limits in groundwater samples and were dropped from the testing program after the August 1989 sampling program (Landau Associates 1992). The SVOCs in groundwater were primarily PAHs and are assumed to be associated with the creosote-treated timber piles beneath Building 9-101 (Landau Associates 1990a).

Frequently detected VOCs in groundwater were benzene, PCE, TCE, DCE, VC, and naphthalene. A summary of concentrations for these constituents for monitoring events since January 1998 is presented in Tables 9 through 14. A complete summary of groundwater analytical data for SWMU-20 is provided on digital media in Appendix A.

The distributions of the chlorinated VOCs PCE, TCE, DCE, and VC in groundwater follow a similar pattern. Concentrations of PCE, TCE, and DCE in groundwater are greatest in the A Horizon near monitoring well MW-9A (i.e., near the former degreaser pit). Concentrations decrease in the downgradient groundwater flow direction from monitoring well MW-9A and generally show a decreasing trend with depth. A trend plot showing VOC concentrations over time for the influent to the groundwater pump and treat system (indicative of dissolved concentrations in the plume area) are presented in Appendix B. Since June 1998, only PCE has been detected in sample from the monitoring wells at concentrations exceeding the preliminary screening level (Table 11). Table 15 presents a summary of infrequently detected VOCs; none of these constituents has been detected at concentrations exceeding the preliminary screening levels. The E Horizon well has not exhibited impact by chlorinated hydrocarbons in excess of laboratory detection limits since August 1997. The only constituents detected in samples collected from Well MW-14E prior to 1997 were acetone (5.9 µg/L in October 1998), cis-1,2-DCE (1.1 µg/L in January 1994), and VC (detected at 10 µg/L, 1.43 µg/L, 1.3 µg/L, 1.3 µg/L, in January 1994, May 1995, August 1995, and May 1996, respectively). No constituents have been detected in samples from well MW-14E at concentrations exceeding the preliminary screening levels.

#### 4.5.2.1 Overview of Remediation System

During the fall of 1993, a pump and treat system was installed to remove the chlorinated VOCs from the groundwater and preclude migration of chlorinated VOCs in groundwater. The pump and treat system consists of two extraction wells (E-1 and E-2), and a sieve tray aerating treatment system. Initially, the remediation system utilized one extraction well (E-1) to extract groundwater. E-1 was installed with a screened interval extending from approximately 23 to 38.3 ft BGS, which indicates that E-1 was capable of collecting groundwater from the A, B, and C horizons of the shallow groundwater present beneath the site. E-1 remained in use as the sole recovery well at the site from March 4, 1994 to December 13, 1995. A second groundwater extraction well (E-2) was utilized for groundwater extraction beginning in July 1996. E-2 was constructed with well screen extending from approximately 22 to

32 ft BGS, so that extraction of water from E-2 would also be within the A, B, and C horizons of the groundwater beneath the site. Since July 1996, the extraction wells have been used alternately for extraction, with E-2 being operated for a majority of the time. The pump and treat system produces approximately 25,000 gal per day of treated water, which is discharged to an national pollution discharge elimination system (NPDES) permitted stormwater outfall (Boeing 2001).

#### 4.5.2.2 Remediation System Evaluation

A complete evaluation of the pump and treat remedial system at SWMU-20 is included in Appendix B. This remedial system evaluation examined the following information:

- Current and historical contaminant distribution (lateral and vertical) to evaluate system effectiveness in plume control and aquifer restoration
- Capture zone of each extraction well within each of four depth intervals (i.e., A, B, C, and D zones) at current pumping rates
- Appropriateness of current extraction well locations and screen depths
- Appropriateness of alternate pumping rates or alternate pumping scenarios (e.g., cyclic pumping, or concurrent extraction from both wells) with respect to plume containment and aquifer restoration
- Current mass removal rates, trends in mass removal, and total VOC mass removed to date
- Natural attenuation mechanisms and effectiveness, including a comparison of current mass removal rates to potential natural biodegradation rates.

A brief review of the findings are summarized below. Refer to Appendix B for further details. The remediation system evaluation focuses on the chlorinated VOCs: PCE, TCE, DCE, and VC. These constituents are considered the primary constituents of interest based on their concentration and frequency of detection in site monitoring wells. The evaluation considered the data collected for the site under two distinct scenarios: prior to the activation of the remediation system (August 1989 to January 1994) and following the activation of the remediation system (January 1994 to December 2000).

The implementation of the groundwater pump and treat system in March 1994 has increased the removal rate of PCE, TCE, DCE, and VC from the groundwater at the site. The influent concentration of the groundwater recovered by the pump and treat system has been declining significantly over the past two years (Figure 8 of Appendix B). The capture zone of the current pump and treat system indicates that it has effectively controlled plume migration (Landau Associates 2001).

### 4.5.3 CURRENT STATUS

The pump and treat remedial system evaluation (Appendix B) also includes a recommended course of action to continue groundwater remediation and to obtain regulatory closure for the site. This recommended course of action involves temporarily shutting down the remediation system and allowing the groundwater to equilibrate for a period of 6 months. In accordance with this recommendation and with Ecology concurrence (Ecology 2001b), the remediation system was temporarily shut down starting December 14, 2001. Following shutdown of the remediation system, sampling will be conducted, and the results will be evaluated to determine if natural attenuation appears to be a viable remedial alternative to reach site clean-up concentrations. The groundwater monitoring wells associated with SWMU-20 will be sampled for VOCs biannually, typically during summer and winter (Boeing 2001). Beginning with the December 2001 sampling event, the scope of groundwater monitoring was reduced as approved by Ecology and sampling of monitoring wells MW-17C, MW-17D, MW-18A, MW-18D, MW-19A, MW-19D, MW-20A, and MW-20D was discontinued.

## 4.6 SWMU-23 THROUGH SWMU-25: ABOVEGROUND STORAGE TANKS (BLDG 9-101)

### 4.6.1 DESCRIPTION OF SWMUS

SWMUs 23 through 25, three former ASTs, (designated A, B, and C), were located near the northwest corner of Building 9-101 (Figure 9). AST A was a 3,000-gal waste alkaline holding tank. It held waste sodium hydroxide and various other alkaline solutions used for chemically milling, stripping, and cleaning. AST B was a 2,000-gal waste acid holding tank which held waste nitric acid, hydrochloric acid, chromic acid, and other acid solutions used for chemically milling, etching, and plating operations. AST C was a 10,000-gal wastewater tank, which held wastewater contaminated with metals that exceeded METRO permit discharge limits. AST C wastewater included process rinse water, general cleaning wash water, and rain water. The rainwater initially accumulated in a sump in the tank line containment area for ASTs A, B, and C. When the sump was full, the water would be analyzed and either discharged to METRO Sewer System, if results met METRO's permit limits, or AST C. The ASTs were in use from 1957 through 1984. In 1982, ASTs A and B were moved to a nearby location to accommodate installation of a new scrubber. All three ASTs were decontaminated, closed, removed, and disposed of in 1985 (SAIC 1994). ASTs A and B were designated as RCRA-regulated tanks. AST C was not a RCRA-regulated storage tank, and therefore did not require RCRA closure.

There were no reported releases from ASTs A, B, and C.

### 4.6.2 SUMMARY OF CORRECTIVE ACTION

A soil and groundwater investigation was performed in 1993 at the former locations of ASTs A and B as a closure requirement (Landau Associates 1993a). Soil samples were collected at the pre- and post-1982 locations of ASTs A and B (Figure 15), and were analyzed for total and toxicity characteristic leaching procedure (TCLP) extractable priority pollutant metals. Groundwater samples were collected from existing monitoring wells MW-7A, MW-13A, and MW-16A (Figure 15) and were analyzed for total and dissolved priority pollutant metals. The performance closure standards were based on MTCA Method A and C cleanup levels for industrial sites. Chemical concentrations in the soil samples and the groundwater samples did not exceed the MTCA cleanup criteria. The soil and groundwater investigation therefore concluded that there were no significant soil or groundwater impacts from metals that may have been associated with the operation of ASTs A or B (Landau Associates 1993a). On September 3, 1997, Ecology accepted the final facility closure certification for the Building 9-101 dangerous waste ASTs (Ecology 1997) (Appendix C).

### 4.6.3 CURRENT STATUS

No further action is required for these SWMUs as Ecology accepted the final facility closure certification for the Building 9-101 dangerous waste ASTs (Ecology 1997).

## 4.7 SWMU-43: STORMWATER SEWER SYSTEM

### 4.7.1 DESCRIPTION OF SWMU

SWMU-43 is the storm water sewer system used to control surface water runoff throughout the BDC facility. There are also floor drains from some of the buildings that enter the stormwater sewer system. Although many of these floor drains have been sealed, some are still in use. Stormwater from areas expected to contain oil passes through oil/water separators (SWMUs-30 through 40) prior to discharge to the stormwater sewer system. There are 16 lines in the stormwater sewer system that discharge to the Duwamish Waterway. There are eleven oil/water separators associated with the stormwater sewer system lines. The stormwater sewer system has been operating since 1956. The sewer system has been modified over the life of the facility (SAIC 1994).

Historically, there have been periodic releases to the stormwater sewer system. In 1986, there were two spills of PS 300 fuel oil that reached the Duwamish Waterway. The first spill occurred in September 1986, when a steam to oil heat exchanger burst, causing oil to spill and enter the stormwater sewer that drained into the Duwamish Waterway. Up to 20 to 30 gal of oil reached the river. Following

cleanup of this spill, the heat exchanger was repaired and its discharge was routed away from the storm sewer. A second spill of 80 gal of PS 300 fuel oil occurred on December 24, 1986. The spill occurred when fuel oil was being transferred from a tank truck to an UST at Building 9-72. The spilled oil entered a storm drain catch basin, which discharged to the river. Contractors cleaned up both of these spills. To contain future spills, Boeing installed curbing around the fill pipes to the tanks and installed oil/water separators on the main stormwater sewer lines. In 1987, there was a 10-gal spill of heat transfer oil from an unspecified location. Approximately 10 percent of this spill reached the storm water sewer system. A spill occurred in 1989 at Building 9-120 of 15,000 gal of 15 percent alkyl trimethylene diamine, a biocide. Most of this spill was recovered; it is unclear if any of it reached the river. In 1992, there was a release of approximately 1 quart of diesel from the diesel tank at Building 9-102, and two releases of water (90 gal in January, and an unknown volume in April) with Dearborn 547 and Steamate from autoclave #4 at Building 9-101. In 1993, there was a spill containing 30 gal of ethylene glycol at Building 9-101, as well as a spill of 4,500 gal of cooling water at Building 9-101. One spill occurred in 1994, when a portion of 75 gal of spilled diesel fuel at Building 9-08 entered a catch basin (SAIC 1994). No information is available regarding any spills since 1994.

### 4.7.2 Summary Of Corrective Action

Boeing is continuously upgrading its training with regards to spill prevention. BMPs have been implemented to prevent future spills. Boeing installed curbing around the fill pipes to the tanks and installed oil/water separators on the main stormwater sewer lines. Boeing produced a video demonstrating practices to protect water quality and the video is used in training on a company-wide basis. Boeing has also marked all storm water catch basins with the phrase "dump no chemicals drains to stream". The signs are black with white lettering and include a fish symbol for added emphasis (Boeing 1998).

### 4.7.3 Current Status

No additional actions are planned with regard to this unit (Boeing 1998). No further action is recommended for SWMU-43.

## 4.8 AOC-01/02: FORMER UNDERGROUND STORAGE TANKS (BLDG 9-52)

### 4.8.1 DESCRIPTION OF AOCS

AOC-01/02 is the location of two former steel USTs (DC-14 and DC-13, respectively) located near Building 9-52, as shown on Figures 9 and 16. The USTs were installed in 1985 and used to store unleaded gasoline in a 500-gal tank (DC-14), and diesel fuel in a 300-gal tank (DC-13). The tanks were part of a fueling station that serviced Boeing vehicles and other motorized equipment (Landau Associates 1993b). A tank tightness test was performed in April 1990 and UST DC-14 (the gasoline tank) was discovered to be leaking, probably as a result of an improperly attached fill pipe. The two USTs were decontaminated, closed, and removed to the ChemPro facility in Tacoma, Washington. After the removal of the USTs, soil was excavated until soil at the base of the excavation met MTCA Method A cleanup criteria. Excavated soil was disposed of at Chem Securities Systems, Inc., Arlington, Oregon. The two USTs were replaced in June 1990 with a 550 gal (DC-18) and 1,100 gal (DC-19) USTs for diesel and unleaded gasoline, respectively (SAIC 1994).

### 4.8.2 SUMMARY OF CORRECTIVE ACTION

Twenty-four soil samples were collected and analyzed for TPH and benzene, toluene, ethylbenzene, and xylenes (BTEX) during and after soil excavation. Soil was removed to a depth of 2 ft below the water table during excavation. Soil concentrations of BTEX at the base of the excavation were below the preliminary soil screening levels. TPH was not detected in the soil samples. Soil analytical results are presented in Table 16.

One groundwater sample was collected from the base of the excavation (Landau 1990b). Free product was not observed on the groundwater but foam was present. The groundwater sample was analyzed for TPH and BTEX. Concentrations of TPH and BTEX in the groundwater sample were below the preliminary groundwater screening levels.

Three groundwater monitoring wells DC-9-52-1 (upgradient) and DC-9-52-2 and DC-9-52-3 (downgradient) were installed up-gradient and down-gradient from the source of the former fuel USTs (Figure 16) (Landau 1993b). A groundwater contour map of the site is presented on Figure 8. The wells were placed in the shallow groundwater depths to evaluate the potential presence of floating product.

The monitoring wells were sampled periodically between February 1991 and November 1995 and approximately annually from May 1997 to June 2001. The samples were analyzed for BTEX, diesel-range petroleum hydrocarbons and gasoline, PCBs, and metals. A summary of groundwater sample results for detected constituents in samples collected since 1998 are presented in Table 17. A complete analytical data summary is provided on the compact disc in Appendix A. Of the detected compounds

(metals, diesel-range petroleum hydrocarbons, toluene, and xylene), only diesel-range petroleum hydrocarbons (in wells DC-9-52-1 and DC-9-52-3) and cadmium and copper (in well DC-9-52-2) have been detected since 1998 at concentrations above the preliminary groundwater screening levels.

Diesel-range petroleum hydrocarbons was detected in wells DC-9-52-1 (2970 μg/L) and DC-9-52-3 (840 μg/L) at concentrations above the preliminary groundwater screening level (500 μg/L) in December 2000. Concentrations of diesel-range petroleum hydrocarbons in these wells decreased to non-detect in December 2001. Detected diesel-range petroleum hydrocarbons concentrations in well DC-9-52-2 have been below the preliminary groundwater screening levels.

Cadmium and copper were detected in one groundwater sample from November 1999 at concentrations (12 and 24 μg/L, respectively). The concentrations of cadmium and copper in this sample were less than two times the marine water preliminary screening level (9 μg/L) and twelve times the fresh water preliminary screening level (1 μg/L). The concentration of copper in this sample was seven times the marine water preliminary screening level (3.4 μg/L) and 2.7 times the fresh water preliminary screening level (8.9 μg/L).

### 4.8.3 CURRENT STATUS

The three monitoring wells will be sampled biannually (during wet and dry seasons) until two consecutive monitoring events are obtained without detections of gasoline-range petroleum hydrocarbons, diesel-range petroleum hydrocarbons, and BTEX (Boeing 2001).

## 4.9 AOC-03/04: FORMER UNDERGROUND STORAGE TANKS (BLDG 9-50)

### 4.9.1 DESCRIPTION OF AOCS

AOC-03/04 is the location of two 20,000-gal double wall composite USTs (DC-20 and DC-21), located near Buildings 9-50 and 9-72 (Figures 9 and 14). The original USTs, both 20,000-gal, (DC-03 and DC-04) were installed in 1957 and were used to store No. 5 fuel oil used by a steam plant in Building 9-50. A 1985 evaluation of soil conditions outside of the two original USTs did not provide any evidence of a release of petroleum hydrocarbons (Norton Corrosion Limited, Inc. 1985). However, in 1991 when tank tightness testing was conducted, the westernmost UST was discovered to be leaking. Both USTs were removed and replaced with two new 20,000-gal tanks in 1992 (Landau Associates 1993c).

### 4.9.2 SUMMARY OF CORRECTIVE ACTION

After removal of USTs DC-03 and DC-04, several holes were noted near the bottom of both former USTs. During the USTs removal, approximately 250 $yd^3$ of petroleum hydrocarbon contaminated soil and 200 to 500 gal of free phase hydrocarbon product were removed from the excavation. The soil was shipped to Woodworth & Company, Inc., Tacoma, Washington for thermal desorption treatment. The free hydrocarbon product was sent offsite to a licensed facility for proper treatment/disposal/recycling. Approximately 80,000 gal of water were generated during remediation. Excess water was pumped to a temporary onsite holding tank, then trucked either to Burlington Environmental's treatment facility at Pier 91 and/or Boeing's wastewater treatment plant in Auburn.

After excavation, a small area of soil (approximately 10 by 20 ft and unknown depth) remained at the base of the excavation with concentrations of petroleum hydrocarbon above the preliminary soil screening level. The soil was not excavated because it was beyond the reach of the excavating equipment, it was beneath the water table, and the affected area was relatively small (Landau Associates 1993c). No further soil removal was necessary due to the relative immobility of the fuel oil (Boeing 2001). Detected analytical results for soil samples are presented in Table 18.

In 1992, a monitoring well (MW-21A) was installed nearby the two former USTs, and the soil and groundwater were sampled for TPH. No TPH was detected in the soil or groundwater at that time (Landau Associates 1993c). The well has been sampled approximately biannually since 1997 and the groundwater samples analyzed for VOCs and diesel-range petroleum hydrocarbons. In June 2001, monitoring well MW-21C was installed within the C-Zone interval to evaluate benzene concentrations that have been detected at this depth interval in nearby SWMU-20 wells. MW-21C was sampled in June 2001 and analyzed for VOCs and diesel-range petroleum hydrocarbons. Analytical results for detected constituents in groundwater samples are presented in Table 19. A complete analytical data summary is provided on the compact disc in Appendix A.

Of the detected analytes (acetone, DCE, and diesel-range petroleum hydrocarbons), only diesel-range petroleum hydrocarbons was detected above the preliminary groundwater screening levels. Acetone (October 1998) and cis-1,2-DCE (June 2001) were detected at low levels in MW-21A and MW-21C, respectively. These analytes have not been detected during the remainder of the monitoring period. Diesel-range petroleum hydrocarbon was detected at a concentration above the preliminary groundwater screening level in MW-21A in December 2000. Concentrations of diesel-range petroleum hydrocarbons were non-detect in MW-21A and MW-21C in December 2001.

### 4.9.3 CURRENT STATUS

The two monitoring wells will be sampled semi-annually until four consecutive groundwater samples are obtained that are non-detect for diesel-range petroleum hydrocarbons (Boeing 2001).

## 4.10 AOC-05: FORMER UNDERGROUND STORAGE TANK

### 4.10.1 DESCRIPTION OF AOC

AOC-05 was a 1,000 gal unleaded gasoline steel UST (DC-01) located south of Buildings 9-60 and 9-61 (Figures 9 and 10). The UST was removed in 1985 after approximately 830 gal of unleaded gasoline leaked out of a puncture in the UST. The leak resulted from damage to the tank bottom from the practice of measuring product volume with a steel rod.

### 4.10.2 SUMMARY OF CORRECTIVE ACTION

During the UST removal, 500 to 600 gal of floating product was removed from the excavation. Additional gasoline contamination was removed within the excavated soils (Boeing 2001). Two monitoring wells (BDC-01-1 and BDC-01-2) were installed in early September 1985. Groundwater samples were collected from the two monitoring wells in July 1986. Benzene was detected in BDC-01-1, located west of the former UST.

Ecology requested Boeing to further investigate this area for gasoline-range petroleum hydrocarbons and BTEX (Ecology 2000). During January 2001, limited push-probe sampling was performed around AOC-05. Six borings were advanced in the vicinity of the former UST DC-01 (Figure 17) (IT Corporation 2001). Two groundwater samples were collected from each boring. One groundwater sample from each boring was collected from 0.5 to 3.5 ft below the top of the water table. The other groundwater sample from each boring was collected from 10.5 to 13.5 ft below the top of the water table. Groundwater samples were analyzed for gasoline-range petroleum hydrocarbons and BTEX. Analytical results are presented in Table 20. Of the detected compounds (gasoline-range petroleum hydrocarbons and BTEX), only gasoline-range petroleum hydrocarbons and benzene were detected at concentrations above the preliminary groundwater screening levels. Samples SB-9 upper and SB-10 upper contained concentrations of gasoline-range petroleum hydrocarbons above the preliminary groundwater screening level. Sample SB-9 upper also contained benzene at a concentration above the preliminary groundwater screening level.

Three monitoring wells were installed in June 2001. One well was upgradient of SB-9 and SB-10 (BDC-103) and two wells were downgradient (BDC-101 and BDC-102). The wells were sampled and

analyzed for gasoline-range petroleum hydrocarbons and BTEX in June 2001. BTEX results for BDC-102 and BDC-103 are presented in Table 21. Benzene was detected at a concentration above the preliminary groundwater screening level in well BDC-103. Gasoline-range petroleum hydrocarbon was detected above the preliminary groundwater screening level in BDC-101 and BDC-103.

### 4.10.3 CURRENT STATUS

The groundwater at AOC-05 will be injected with oxygen releasing compound (ORC®) to promote aerobic biodegradation or the residual petroleum hydrocarbon constituents in the groundwater. Up to 10 borings will be installed to a total depth of approximately 20 ft BGS for injection of ORC® into the groundwater in the vicinity of the former UST. ORC® will be injected in a slurry form into the portion of the boring intersecting the groundwater table.

Following the injection event, the effect of the ORC® in the groundwater will be monitored on a monthly basis for the following 3 months. Groundwater samples will be collected from BDC-102 and BDC-103 for analysis of dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, and pH in the field. The groundwater samples will also be submitted to a laboratory for analysis of BTEX and gasoline-range petroleum hydrocarbons.

Following the ORC® evaluation, the three wells will be monitored quarterly for BTEX and gasoline-range petroleum hydrocarbons for one year. Then the wells will be monitored semi-annually for BTEX and gasoline-range petroleum hydrocarbons.

# 5.0 SUMMARY OF CORRECTIVE ACTIONS

The RFA of the BDC identified 157 SWMUs and 5 AOCs. The majority of the SWMUs were excluded from further investigation based on a determination that they do not pose a threat to human health or the environment (Table 1). The remaining eight SWMUs and five AOCs through Ecology's voluntary cleanup program under MTCA. The status of these SWMUs/AOCs is summarized below:

| SWMU/AOC | Status | Rationale |
|---|---|---|
| SWMU-15, paper shredder, Building 9-67 | No Further Action Recommended | The release of paper slurry waste noted was a one-time release of a non-hazardous material. Modifications to the BMPs have been implemented to prevent future releases. |
| SWMU-16, former regulated materials storage area, Buildings 9-69/70 | No Further Actions Recommended | Ecology approved the RCRA closure of the former Building 9-69/70 Container Storage Area. Boeing performed a supplemental investigation to verify that residual PCB concentrations in soil in the area beyond the boundaries for the former storage area are protective of groundwater. PCBs were not detected in groundwater samples collected during this investigation. |
| SWMU-17, former sump and USTs, Building 9-75 | Groundwater Monitoring | No current observed constituent concentrations in soil or groundwater exceed preliminary screening levels (VOCs) or apparent background levels (metals). Monitoring wells (BDC-05-2A, BDC-05-3, BDC-05-4, BDC-05-5, and BDC-05-7) are currently sampled semi-annually for VOCs, diesel-range petroleum hydrocarbons, and metals as specified in the Developmental Center Groundwater Monitoring Plan (Boeing 2001). |
| SWMU-20, former degreaser pit, Building 9-101 | Evaluating pump and treat system shutdown with ongoing monitoring | The remediation system has been temporarily shut down for a period of six months. Following shutdown of the remediation system, sampling will be conducted, and the results will be evaluated to determine if natural attenuation appears to be a viable remedial alternative to reach site screening levels. The groundwater monitoring wells associated with SWMU-20 will be sampled for VOCs biannually, typically during summer and winter (Boeing 2001). |
| SWMUs-23 through 25, former waste water ASTs, Building 9-101 | No Further Actions Recommended | Ecology has accepted the final facility closure certification for these former dangerous waste ASTs (Ecology 1997). |

| SWMU/AOC | Status | Rationale |
|---|---|---|
| SWMU-43, storm water sewer system | No Further Actions Recommended | BMPs have been implemented to prevent future spills. |
| AOC-01/02, former unleaded gasoline USTs, Building 9-52 | Groundwater Monitoring | Three monitoring wells will be sampled biannually (during wet and dry seasons) until two consecutive monitoring events are obtained without detections of gasoline-range petroleum hydrocarbons, diesel-range petroleum hydrocarbons, and BTEX (Boeing 2001). |
| AOC-03/04, former No. 5 fuel oil USTs, Buildings 9-50 and 9-72 | Groundwater Monitoring | Two monitoring wells will be sampled semi-annually until four consecutive groundwater samples are obtained that are non-detect for diesel-range petroleum hydrocarbons (Boeing 2001). |
| AOC-05, former unleaded gasoline UST, Buildings 9-60 and 9-61 | Groundwater Monitoring | ORC® will be injected into groundwater to promote aerobic biodegradation of residual petroleum hydrocarbon constituents in groundwater. Groundwater samples will be collected monthly for three months following ORC® injection for BTEX and gas-range petroleum hydrocarbons. |

# 6.0 USE OF THIS REPORT

This investigation summary report has been prepared for the exclusive use of The Boeing Company for specific application to the Boeing Developmental Center. 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 and 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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By:

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JPB/ SMD/jzs

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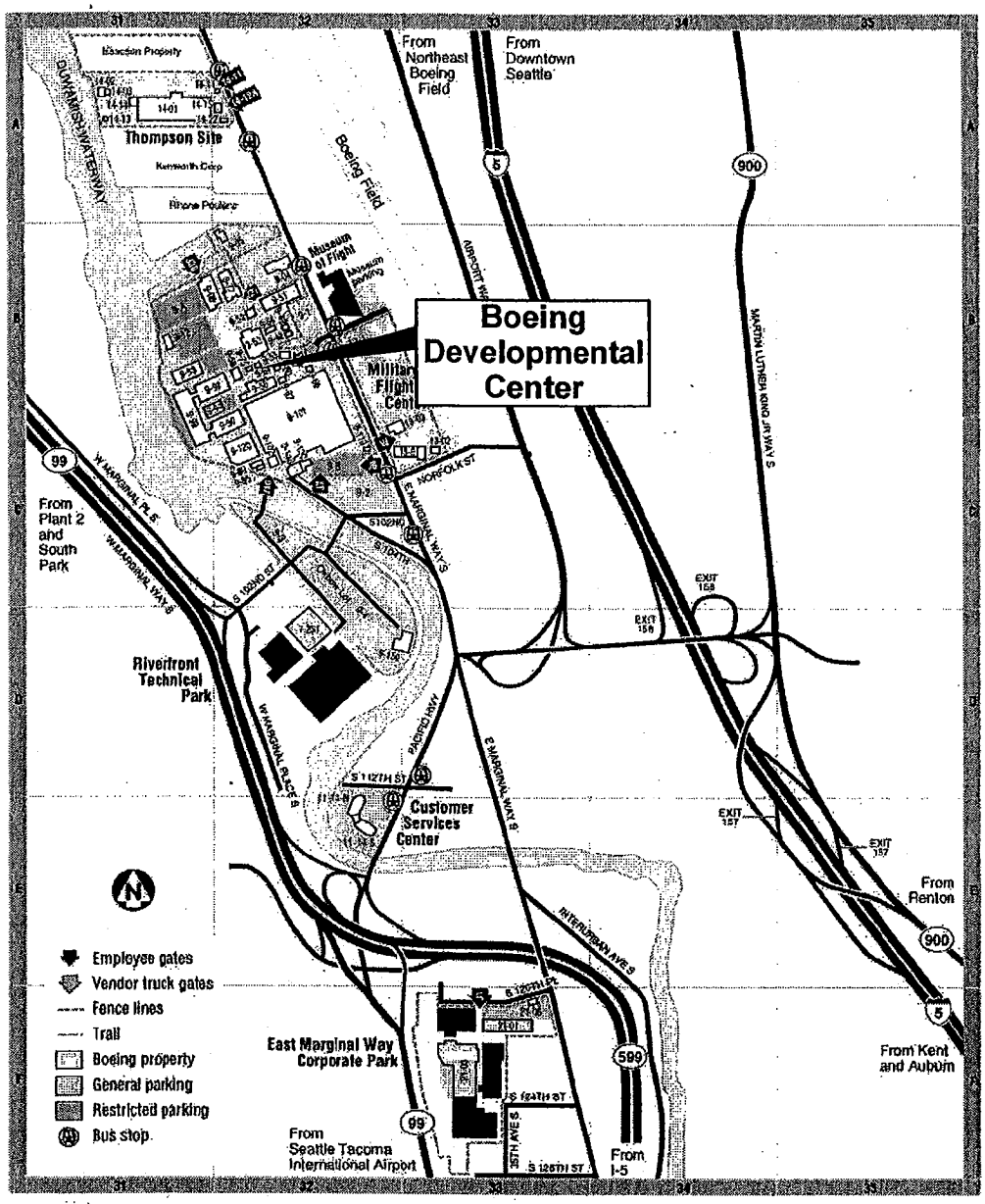
9725 East Marginal Way South, Seattle, WA 98108




Map provided by Boeing, March 2000

**Not To Scale**

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Landau Associates

| Boeing Developmental Center<br>Seattle, Washington | **Location Map** | Figure<br>1 |
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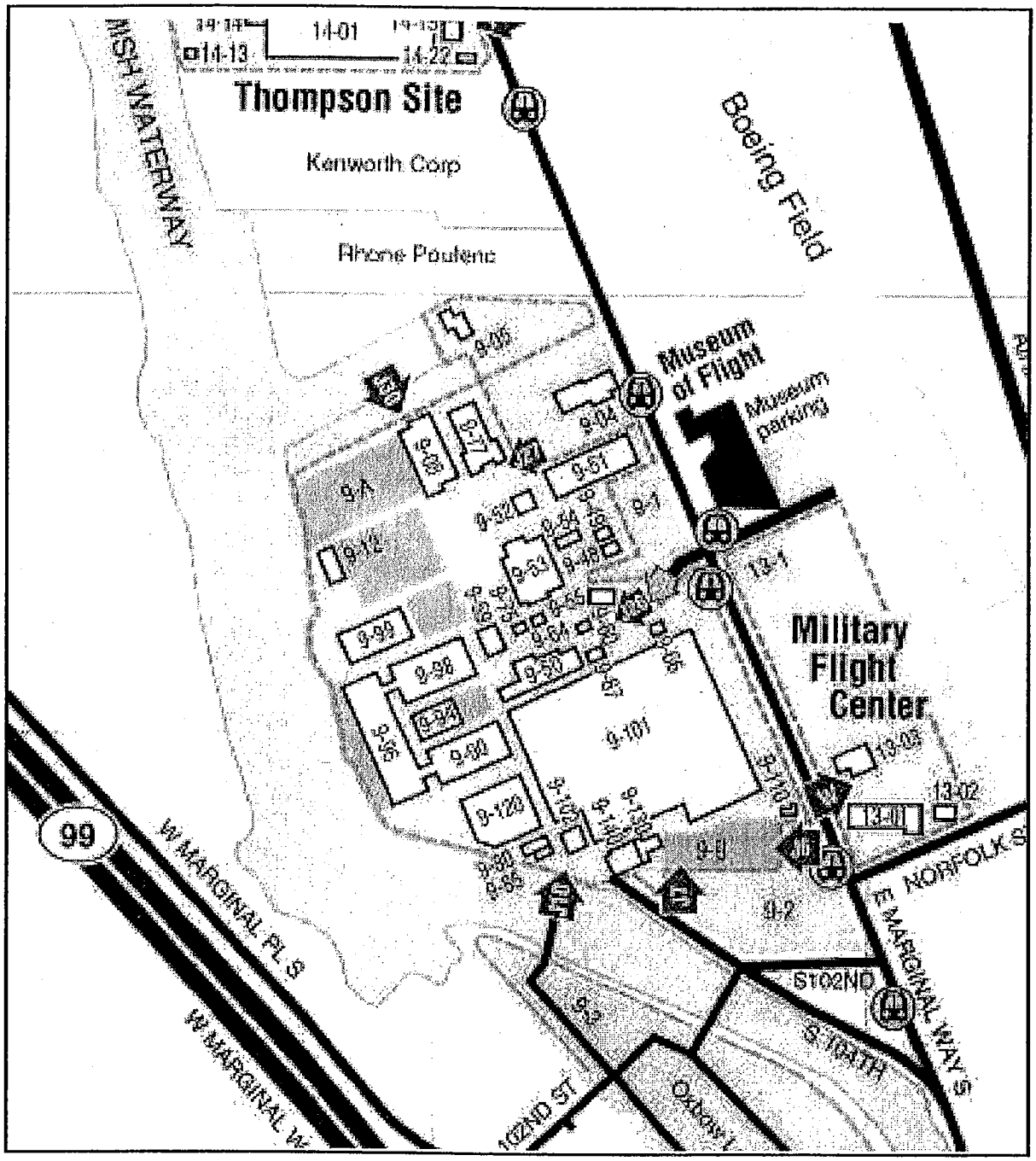


Map provided by Boeing, March 2000

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| Boeing Developmental Center<br>Seattle, Washington | **Adjacent Land Use** | Figure<br>3 |
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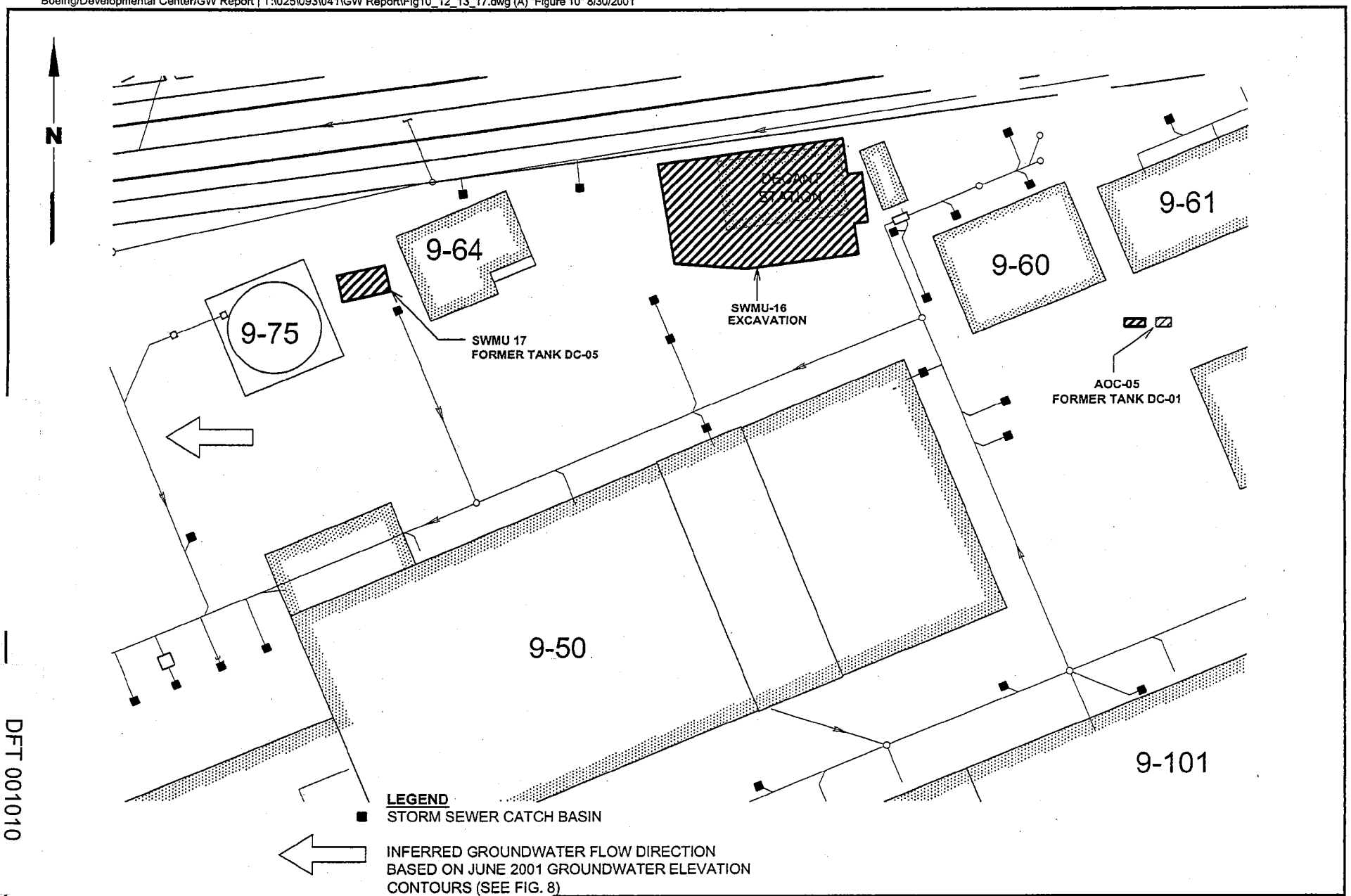


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Boeing Developmental Center
Tukwila, Washington

**SWMU-16, SWMU-17, and AOC-05 Location Map**

Figure 10

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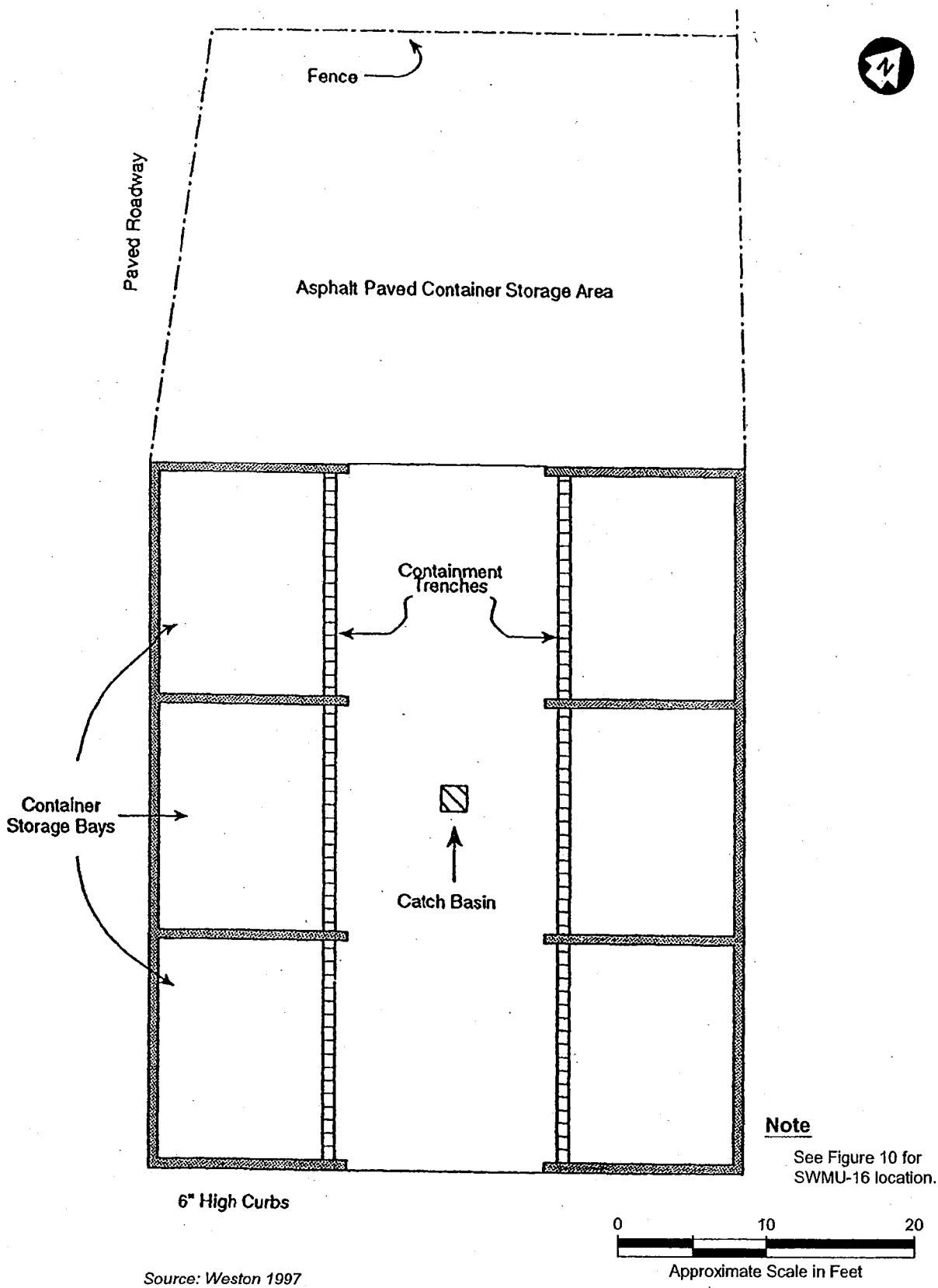


*Source: Weston 1997*

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Boeing Developmental Center
Tukwila, Washington

**SWMU-16 Former Container Storage Area Layout**

Figure 11

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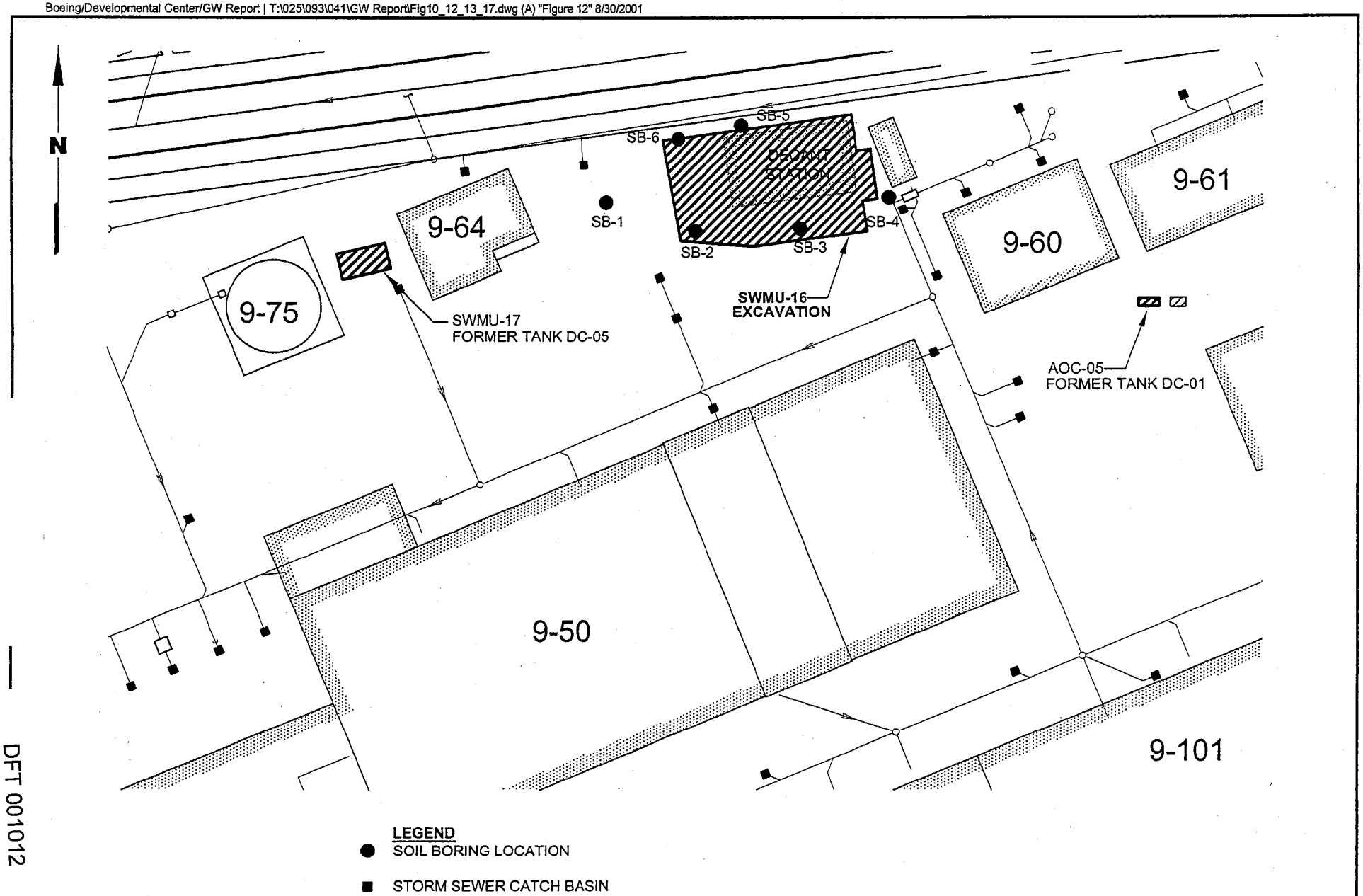


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Scale in Feet

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**SWMU-16 Details**

Figure
12

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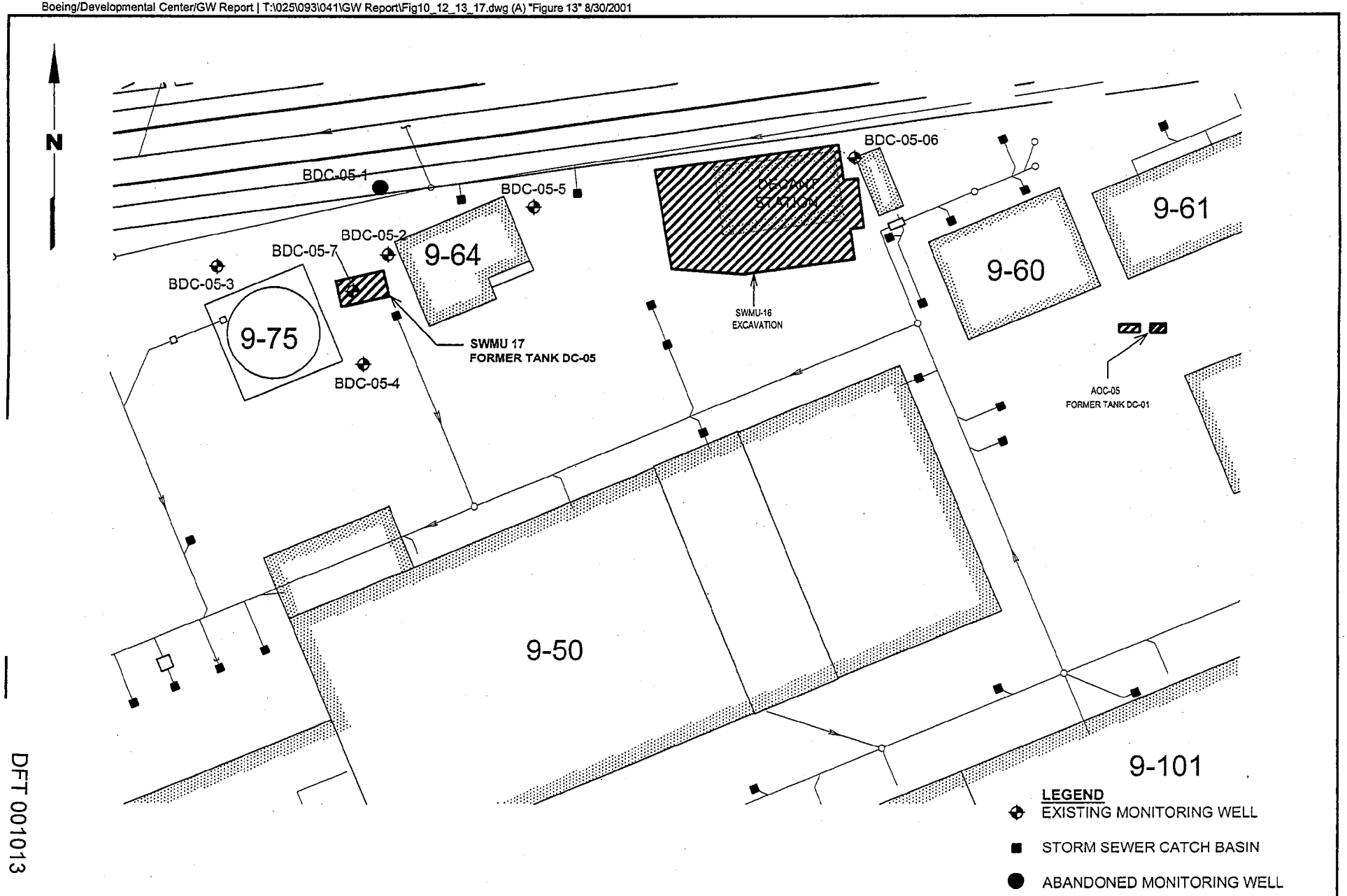


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Scale in Feet

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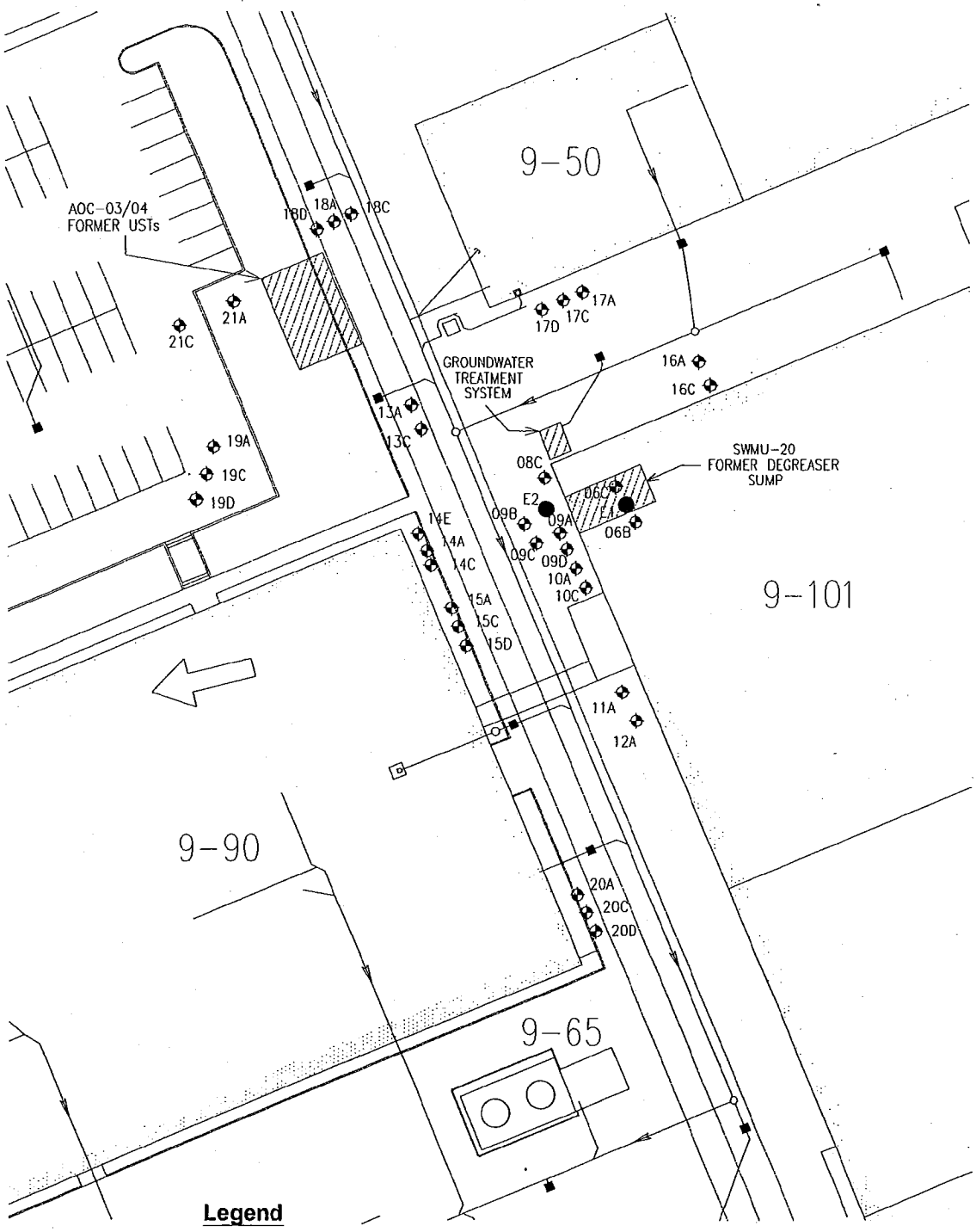
**SWMU-17 DETAILS**

Figure 13

DFT 001013




**Legend**

Monitoring Well

Extraction Well

Inferred Groundwater Flow Direction
Based on June 2001 Groundwater Elevation
Contours (See Figure 8)

0 60 120
Scale in Feet

Boeing/Developmental Center/GW Report | T:\025\093\0441\GW Report\Fig14.dwg (A) "Figure 14" 8/24/2001

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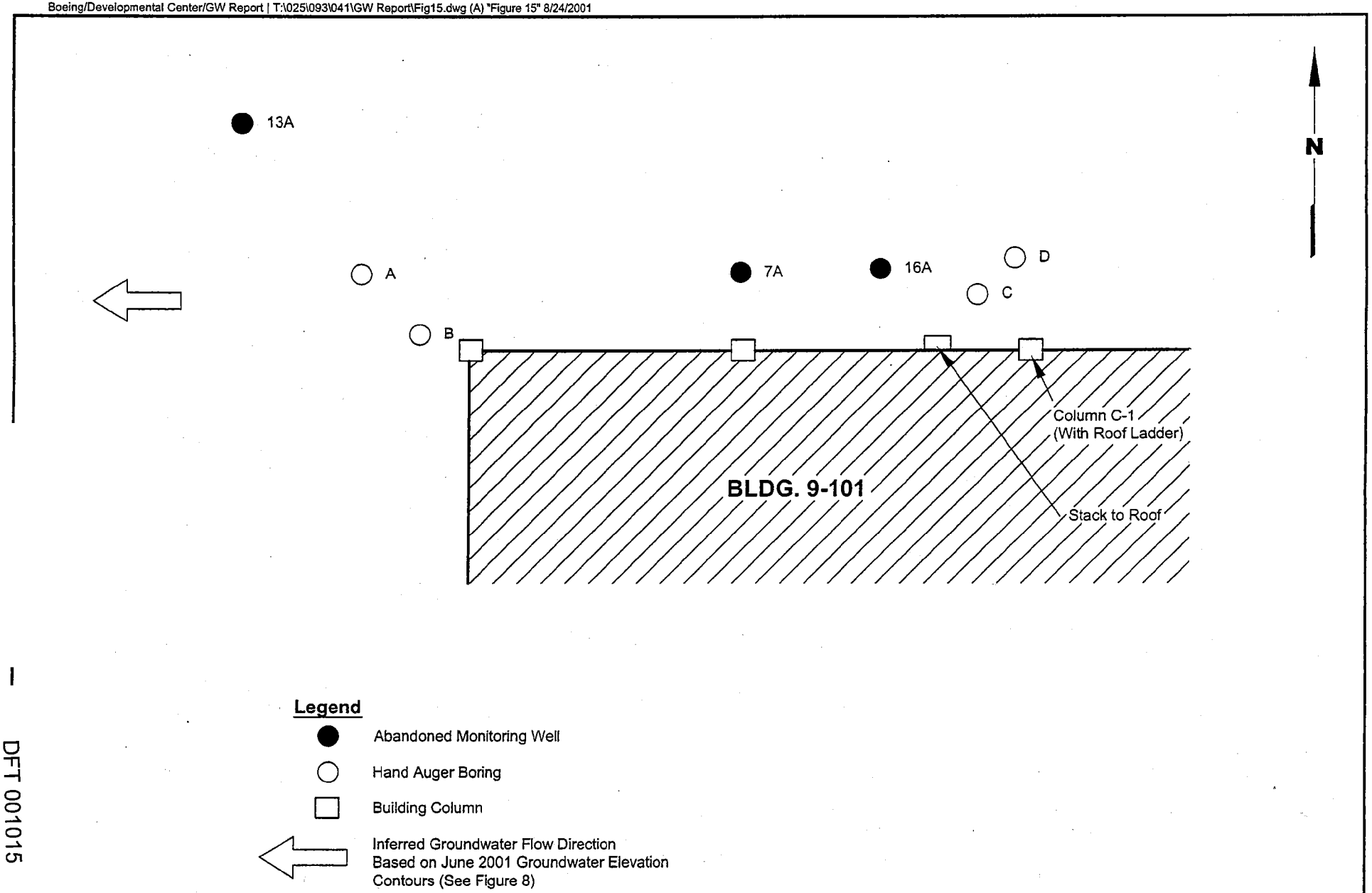
Boeing Developmental Center
Tukwila, Washington

**SWMU-20 and AOC-03/04**
**Location & Details Map**

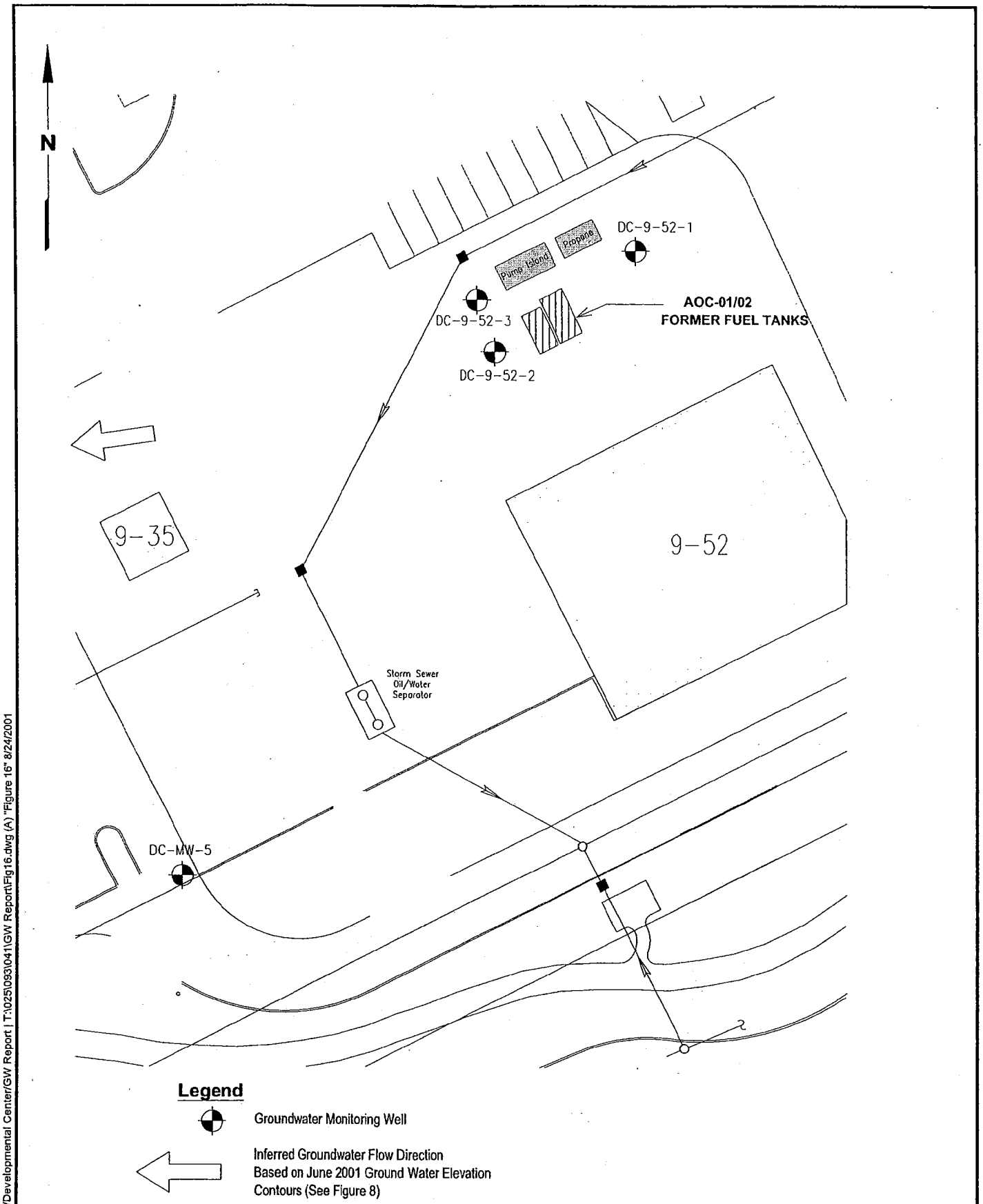
Figure
14

DFT 001014




Landau Associates

| Boeing Developmental Center<br>Tukwila, Washington | SWMU-23 & 25 Details | Figure<br>15 |
|---|---|---|




Boeing/Developmental Center/GW Report | T:\025\093\041\GW Report\Fig16.dwg (A) "Figure 16" 8/24/2001

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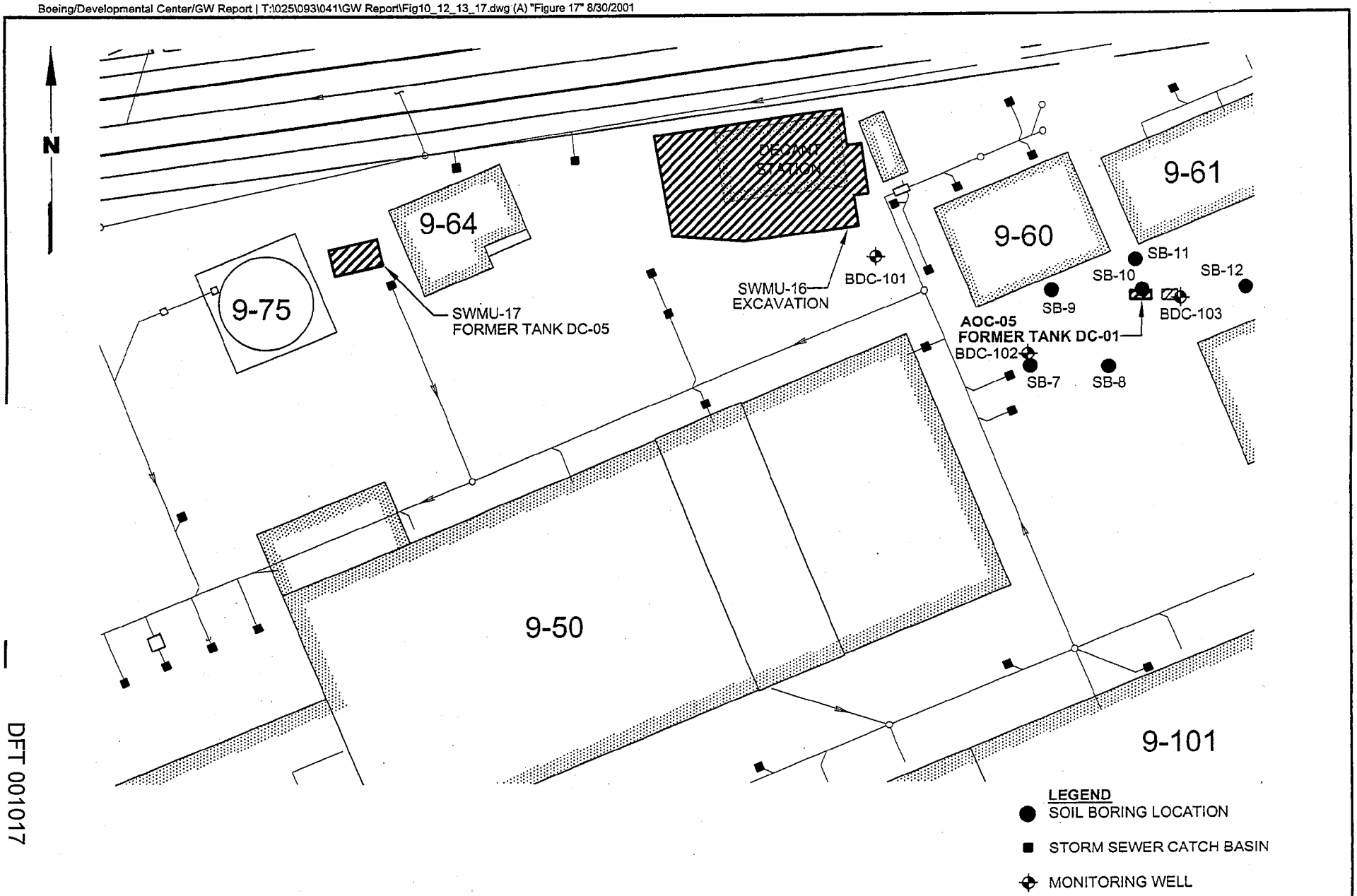
Boeing Developmental Center
Tukwila, Washington

**AOC-01/02 Location & Details Map**

Figure
16

Boeing/Developmental Center/GW Report | T:\025\093\041\GW Report\Fig10_12_13_17.dwg (A) "Figure 17" 8/30/2001




0 60 120
Scale in Feet

Landau Associates

| Boeing Developmental Center<br>Tukwila, Washington | **AOC-05 Details** | Figure<br>17 |
|---|---|---|

DFT 001017

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-1 | Bldg 9-04, Final Accumulation Area | SWMU-1 was the final accumulation point for drums of hazardous waste from BDC prior to being shipped offsite for disposal. Wastes were removed every other week for offsite disposal. SWMU-1 had secondary containment with a sealed concrete floor that drained to blind trenches or containment vaults. SWMU-1 operated from March 1992 to July 2001. The final accumulation point was moved to Building 9-60 in July 2001. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-2 | Bldg 9-04, Consolidation Room | SWMU-2 was the accumulation and consolidation area for solid wastes, including rags, spent aerosol cans, and used batteries. Wastes were placed in plastic bag lined-drums. Once filled, drums were transported to SWMU-1 for offsite disposal. SWMU-2 had secondary containment with a floor that drains to a containment vault. SWMU-2 operated from March 1992 to July 2001. The consolidation area was moved to Building 9-60 in July 2001. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-3 | Bldg 9-04, Loading Dock | SWMU-3 is a loading dock that was used to ship off containerized waste from SWMU-1. SWMU-3 operated from March 1992 to July 2001. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-4 | Bldg 9-04, Bulk Waste Oil Recycling Tank | SWMU-4 is a 500 gal AST for storing waste oil prior to removal offsite for recycling. The AST has secondary containment with blind trenches with closed sumps located beneath it. SWMU-4 has been in operation from February 1994 to July 2001 at this location. The tank was moved to Building 9-60 in July 2001. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-5 | Bldg 9-08, Former Temporary Incinerator | SWMU-5 was an incinerator used to destroy classified microfilm and mylar prints. The non-hazardous ash was disposed of at an off site landfill. SWMU-5 operated from 1986 to 1988. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-6 | Bldg 9-50, Former Container Storage Area | SWMU-6 was the final accumulation point for hazardous wastes from BDC prior to being shipped offsite for disposal. SWMU-6 operated from 1988 to 1992 and has been closed. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix C). |
| SWMU-7 | Bldg 9-50, Former Steam Cleaning Area | SWMU-7 was a 5 to 7 gal sludge trap. The sludge trap removed grease from the steam cleaning waste water. SWMU-7 operated prior to 1985. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-8 | Bldg 9-50, Solid Waste Collection Area | SWMU-8 is the accumulation and consolidation area for non-hazardous solid wastes prior to being shipped offsite for recyling or disposal. SWMU-8 had been in operation from 1957 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-9 | Bldg 9-51, Steam Cleaning Tank | SWMU-9 is a 3000 gal AST for steam cleaning waste water. Steam cleaning waste water is pumped from SWMU-10 to SWMU-9, where it is stored prior to disposal. The AST has diked steel secondary containment. SWMU-9 has been in operation from 1987 to present. | No further action recommended based on low potential for future releases (SAIC 1994 and EPA 1994). |
| SWMU-10 | Bldg 9-51, Steam Cleaning Sump | SWMU-10 is a sump used to collect steam cleaning waste water prior to pumping it to SWMU-9. The sump has secondary containment with a leak detection system. SWMU-10 has been in operation from 1985 to present. | No further action recommended based on low potential for future releases (SAIC 1994 and EPA 1994). |

DFT 001018

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-11 | Bldg 9-51, Former Steam Cleaning Tank | SWMU-11 was a 300 gal UST used for storing steam cleaning waste water prior to offsite disposal. SWMU-11 operated from 1985 to 1987. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-12 | Bldg 9-52, Former Wash Water Paint Booth | SWMU-12 was a water wash paint booth used to remove paint overspray from the air. SWMU-12 operated from 1985 to 1990 or 1991. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-13 | Bldg 9-60, Former Container Storage Area | SWMU-13 was an accumulation area for hazardous waste prior to being shipped offsite for disposal. SWMU-13 operated from 1961 to 1992 and has been closed. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix D). |
| SWMU-14 | Bldg 9-67, Incinerator | SWMU-14 is an incinerator used to destroy classified microfilm, mylar, and computer disks. Non-hazardous ash is disposed of offsite. SWMU-14 has been in operation from 1988 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-15 | Bldg 9-67, Paper Shredder | SWMU-15 is two adjacent paper shredders used to destroy classified documents. The shredded paper is slurried with water to facilitate the management and consolidation of the shredded paper. SWMU-15 has been in operation from 1984 to present. A release of paper slurry waste water (a non-hazardous solid waste) occurred on June 30, 1994. More information on SWMU-15 is presented in Section 4.2. | Best management practices (BMPs) have been implemented at SWMU-15 to prevent future releases. No additional actions are planned. No further action is recommended. |
| SWMU-16 | Bldg 9-69/9-70, Former Regulated Materials Storage Area | SWMU-16 was an accumulation point for hazardous waste. SWMU-16 operated from 1979 to 1992 and has been closed. More information on SWMU-16 is presented in Section 4.3. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix D). |
| SWMU-17 | Bldg 9-75, Former UST Waste Storage Tank | SWMU-17 was a 65 gal sump and associated 4000 gal UST used to store waste oil. SWMU-17 operated from 1958 to 1986 and has been closed. The UST was closed and removed in 1986. During closure it was observed that the UST had leaked. More information on SWMU-17 is presented in Section 4.4. | The 5 monitoring wells around SWMU-17 will be sampled biannually for VOCs, metals, and TPH biannually (Boeing 2001). |
| SWMU-18 | Bldg 9-101, Former Wash Water Paint Booth | SWMU-18 was a water wash paint booth used to remove paint overspray from the air. SWMU-18 operated from 1984 to 1990 or 1991. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-19 | Bldg 9-101, Waste Hydraulic Oil Tank | SWMU-19 is a 250 gal AST used to store waste hydraulic oil prior to being transported to SWMU-4. SWMU-19 has been in operation from 1980 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-20 | Bldg 9-101, Former Degreaser Pit | SWMU-20 was a degreaser pit used to accumulate solvents from the vapor degreaser. SWMU-20 operated from 1958 to 1984 and is currently undergoing closure. The degreaser pit apparently leaked. During closure 1400 tons of soil was excavated and disposed of from SWMU-20. A pump and treat system was installed to remove chlorinated VOCs from the groundwater. More information on SWMU-20 is presented in Section 4.5. | The remediation system has been temporarily shut down for six months (Ecology 2001b). Following shutdown of the remediation system, sampling will be conducted, and the results will be evaluated to determine if natural attenuation appears to be a viable remedial alternative to reach site screening levels. The groundwater monitoring wells associated with SWMU-20 will be sampled for VOCs biannually, typically during summer and winter (Boeing 2001). |
| SWMU-21 | Bldg 9-101, Former First Sump | SWMU-21 was a sump used to accumulate waste water from the anodizing tank line prior to discharge to the sanitary sewer or SWMUs-23 through 25. SWMU-21 operated from 1958 to 1984. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-22 | Bldg 9-101, Former Second Sump | SWMU-22 was a sump used to accumulate waste water from the anodizing tank line prior to discharge to the sanitary sewer or SWMUs-23 through 25. SWMU-22 operated from 1967 to 1984. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001019

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-23 | Bldg 9-101, Former Tank A Waste Alkaline | SWMU-23 was a 3000 gal AST used to store waste alkaline water prior to disposal. SWMU-23 operated from 1957 to 1984. The AST was closed and removed from the site in 1985. Chemical concentrations in soil and groundwater samples collected in 1993 were below the MTCA Method A and C cleanup criteria. More information on SWMU-23 is presented in Section 4.6. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix C). |
| SWMU-24 | Bldg 9-101, Former Tank B Waste Acid | SWMU-24 was a 2000 gal AST used to store waste acid water prior to disposal. SWMU-24 operated from 1957 to 1984. The AST was closed and removed from the site in 1985. Chemical concentrations in soil and groundwater samples collected in 1993 were below the MTCA Method A and C cleanup criteria. More information on SWMU-24 is presented in Section 4.6. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix C). |
| SWMU-25 | Bldg 9-101, Former Tank C Waste Water | SWMU-25 was a 10,000 gal AST used to store water water prior to disposal. SWMU-25 operated from 1957 to 1984. The AST was closed and removed from the site in 1985. Chemical concentrations in soil and groundwater samples collected in 1993 were below the MTCA Method A and C cleanup criteria. More information on SWMU-25 is presented in Section 4.6. | No further action required based closure in accordance with RCRA closure requirements and Ecology's approval of closure in a 1997 letter from Ecology (Appendix C). |
| SWMU-26 | Bldg 9-101, Former Pilot Plating Sump | SWMU-26 was a 3000 gal UST used for storage of waste water from the titanium chem mill and metal plating line prior to pumping to SWMU-28. SWMU-26 operated from 1966 to the early 1970s. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-27 | Bldg 9-101, Former Maskant Dump Tank and Control Pit | SWMU-27 was the sumps associated with SWMU-26 and the chem mill and metal plating line. SWMU-27 operated from 1966 to the early 1970s. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-28 | Bldg 9-101, Former Waste Water Treatment Plant | SWMU-28 was the waste water treatment plant for the chem mill and plating lines. SWMU-28 operated from 1966 to the early 1970s. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-29 | Bldg 9-99, Oil/ Water Separator | SWMU-29 is the oil/water separator for potential spills from Building 9-99. Once a year, the oil/water separator is cleaned out and the wastes are disposed of off site. SWMU-29 has been in operation from 1968 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-30 | Bldg 9-007, Oil/ Water Separator 3 | SWMU-30 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-30 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-31 | Bldg 9-08, Oil/ Water Separator 2 | SWMU-31 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-31 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-32 | Bldg 9-12, Oil/ Water Separator 1 | SWMU-32 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-32 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-33 | Bldg 9-51, Oil/ Water Separator 951 | SWMU-33 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-33 has been in operation from 1985 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-34 | Bldg 9-52, Oil/ Water Separator DM | SWMU-34 is an oil/water separator used to collect fuel station spills and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-34 has been in operation from 1985 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-35 | Bldg 9-60, Oil/ Water Separator BMA003 | SWMU-35 is an oil/water separator used to collect storm water from the storage yard at the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-35 has been in operation from 1961 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-36 | Bldg 9-96, Oil/ Water Separator C | SWMU-36 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-36 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-37 | Bldg 9-99, Oil/ Water Separator A | SWMU-37 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-37 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-38 | Bldg 9-99, Oil/ Water Separator B | SWMU-38 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-38 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-39 | Bldg 9-101, Oil/ Water Separator SDC | SWMU-39 is an oil/water separator used to collect storm water from a parking lot in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-39 has been in operation from 1987 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-40 | Bldg 9-120, Oil/ Water Separator G | SWMU-40 is an oil/water separator used to collect storm water from a parking lot and an autoclave in the BDC and remove oil from the water prior to discharge to the Duwamish Waterway. SWMU-40 has been in operation from 1990 to present. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-41 | Bldg 9-64, Former Oil/ Water Separator | SWMU-41 was a 500 gal oil/water separator used to collect steam cleaning waste water and remove oil prior to discharge to the sanitary sewer. The oil/water separator was periodically cleaned and the waste was disposed of off site. SWMU-41 operated from 1979 to 1987. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-42 | Bldg 9-101, Former Oil/ Water Separator | SWMU-42 was a 500 gal oil/water separator used to collect process water from Building 9-101 and remove oil from the water prior to discharge. The oil/water separator was periodically cleaned and the waste was disposed of offsite. SWMU-42 operated from an unknown time to 1987. | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-43 | Storm Water Sewer System | SWMU-43 is the storm water sewer system. It is used to control surface water runoff and some building drains throughout the BDC. SWMUs 30 through 40 discharge into SWMU-43. Sixteen lines in the storm water sewer system discharge into the Duwamish Waterway. SWMU-43 has been in operation from 1956 to present. More information on SWMU-43 is presented in Section 4.7. | BMPs have been implemented to reduce the potential for future release. No further action recommended based on low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001021

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-44 | Bldg 9-49, Accumulation Area D003 | SWMU-44 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and batteries. The waste is sent to SWMU-2 for consolidation. SWMU-44 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-45 | Bldg 9-51, Accumulation Area D004 | SWMU-45 is an accumulation station for hazardous or dangerous waste including oily rags, aerosol cans, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-45 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-46 | Bldg 9-52, Accumulation Area D005 | SWMU-46 is an accumulation station for hazardous or dangerous waste including solvent rags, aerosol cans, paints, and inks. The waste is sent to SWMU-2 for consolidation. SWMU-46 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-47 | Bldg 9-99, Accumulation Area D007 | SWMU-47 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, paints, inks, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-47 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-48 | Bldg 9-99, Accumulation Area D008 | SWMU-48 is an accumulation station for hazardous or dangerous waste including oily rags. The waste is sent to SWMU-2 for consolidation. SWMU-48 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-49 | Bldg 9-101, Accumulation Area D009 | SWMU-49 is an accumulation station for hazardous or dangerous waste including solvent rags, aerosol cans, paints, and inks. The waste is sent to SWMU-2 for consolidation. SWMU-49 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-50 | Bldg 9-101, Accumulation Area D010 | SWMU-50 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-50 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-51 | Bldg 9-101, Accumulation Area D011 | SWMU-51 is an accumulation station for hazardous or dangerous waste including oil for recycling. The waste is sent to SWMU-4 for consolidation. SWMU-51 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-52 | Bldg 9-101, Accumulation Area D012 | SWMU-52 is an accumulation station for hazardous or dangerous waste including oily rags and solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-52 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-53 | Bldg 9-101, Accumulation Area D013 | SWMU-53 is an accumulation station for hazardous or dangerous waste including oily rags. The waste is sent to SWMU-2 for consolidation. SWMU-53 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001022

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-54 | Bldg 9-101, Accumulation Area D014 | SWMU-54 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and alodine rags. The waste is sent to SWMU-2 for consolidation. SWMU-54 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-55 | Bldg 9-101, Accumulation Area D016 | SWMU-55 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, and aerosol cans. The waste is sent to SWMU-2 for consolidation. SWMU-55 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-56 | Bldg 9-101, Accumulation Area D017 | SWMU-56 is an accumulation station for hazardous or dangerous waste including solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-56 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-57 | Bldg 9-101, Accumulation Area D019 | SWMU-57 is an accumulation station for hazardous or dangerous waste including solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-57 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-58 | Bldg 9-101, Accumulation Area D020 | SWMU-58 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, and aerosol cans. The waste is sent to SWMU-2 for consolidation. SWMU-58 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-59 | Bldg 9-101, Accumulation Area D021 | SWMU-59 is an accumulation station for hazardous or dangerous waste including solvent rags, aerosol cans, paints, and inks. The waste is sent to SWMU-2 for consolidation. SWMU-59 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-60 | Bldg 9-101.2, Accumulation Area D024 | SWMU-60 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, batteries, paints, inks, and alodine rags. The waste is sent to SWMU-2 for consolidation. SWMU-60 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-61 | Bldg 9-101.2, Accumulation Area D025 | SWMU-61 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-61 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-62 | Bldg 9-102, Accumulation Area D027 | SWMU-62 is an accumulation station for hazardous or dangerous waste including oil for recycling. The waste is sent to SWMU-4 for consolidation. SWMU-62 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-63 | Bldg 9-120, Accumulation Area D028 | SWMU-63 is an accumulation station for hazardous or dangerous waste including oily rags. The waste is sent to SWMU-2 for consolidation. SWMU-63 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-64 | Bldg 9-120.1, Accumulation Area D029 | SWMU-64 is an accumulation station for hazardous or dangerous waste including oil for recycling. The waste is sent to SWMU-4 for consolidation. SWMU-64 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-65 | Bldg 9-120, Accumulation Area D031 | SWMU-65 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and batteries. The waste is sent to SWMU-1 for consolidation. SWMU-65 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-66 | Bldg 9-120, Accumulation Area D032 | SWMU-66 is an accumulation station for hazardous or dangerous waste including solvent rags, paints, and inks. The waste is sent to SWMU-2 for consolidation. SWMU-66 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-67 | Bldg 9-51, Accumulation Area D033 | SWMU-67 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and batteries. The waste is sent to SWMU-2 for consolidation. SWMU-67 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-68 | Bldg 9-120, Accumulation Area D034 | SWMU-68 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, paints, inks, and containers with paints and inks. The waste is sent to SWMU-2 for consolidation. SWMU-68 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-69 | Bldg 9-120.3, Accumulation Area D036 | SWMU-69 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and batteries. The waste is sent to SWMU-2 for consolidation. SWMU-69 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-70 | Bldg 9-140, Accumulation Area D037 | SWMU-70 is an accumulation station for hazardous or dangerous waste including photographic developer and photographic fluids. The waste is sent to SWMU-2 for consolidation. SWMU-70 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-71 | Bldg 9-102, Accumulation Area D039 | SWMU-71 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-71 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-72 | Bldg 9-08.4, Accumulation Area D042 | SWMU-72 is an accumulation station for hazardous or dangerous waste including aerosol cans and toner. The waste is sent to SWMU-2 for consolidation. SWMU-72 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-73 | Bldg 9-101, Accumulation Area D043 | SWMU-73 is an accumulation station for hazardous or dangerous waste including oily rags and solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-73 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-74 | Bldg 9-51, Accumulation Area D047 | SWMU-74 is an accumulation station for hazardous or dangerous waste. The waste is sent to SWMU-2 for consolidation. SWMU-74 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-75 | Bldg 9-51, Accumulation Area D048 | SWMU-75 is an accumulation station for hazardous or dangerous waste. The waste is sent to SWMU-2 for consolidation. SWMU-75 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001024

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-76 | Bldg 9-101, Accumulation Area D051 | SWMU-76 is an accumulation station for hazardous or dangerous waste including batteries. The waste is sent to SWMU-2 for consolidation. SWMU-76 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-77 | Bldg 9-101.1, Accumulation Area D053 | SWMU-77 is an accumulation station for hazardous or dangerous waste including oily rags and solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-77 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-78 | Bldg 9-101, Accumulation Area D054 | SWMU-78 is an accumulation station for hazardous or dangerous waste including solvent rags. The waste is sent to SWMU-2 for consolidation. SWMU-78 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-79 | Bldg 9-53, Accumulation Area D058 | SWMU-79 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, and batteries. The waste is sent to SWMU-2 for consolidation. SWMU-79 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-80 | Bldg 9-101.1, Accumulation Area D061 | SWMU-80 is an accumulation station for hazardous or dangerous waste including oily rags, solvent rags, aerosol cans, and oil for recycling. The waste is sent to SWMU-2 or SWMU-4 for consolidation. SWMU-80 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-81 | Bldg 9-96.2, Accumulation Area, D062 | SWMU-81 is an accumulation station for hazardous or dangerous waste including oil for recycling. The waste is sent to SWMU-4 for consolidation. SWMU-81 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-82 | Bldg 9-101.1, Accumulation Area D063 | SWMU-82 is an accumulation station for hazardous or dangerous waste including oily rags. The waste is sent to SWMU-2 for consolidation. SWMU-82 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-83 | Bldg 9-101.2, Accumulation Area D064 | SWMU-83 is an accumulation station for hazardous or dangerous waste including waste hydrofluoric acid. The waste is sent to SWMU-2 for consolidation. SWMU-83 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-84 | Bldg 9-98.2, Accumulation Area D065 | SWMU-84 is an accumulation station for hazardous or dangerous waste including aerosol cans and batteries. The waste is sent to SWMU-2 for consolidation. SWMU-84 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-85 | Bldg 9-101.1, Accumulation Area D066 | SWMU-85 is an accumulation station for hazardous or dangerous waste including paints, inks, and solvents. The waste is sent to SWMU-2 for consolidation. SWMU-85 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-86 | Bldg 9-101, Accumulation Area D071 | SWMU-86 is an accumulation station for hazardous or dangerous waste including paper filters with composite sludge/coolant. The waste is sent to SWMU-2 for consolidation. SWMU-86 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-87 | Bldg 9-61, Accumulation Area D072 | SWMU-87 is an accumulation station for hazardous or dangerous waste including oily rags. The waste is sent to SWMU-2 for consolidation. SWMU-87 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-88 | Bldg 9-101, Accumulation Area D074 | SWMU-88 is an accumulation station for hazardous or dangerous waste including mixed acid plating solutinos and sodium hydroxide/chromium wastes. The waste is sent to SWMU-2 for consolidation. SWMU-88 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-89 | Bldg 9-08, Accumulation Area D075 | SWMU-89 is an accumulation station for hazardous or dangerous waste including oily rags, aerosol cans, batteries, and spent toner cartridges. The waste is sent to SWMU-2 for consolidation. SWMU-89 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-90 | Bldg 9-60, Accumulation Area D076 | SWMU-90 is an accumulation station for hazardous or dangerous waste including oily rags, paint and ink contaminated debris, and alodine contaminated rags. The waste is sent to SWMU-2 for consolidation. SWMU-90 operated from unknown date to at least 1994 (a). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-91 | Bldg 9-08.3, Former Accumulation Area D001 | SWMU-91 was an accumulation station for hazardous or dangerous waste. SWMU-91 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-92 | Bldg 9-48, Former Accumulation Area D002 | SWMU-92 was an accumulation station for hazardous or dangerous waste. SWMU-92 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-93 | Bldg 9-99, Former Accumulation Area D006 | SWMU-93 was an accumulation station for hazardous or dangerous waste. SWMU-93 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-94 | Bldg 9-101, Former Accumulation Area D015 | SWMU-94 was an accumulation station for hazardous or dangerous waste. SWMU-94 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-95 | Bldg 9-101, Former Accumulation Area D018 | SWMU-95 was an accumulation station for hazardous or dangerous waste. SWMU-95 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-96 | Bldg 9-101.1, Former Accumulaiton Area D022 | SWMU-96 was an accumulation station for hazardous or dangerous waste. SWMU-96 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-97 | Bldg 9-101, Former Accumulation Area D023 | SWMU-97 was an accumulation station for hazardous or dangerous waste. SWMU-97 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-98 | Bldg 9-101.2, Former Accumulation Area D026 | SWMU-98 was an accumulation station for hazardous or dangerous waste. SWMU-98 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-99 | Bldg 9-101.1, Former Accumulation Area D030 | SWMU-99 was an accumulation station for hazardous or dangerous waste. SWMU-99 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-100 | Bldg 9-120, Former Accumulation Area D035 | SWMU-100 was an accumulation station for hazardous or dangerous waste. SWMU-100 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-101 | Bldg 9-101, Former Accumulation Area D038 | SWMU-101 was an accumulation station for hazardous or dangerous waste. SWMU-101 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001026

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-102 | Bldg 9-70, Former Accumulation Area D040 | SWMU-102 was an accumulation station for hazardous or dangerous waste. SWMU-102 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-103 | Bldg 9-50, Former Accumulation Area D041 | SWMU-103 was an accumulation station for hazardous or dangerous waste. SWMU-103 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-104 | Bldg 9-101, Former Accumulation Area D044 | SWMU-104 was an accumulation station for hazardous or dangerous waste. SWMU-104 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-105 | Bldg 9-90.2, Former Accumulation Area D045 | SWMU-105 was an accumulation station for hazardous or dangerous waste. SWMU-105 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-106 | Bldg 9-101, Former Accumulation Area D046 | SWMU-106 was an accumulation station for hazardous or dangerous waste. SWMU-106 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-107 | Bldg 9-101.1, Former Accumulation Area D049 | SWMU-107 was an accumulation station for hazardous or dangerous waste. SWMU-107 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-108 | Bldg 9-101, Former Accumulation Area D050 | SWMU-108 was an accumulation station for hazardous or dangerous waste. SWMU-108 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-109 | Bldg 9-52, Former Accumulation Area D052 | SWMU-109 was an accumulation station for hazardous or dangerous waste. SWMU-109 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-110 | Bldg 9-101, Former Accumulation Area D055 | SWMU-110 was an accumulation station for hazardous or dangerous waste. SWMU-110 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-111 | Bldg 9-101.2, Former Accumulation Area D056 | SWMU-111 was an accumulation station for hazardous or dangerous waste. SWMU-111 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-112 | Bldg 9-101.2, Former Accumulation Area D057 | SWMU-112 was an accumulation station for hazardous or dangerous waste. SWMU-112 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-113 | Bldg 9-77.3, Former Accumulation Area D059 | SWMU-113 was an accumulation station for hazardous or dangerous waste. SWMU-113 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-114 | Bldg 9-101.1, Former Accumulation Area D060 | SWMU-114 was an accumulation station for hazardous or dangerous waste. SWMU-114 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-115 | Bldg 9-101.1, Former Accumulation Area D067 | SWMU-115 was an accumulation station for hazardous or dangerous waste. SWMU-115 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-116 | Bldg 9-140, Former Accumulation Area D068 | SWMU-116 was an accumulation station for hazardous or dangerous waste. SWMU-116 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-117 | Bldg 9-140, Former Accumulation Area D069 | SWMU-117 was an accumulation station for hazardous or dangerous waste. SWMU-117 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

DFT 001027

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-118 | Bldg 9-120, Former Accumulation Area D070 | SWMU-118 was an accumulation station for hazardous or dangerous waste. SWMU-118 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-119 | Bldg 9-101.2, Former Accumulation Area D073 | SWMU-119 was an accumulation station for hazardous or dangerous waste. SWMU-119 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-120 | Bldg 9-102, Former Accumulation Area D077 | SWMU-120 was an accumulation station for hazardous or dangerous waste. SWMU-120 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-121 | Bldg 9-43, Former Accumulation Area D078 | SWMU-121 was an accumulation station for hazardous or dangerous waste. SWMU-121 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-122 | Former Accumulation Area DT01 | SWMU-122 was an accumulation station for hazardous or dangerous waste. SWMU-122 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-123 | Bldg 9-90, Former Accumulation Area Photographic Waste | SWMU-123 was an accumulation station for hazardous or dangerous waste. SWMU-123 operated from an unknown time and ceased operation prior to 1991 (b). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-124 | Bldg 9-51, Newyork Blower Baghouse | SWMU-124 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-125 | Bldg 9-51, Spencer Baghouse | SWMU-125 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-126 | Bldg 9-53, Delta Filter/ Pack Box | SWMU-126 is a metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-127 | Bldg 9-53, Kel Filter Bag | SWMU-127 is a metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-128 | Bldg 9-77, Sternvent Filter/ Pack Box | SWMU-128 is a wood and metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-129 | Bldg 9-77, Sternvent Filter/ Pack Box | SWMU-129 is a wood and metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-130 | Bldg 9-77, Sternvent Filter/ Pack Box | SWMU-130 is a wood and metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-131 | Bldg 9-99, Aget Filter/ Pack Box | SWMU-131 is a metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-132 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-132 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-133 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-133 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-134 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-134 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-135 | Bldg 9-101, Clemco industries Sand Blaster with a Drum/ Filter | SWMU-135 is a metal, sand, and phenolic dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-136 | Bldg 9-101, Empire Abrasive Sand Blaster with a Drum/ Filter | SWMU-136 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-137 | Bldg 9-101, Agent Manufacturing Filter/ Pack Box | SWMU-137 is a metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-138 | Bldg 9-101, Delta Filter/ Pack Box | SWMU-138 is a wood and metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-139 | Bldg 9-101, Aget Dustkop Filter/ Pack Box | SWMU-139 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-140 | Bldg 9-101, Rockwell Filter/ Pack Box | SWMU-140 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-141 | Bldg 9-101, Micropulse Baghouse | SWMU-141 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-142 | Bldg 9-101, Spencer Baghouse | SWMU-142 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-143 | Bldg 9-101, Spencer Baghouse | SWMU-143 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-144 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-144 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-145 | Bldg 9-101, Donaldson Industries Baghouse | SWMU-145 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-146 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-146 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-147 | Bldg 9-101, Donaldson Torit Bag/ Filter | SWMU-147 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-148 | Bldg 9-101, Hoffman | SWMU-148 is a composite dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-149 | Bldg 9-101, Torit Corp. Filter/ Pack Box | SWMU-149 is a metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-150 | Bldg 9-101, Rockwell Filter/ Pack Box | SWMU-150 is a wood and metal dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |

# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| SWMU-151 | Bldg 9-120, Torit Filter/ Pack Box | SWMU-151 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-152 | Bldg 9-120, Torit Filter/ Pack Box | SWMU-152 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-153 | Bldg 9-120, Torit Filter/ Pack Bags | SWMU-153 is a plastic dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-154 | Bldg 9-120, Spencer Baghouse | SWMU-154 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-155 | Bldg 9-120, Spencer Baghouse | SWMU-155 is a wood dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-156 | Bldg 9-120, Donaldson Torit Baghouse | SWMU-156 is a wood, metal, and plastic dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| SWMU-157 | Bldg 9-120, Torit Baghouse | SWMU-157 is a plastic dust collector. The dust collector is used as containment for air releases of dust as a result of manufacturing processes (c). | No further action recommended based on no indication of past releases and low potential for future release (SAIC 1994 and EPA 1994). |
| AOC-01 | Underground Storage Tank DC 14 | AOC-01 is the location of a 1100 gal UST used to store gasoline. The 1100 gal UST replaced a leaking 500 gal gasoline UST in 1990. After the removal of the older UST, soil was excavated until soil at the base of the excavation met MTCA Method A cleanup levels. AOC-01 has been in operation from 1985 to present. More information on AOC-01 is presented in Section 4.8. | The three monitoring wells will be sampled biannually until two consecutive monitoring events are obtained without detections of TPH gasoline, TPH diesel, and BTEX (Boeing 2001). |
| AOC-02 | Underground Storage Tank DC 13 | AOC-02 is the location of a 550 gal UST used to store diesel. The 550 gal UST replaced a 300 gal diesel UST in 1990. After the removal of the older UST, soil was excavated until soil at the base of the excavation met MTCA Method A cleanup levels. AOC-02 has been in operation from 1985 to present. More information on AOC-02 is presented in Section 4.8. | The three monitoring wells will be sampled biannually until two consecutive monitoring events are obtained without detections of TPH gasoline, TPH diesel, and BTEX (Boeing 2001). |
| AOC-03 | Underground Storage Tank DC 20 | AOC-03 is the location of a 20,000 gal UST used to store No. 5 fuel oil used by the steam plant in Building 9-50. The UST replaced a similar UST when a leak was discovered in 1991. During the UST removal, approximately 250 yd^3 of TPH contaminated soil and 200-500 gals of free phase hydrocarbon product were removed from the excavation. AOC-03 has been in operation from 1957 to present. More information on AOC-03 is presented in Section 4.9. | The two monitoring wells will be sampled biannually until four consecutive groundwater samples are obtained that are non-detect for TPH diesel (Boeing 2001). |
| AOC-04 | Underground Storage Tank DC 21 | AOC-04 is the location of a 20,000 gal UST used to store No. 5 fuel oil used by the steam plant in Building 9-50. The UST replaced a similar UST when a leak was discovered in 1991. During the UST removal, approximately 250 yd^3 of TPH contaminated soil and 200-500 gal of free phase hydrocarbon product were removed from the excavation. AOC-04 has been in operation from 1957 to present. More information on AOC-04 is presented in Section 4.9. | The two monitoring wells will be sampled biannually until four consecutive groundwater samples are obtained that are non-detect for TPH diesel (Boeing 2001). |

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# TABLE 1
## BOEING DEVELOPMENTAL CENTER
## DESCRIPTION OF SWMUs AND AOCs

| SWMU/AOC-ID | LOCATION | DESCRIPTION | STATUS |
|---|---|---|---|
| AOC-05 | Underground Storage Tank DC 01 | AOC-05 was the location of a 1000 gal UST used to store gasoline. A leak of gasoline occurred in 1985. The UST was closed and removed after the leak occurred. During the UST removal, 500-600 gals of floating product was removed from the excavation. Additional gasoline contamination was removed within the excavated soils (Boeing 2001). AOC-05 operated from an unknown time to 1985. More information on AOC-05 is presented in Section 4.10. | ORC will be injected into groundwater to promote aerobic biodegradation of residual petroleum hydrocarbon constituents in groundwater. Groundwater samples will be collected monthly for three months following ORC injection for BTEX and gas-range petroleum hydrocarbons. |

Notes:

(a) Waste accumulation areas are designed to be self-contained. Small quantity waste collection areas are moved around to accommodate manufacturing operations. SWMU-51 to 90 were observed in 1994 and may not currently exist.

(b) Waste accumulation areas are designed to be self-contained. Small quantity waste collection areas are moved around to accommodate manufacturing operations. SWMU-91 to 123 were observed in 1991 but were not present in 1994.

(c) Filtering systems are designed to be self-contained. Filtering systems are moved around to accommodate manufacturing operations. SWMU-124 to 157 were observed in 1994 and may not currently exist.

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# TABLE 2
## PRELIMINARY GROUNDWATER SCREENING LEVELS
## in µg/L

| Constituent | Ambient Water Quality Criteria: Aquatic Life - Marine, State - Chronic | Aquatic Life - Marine, Federal - Chronic | Aquatic Life - Fresh Water, State - Chronic | Aquatic Life - Fresh Water, Federal - Chronic | Human Health, Federal - Ing. of Org. | MTCA Method B Surface Water Equation for Human Health (a)(b) | PQL | Method B Preliminary Screening Level Marine Surface Water | Method B Preliminary Screening Level Fresh Surface Water |
|---|---|---|---|---|---|---|---|---|---|
| Volatile Organics | | | | | | | | | |
| acetone | NA | NA | NA | NA | NA | NA | 10 (c) | NA | NA |
| benzene | NA | NA | NA | NA | 71 | 22 | 5 (d) | 71 | 71 |
| carbon disulfide | NA | NA | NA | NA | NA | NA | 100 (c) | NA | NA |
| 2-chloroethyl vinyl ether | NA | NA | NA | NA | NA | NA | 10 (c) | NA | NA |
| chloroform | NA | NA | NA | NA | 470 | 280 | 5 (c) | 470 | 470 |
| 1,2-dichloro-1,1,2-trifluoroethene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,1-dichloroethane | NA | NA | NA | NA | NA | NA | 5 (c) | NA | NA |
| 1,2-dichloroethane | NA | NA | NA | NA | 99 | 59 | 5 (c) | 99 | 99 |
| 1,1-dichloroethene | NA | NA | NA | NA | 3.2 | 1.9 | 4 (l) | 4 | 4 |
| cis-1,2-dichloroethene | NA | NA | NA | NA | NA | NA | 5 (d) | NA | NA |
| trans-1,2-dichloroethene | NA | NA | NA | NA | NA | 32,800 | 5 (c) | 32,800 | 32,800 |
| ethylbenzene | NA | NA | NA | NA | 29,000 | 6910 | 5 (d) | 29,000 | 29,000 |
| Freon | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| methylene chloride | NA | NA | NA | NA | 1,600 | 960 | 5 (c) | 1,600 | 1,600 |
| methyl ethyl ketone | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| styrene | NA | NA | NA | NA | NA | NA | 5 (c) | NA | NA |
| tetrachloroethene | NA | NA | NA | NA | 8.85 | 4.2 | 5 (d) | 9 | 9 |
| toluene | NA | NA | NA | NA | 200,000 | 48,500 | 5 (d) | 200,000 | 200,000 |
| Trichloroethane | NA | NA | NA | NA | NA | 417000 (j) | NA | 417,000 | 417,000 |
| 1,1,1-trichloroethane | NA | NA | NA | NA | NA | 417,000 | 5 (c) | 417,000 | 417,000 |
| 1,1,2-Trichloroethane | NA | NA | NA | NA | 42 | 25 | 5 (c) | 42 | 42 |
| trichloroethene | NA | NA | NA | NA | 81 | 56 | 5 (d) | 81 | 81 |
| 1,2,4-trimethylbenzene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1,3,5-trimethylbenzene | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| vinyl chloride | NA | NA | NA | NA | 525 | 3.7 | 5 (d) | 525 | 525 |
| m-xylene | NA | NA | NA | NA | NA | NA | 5 (c,e) | NA | NA |
| o-xylene | NA | NA | NA | NA | NA | NA | 5 (c,e) | NA | NA |
| p-Xylene | NA | NA | NA | NA | NA | NA | 5 (c,e) | NA | NA |
| Semivolatile Organics | | | | | | | | | |
| bis(2-ethylhexyl) phthalate | NA | NA | NA | NA | 5.9 | 3.6 | 3 (l) | 3.6 | 3.6 |
| di-butyl phthalate | NA | NA | NA | NA | 12,000 | 2,900 | NA | 12,000 | 12,000 |
| diethyl phthalate | NA | NA | NA | NA | 120,000 | 28,000 | 10 (c) | 120,000 | 120,000 |
| naphthalene | NA | NA | NA | NA | NA | 4,940 | 10 (c) | 4,940 | 4,940 |
| Benz(a)anthracene | NA | NA | NA | NA | 0.031 | 0.0296 | 0.1 (l) | 0.1 | 0.1 |
| Chrysene | NA | NA | NA | NA | 0.031 | 0.0296 | 0.1 (l) | 0.1 | 0.1 |
| Acenaphthene | NA | NA | NA | NA | NA | 640.0 | 10 (c) | 640.0 | 640.0 |
| Anthracene | NA | NA | NA | NA | 110,000 | 26,000 | 10 (c) | 110,000 | 26,000 |
| Fluoranthene | NA | NA | NA | NA | 370 | 90 | 10 (c) | 370 | 90 |
| Fluorene | NA | NA | NA | NA | 14,000 | 3,500 | 10 (c) | 14,000 | 3,500 |
| Phenanthrene | NA | NA | NA | NA | NA | NA | 10 (c) | NA | NA |
| Pyrene | NA | NA | NA | NA | 11,000 | 2,600 | 10 (c) | 11,000 | 2,600 |
| Dibenzofuran | NA | NA | NA | NA | NA | NA | 10 (c) | NA | NA |
| Total PCBs | | | | | | | | | |
| Total PCBs | NA | 0.03 | NA | 0.014 | 0.00017 | 0.00166 | 3.7 (i, l) | 3.7 | 3.7 |
| Total Petroleum Hydrocarbons | | | | | | | | | |
| TPH-diesel | NA | NA | NA | NA | NA | 500 (f) | 1.25 (d) | 500 | 500 |
| TPH-gasoline | NA | NA | NA | NA | NA | 800 (f) | 1.25 (d) | 800 | 800 |
| Metals | | | | | | | | | |
| aluminum | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| arsenic, inorganic | 36 | 36 | 190 | 190 | 0.14 | 0.098 | 5 (l) | 5 | 5 |
| barium | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| beryllium | NA | NA | NA | NA | NA | 273 | 2 (c) | 273 | 273 |
| cadmium | 9.3 | 9.3 | 0.84 (g) | 1 (h) | NA | 20.3 | 0.2 (l) | 9 | 1 (h) |
| calcium | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| chromium (III) | NA | NA | 141 (g) | 180 (h) | NA | 243,000 | 10 (c) | 243,000 | 180 (h) |

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# TABLE 2
## PRELIMINARY GROUNDWATER SCREENING LEVELS
## in µg/L

| | Ambient Water Quality Criteria | | | | | MTCA Method B | | Method B Preliminary | Method B Preliminary |
|---|---|---|---|---|---|---|---|---|---|
| | Aquatic Life - Marine | | Aquatic Life - Fresh Water | | Human Health | Surface Water Equation | | Screening Level | Screening Level |
| Constituent | State - Chronic | Federal - Chronic | State - Chronic | Federal - Chronic | Federal - Ing. of Org. | for Human Health (a)(b) | PQL | Marine Surface Water | Fresh Surface Water |
| chromium (VI) | 50 | 50 | 10 | 10 | NA | 490 | 50 (c) | 50 | 50 |
| cobalt | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| copper | 3.1 | 3.1 | 8.9 (g) | 11 (h) | NA | 2,660 | 3.4 (l) | 3.4 | 8.9 (g) |
| iron | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| lead | 8.1 | 8.1 | 1.85 (g) | 2.5 (h) | NA | NA | 8 (l) | 8.1 | 8 |
| magnesium | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| manganese | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| mercury | 0.025 | 0.025 | 0.012 | 0.012 | 0.15 | NA | 0.3 (l) | 0.3 | 0.3 |
| molybdenum | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| nickel | 8.2 | 8.2 | 124 (g) | 160 (h) | 4,600 | 1100 | 34 (l) | 34 | 160 (h) |
| silver | NA | NA | NA | NA | NA | 26,000 | 70 (c) | 26,000 | 26,000 |
| zinc | 81 | 81 | 82.3 (g) | 100 (h) | NA | 16,500 | 45 (d) | 81 | 100 (h) |

(a) Equation values listed only for constituents for which sufficiently protective human-health based criteria have not been established under applicable state and federal laws.
(b) Ecology 2001.
(c) Practical quantitation limit from Ecology 1995.
(d) Practical quantitation limit from Developmental Center Groundwater Monitoring Plan, Boeing 2001.
(e) PQL for total xylene.
(f) MTCA Method A groundwater screening level for drinking water, Ecology 2001.
(g) Hardness dependent, hardness assumed to be 75.4 mg/L.
(h) Hardness and water effect ratio dependent, hardness assumed to be 100 mg/L, water effect ratio assumed to be 1.0.
(i) PQL for individual Aroclor with highest MDL.
(j) Criteria for 1,1,1-trichloroethane
(l) Ten times ARI method detection limit
NA = water screening level not available.
compounds detected in soil but not in water

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# TABLE 3
## PRELIMINARY SOIL SCREENING LEVELS

| | BDC PSL (a) mg/kg | Protection of groundwater based on marine surface water PSL mg/kg | Protection of groundwater based on fresh surface water PSL mg/kg | PQL (b) mg/kg | Background from Ecology (c) mg/kg |
|---|---|---|---|---|---|
| Volatile organics | | | | | |
| acetone | NA | NA | NA | 0.01 | |
| benzene | 220 | 216 | 216 | 0.005 | |
| carbon disulfide | NA | NA | NA | 0.1 | |
| 2-chloroethyl vinyl ether | NA | NA | NA | NA | |
| chloroform | 2.5 | 2.5 | 2.5 | 0.005 | |
| 1,1-dichloroethane | NA | NA | NA | 0.005 | |
| 1,2-dichloroethane | 0.48 | 0.48 | 0.48 | 0.005 | |
| 1,1-dichloroethene | 0.02 | 0.02 | 0.02 | 0.005 | |
| cis-1,2-,dichloroethene | NA | NA | NA | 0.005 | |
| trans-1,2-dichloroethene | 180 | 178 | 178 | 0.005 | |
| 1,2-dichloro-1,1,2-trichoroethene | NA | NA | NA | NA | |
| ethylbenzene | 250 | 251 | 251 | 0.005 | |
| freon | NA | NA | NA | NA | |
| methyl ethyl ketone | NA | NA | NA | 0.01 | |
| methylene chloride | 7 | 7.0 | 7.0 | 0.005 | |
| naphthalene | 140 | 138 | 138 | 0.66 | |
| styrene | NA | NA | NA | 0.005 | |
| tetrachloroethene | 0.1 | 0.10 | 0.10 | 0.005 | |
| toluene | 1450 | 145 | 145 | 0.005 | |
| 1,1,1-trichloroethane | 3300 | 330 | 330 | 0.005 | |
| 1,1,2-trichloroethane | 0.23 | 0.23 | 0.23 | 0.005 | |
| trichloroethylene | 0.54 | 0.54 | 0.54 | 0.001 | |
| 1,2,4-trimethylbenzene | NA | NA | NA | NA | |
| 1,3,5-trimethylbenzene | NA | NA | NA | NA | |
| vinyl chloride | 3.3 | 3.3 | 3.3 | 0.02 | |
| m-xylene | NA | NA | NA | 0.005 | |
| o-xylene | NA | NA | NA | 0.005 | |
| p-xylene | NA | NA | NA | 0.005 | |
| Semivolatile organics | | | | | |
| bis(2-ethylhexyl) phthalate | 13 | 13 | 13 | 0.66 | |
| di-butyl phthalate | 420 | 424 | 424 | NA | |
| diethyl phthalate | 680 | 677 | 677 | 0.66 | |
| PAHs | | | | | |
| acenaphthene | 70 | 70 | 70 | 0.66 | |
| anthracene | 52,000 | 52,100 | 52,100 | 0.66 | |
| benzo[a]anthracene | 0.22 | 0.22 | 0.22 | 0.008 (d) | |
| chrysene | 0.25 | 0.25 | 0.25 | 0.01 (d) | |
| dibenzofuran | NA | NA | NA | 0.33 | |
| fluoranthene | 370 | 365 | 365 | 0.66 | |
| fluorene | 2200 | 2210 | 2210 | 0.66 | |
| phenanthrene | NA | NA | NA | 0.66 | |
| pyrene | 15,000 | 15,000 | 15,000 | 0.66 | |
| Total PCBs | | | | | |
| PCBs | 0.33 | 0.01 | 0.01 | 0.33 (d) | |
| TPH | | | | | |
| diesel | 2000 (e) | | | | |
| gasoline | 100 (e) | | | | |
| Metals | | | | | |
| aluminum | NA | NA | NA | NA | 32,600 |
| arsenic, inorganic | 7 | 0.08 | 0.08 | 0.5 | 7 |
| barium and compounds | NA | NA | NA | NA | NA |
| beryllium | 4300 | 4310 | 4310 | NA | 0.6 |
| cadmium | 1 | 1.2 | 0.14 | 0.05 | 1 |

# TABLE 3
## PRELIMINARY SOIL SCREENING LEVELS

| | BDC PSL (a) mg/kg | Protection of groundwater based on marine surface water PSL mg/kg | Protection of groundwater based on fresh surface water PSL mg/kg | PQL (b) mg/kg | Background from Ecology (c) mg/kg |
|---|---|---|---|---|---|
| calcium | NA | NA | NA | NA | NA |
| chromium(III) | 6,500,000 | 8,748,000,000 | 6,480,000 | 0.5 | NA |
| chromium(VI) | 3.8 | 19 | 3.8 | NA | NA |
| cobalt | NA | NA | NA | NA | NA |
| copper | 36 | 1.4 | 4.9 | 0.5 | 36 |
| iron | NA | NA | NA | NA | 36,100 |
| lead | 500 | 1620 | 500 | 0.5 | 24 |
| magnesium | NA | NA | NA | NA | NA |
| manganese | NA | NA | NA | NA | NA |
| mercury | 0.07 | 0.03 | 0.01 | 0.002 | 0.07 |
| molybdenum | NA | NA | NA | NA | NA |
| nickel | 20 | 11 | 209 | 20 | 48 |
| silver | 4400 | 4420 | 4420 | 5 | NA |
| zinc | 100 | 101 | 124 | 1 | 85 |

(a) Most stringent SSL selected. SSL replace with PQL or background concentration if SSL less than either of these values.
(b) Practical quantitation limit from Ecology 1995.
(c) Puget sound basin 90th percentile value from Ecology 1994.
(d) Ten times ARI method detection limit.
(e) MTCA Method A industrial value.

# TABLE 4
## SWMU 16: PCB CONCENTRATIONS IN GROUNDWATER SAMPLES
## in ug/L

| Sample ID | SB-1 | SB-1 | SB-2 | SB-2 | SB-3 | SB-3 | SB-4 | SB-4 | SB-5 | SB-5 | SB-6 | SB-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | 1/23/01 | 1/23/01 | 1/23/01 | 1/23/01 | 1/23/01 | 1/23/01 | 1/24/01 | 1/24/01 | 1/24/01 | 1/24/01 | 1/24/01 | 1/24/01 |
| Depth below Water Table in ft. | 0-3.5 | 10-13.5 | 0-3.5 | 10-13.5 | 0-3.5 | 10-13.5 | 0-3.5 | 10-13.5 | 0-3.5 | 10-13.5 | 0-3.5 | 10-13.5 |
| Aroclor 1016 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Aroclor 1242 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Aroclor 1248 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Aroclor 1254 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Aroclor 1260 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Aroclor 1221 | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| Aroclor 1232 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |

U = Analyte not detected at indicated detection limit
*Data from IT 2001.*

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# TABLE 5
## SWMU 17: DETECTED ANALYTES IN SOIL SAMPLE BDC-05-2

| Analyte | Concentration | PSL (a) |
|---|---|---|
| Metals in mg/kg | | |
| Arsenic | 2.8 | 7 |
| Beryllium | 0.5 | 4300 |
| Chromium | 11 | 6,500,000 |
| Copper | 41 | 36 |
| Lead | 1.2 | 500 |
| Nickel | 9 | 20 |
| Silver | 0.4 | 4400 |
| Zinc | 36 | 100 |
| Volatile Organics in ug/kg | | |
| Methylene Chloride | trace | 7000 |
| Acetone | 460 | NA |
| Toluene | trace | 1,400,000 |
| Total Xylenes | trace | NA |

trace Analyte detected between 5-25 ug/kg

Analyte detected at concentration above the screening level

(a) Preliminary screening level, see table 3

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# TABLE 6
## SWMU 17: METALS DETECTED IN GROUNDWATER SAMPLES

| Analyte | Maximum Detection (ug/L) [a] | PSL Marine (ug/L) | PSL Fresh (ug/L) | Number of Samples | Number of Marine PSL Exceedances | Number of Fresh PSL Exceedances | Frequency of Marine PSL Exceedance | Frequency of Fresh PSL Exceedance |
|---|---|---|---|---|---|---|---|---|
| Aluminum | 3000 | na | na | 23 | - | - | - | - |
| Arsenic | 47 | 5 | 5 | 18 | 3 | 3 | 17% | 17% |
| Barium | 63 | na | na | 23 | - | - | - | - |
| Cadmium | 28 | 9 | 1 | 27 | 6 | 13 | - | 48% |
| Calcium | 39000 | na | na | 23 | - | - | - | - |
| Chromium | 3.6 | 243000 | 180 | 27 | - | - | - | - |
| Cobalt | 48 | na | na | 23 | - | - | - | - |
| Copper | 44 | 3.4 | 8.9 | 27 | 26 | 24 | 96% | 89% |
| Iron | 73000 | na | na | 27 | - | - | - | - |
| Lead | 42 | 8.1 | 8 | 28 | 3 | 3 | 11% | 11% |
| Magnesium | 15000 | na | na | 23 | - | - | - | - |
| Molybdenum | 130 | na | na | 23 | - | - | - | - |
| Nickel | 19 | 34 | 160 | 27 | - | - | - | - |
| Silver | ND | 26000 | 26000 | 4 | - | - | - | - |
| Zinc | 42 | 81 | 100 | 27 | - | - | - | - |

(a) data collected since January 1998
PSL preliminary screning level, see Table 2
na not available
ND non-detect

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# TABLE 7
## SWMU 17: DETECTED VOC CONCENTRATIONS IN GROUNDWATER SAMPLES
## in ug/L

| Well | Jun-98 | Nov-99 | May-00 | Dec-00 | Jun-01 | Dec-01 | PSL |
|---|---|---|---|---|---|---|---|
| **1,1-dichloroethane** | | | | | | | na |
| BDC-05-02A | - | 1.1 | 1.2 | - | 1.22 J | 1.4 | |
| BDC-05-03 | nt | 1.8 | 2.5 | 1.46 | 2.7 | - | |
| BDC-05-04 | 3.7 | 3.7 | - | 3.2 | 2.45 | 4.8 | |
| BDC-05-05 | - | - | - | - | - | - | |
| BDC-05-07 | 1.4 | 1.6 | 1.5 | 1.67 | 1.41 | 3.3 | |
| **1,1,1-trichloroethane** | | | | | | | 417,000 |
| BDC-05-02A | 4 | 6.5 | 7.4 | 1.73 | 7.29 J | 8.8 | |
| BDC-05-03 | - | 1.7 | 2.2 | 1.57 | 1.77 J | 3.5 | |
| BDC-05-04 | - | - | - | - | - | - | |
| BDC-05-05 | - | - | - | - | - | - | |
| BDC-05-07 | 8.5 | 8.6 | 7.2 | 11.49 | 5.88 J | 8.4 | |
| **cis-1,2-dichloroethene** | | | | | | | na |
| BDC-05-02A | 2 | 1.4 | 1.6 | 1.48 | 2.9 J | 4.8 | |
| BDC-05-03 | | 3.1 | 8.7 | 4.7 | 11.62 | 1.1 | |
| BDC-05-04 | 10.3 | 6.2 | 5.9 | 7.9 | 7.79 J | 11 | |
| BDC-05-05 | - | - | - | - | - | - | |
| BDC-05-07 | 2.9 | 2.2 | 3.4 | 4.3 | 4.79 J | 9.9 | |
| **tetrachloroethene** | | | | | | | 9 |
| BDC-05-02A | 6.7 | 15.8 | 19.8 | 8.67 | 9.82 J | 8.2 | |
| BDC-05-03 | nt | 6 | 5.4 | 4.49 | 2.6 J | 1.7 | |
| BDC-05-04 | - | - | - | - | - | 1.4 | |
| BDC-05-05 | - | - | - | - | - | - | |
| BDC-05-07 | 5.9 | 10.1 | 9.3 | 16.26 | 4.91 J | 5.6 | |
| **trichloroethene** | | | | | | | 81 |
| BDC-05-02A | 12.4 | 30.2 | 39.5 | 12.64 | 38.94 | 37 | |
| BDC-05-03 | nt | 12.2 | 18 | 13.4 | 17.59 | 3.6 | |
| BDC-05-04 | 1.5 | 1.6 | 1.5 | 1.96 | 1.26 J | 1.4 | |
| BDC-05-05 | 1.4 | 1 | 1.33 | 2.01 | 1.87 J | 1 | |
| BDC-05-07 | 15.2 | 27.1 | 26.7 | 37.95 | 25.82 | 30 | |

- not detected
nt not tested
J estimated value
PSL preliminary screening level
na not available
[ ] analyte detected at concentration above preliminary screening level

# TABLE 8a
## SWMU 20: METALS AND CYANIDE RESULTS FOR PHASE I SOIL SAMPLES
## in mg/kg

| Analyte | PSL | Sample ID (a,b): | 1-12.0 | | 2-14.0 | | 2-15.5 | | 4-11.5 | | 5-12.5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antimony | - | | 0.5 | UR | 0.5 | UR | 0.5 | UR | 0.5 | UR | 0.5 | UR |
| Arsenic | 7 | | 3.2 | | 2.7 | | 3 | | 7.8 | | 4.1 | |
| Barium | NA | | 44 | | 37 | | 48 | | 53 | | 54 | |
| Beryllium | 4300 | | 0.1 | | 0.1 | | 0.2 | | 0.3 | | 0.3 | |
| Cadmium | 1 | | 0.5 | U | 0.5 | U | 0.5 | | 0.5 | U | 0.7 | |
| Chromium | 6,500,000 | | 14 | | 14 | | 16 | | 15 | | 16 | |
| Cobalt | NA | | 5 | | 5 | | 5 | | 4 | | 6 | |
| Copper | 36 | | 16 | | 10 | | 17 | | 21 | | 16 | |
| Lead | 500 | | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U |
| Mercury | 0.07 | | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U | 0.1 | U |
| Molybdenum | NA | | 5 | U | 5 | U | 5 | U | 5 | U | 5 | U |
| Nickel | 20 | | 8 | | 6 | | 8 | | 6 | | 11 | |
| Silver | 4400 | | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Selenium | - | | 0.5 | U | 0.5 | U | 0.5 | U | 0.5 | U | 0.5 | U |
| Strontium | - | | 68 | | 42 | | 56 | | 83 | | 58 | |
| Thallium | - | | 0.5 | U | 0.5 | U | 0.5 | U | 0.5 | U | 0.5 | U |
| Vanadium | - | | 44 | | 42 | | 50 | | 64 | | 54 | |
| Zinc | 100 | | 32 | | 34 | | 31 | | 32 | | 38 | |
| Cyanide | - | | 0.5 | UJ | 0.5 | UJ | 0.5 | UJ | | | 0.5 | UJ |

(a) Sample ID indicates location and depth in ft BGS.
(b) These samples were collected in the area of the degreaser. The soil was subsequently excavated in 1989.
U = Element not detected at listed instrument detection limit.
R = Data unusable because of low spike recovery caused by matrix interferences.
J = Concentration estimated; low surrogate recovery.
NA = soil screening level not available
- = soil screening level not determined

# TABLE 8b
## SWMU 20: DETECTED ANALYTES FOR PHASE II SOIL SAMPLES
### in ug/kg

| Analyte | PSL | | Boring ID: | 6C | 6C | 6C | 6C | 6C | 6C | 6C | 7C | 7C | 7C | 7C | 7C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID (a): | 6C-10.5 | 6C-12.0 | 6C-13.5 | 6C-15 | 6C-33.5 | 6C-35.0 | 6C-39 | 7C-10.5 | 7C-12.5 | 7C-15 | 7C-35 | 7C-39 |
| | | | Date Collected: | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 |
| Volatile Organics in ug/kg | | | | | | | | | | | | | | | |
| Acetone | NA | | | - | - | - | - | 10 | - | - | - | - | - | 47 | 18 |
| Carbon Disulfide | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,1-Dichloroethene | 2.00E+01 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,2-Dichloroethene (b) | 1.78E+05 | (c) | | 35 | 710 | 81 | 71 | 24 | 18 | 1300 | | 350 | 120 | 2300 | 47 |
| Ethylbenzene | 2.51E+05 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Methylethyl Ketone | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Tetrachloroethene | 100 | | | 790 | 10000 | 450 | 280 | - | - | - | 27 | 1300 | 18 | 550 | 110 |
| Trichloroethene | 540 | | | 130 | 1300 | 100 | 74 | - | - | - | | 320 | 21 | 830 | 110 |
| Toluene | 1.40E+06 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,1,1-Trichloroethane | 3300000 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,1,2-Trichloroethane | 230 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Vinyl Chloride | 3300 | | | - | - | - | - | - | 19 | - | - | - | 40 | 690 | 26 |
| Xylenes (d) | NA | (e) | | - | - | - | - | - | - | - | - | - | - | - | - |
| Semivolatile Organics in ug/kg | | | | | | | | | | | | | | | |
| Benz(a)anthracene | 220 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Chrysene | 250 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Acenaphthene | 7.00E+04 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Anthracene | 5.20E+07 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Fluoranthene | 3.70E+05 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Fluorene | 2.20E+06 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Phenanthrene | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Pyrene | 1.50E+07 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Dibenzofuran | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Petroleum Hydrocarbons in mg/kg | | | | | | | | | | | | | | | |
| TPH (f) | 2000 | (g) | | - | - | - | - | - | - | - | - | - | - | - | - |

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# TABLE 8b
## SWMU 20: DETECTED ANALYTES FOR PHASE II SOIL SAMPLES
### in ug/kg

| Analyte | PSL | | Boring ID: | 10C | 10C | 10C | 10C | 10C | 12A | 13C | 13C | 14C | 14C | 14C | 14C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID (a): | 10C-3 | 10C-12 | 10C-15 | 10C-15dup | 10C-22.5 | 12A-35 | 13C-30 | 13C-35 | 14C-12.5 | 14C-18.5 | 14C-27.5 | 14C-34 |
| | | | Date Collected: | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 |
| Volatile Organics in ug/kg | | | | | | | | | | | | | | | |
| Acetone | NA | | | - | - | - | - | - | 24 | - | 17 | - | - | - | 52 |
| Carbon Disulfide | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,1-Dichloroethene | 2.00E+01 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| 1,2-Dichloroethene (b) | 1.78E+05 | (c) | | 11 | 200 | 1300 | 1300 | 51 | | | 21 | 160 | 410 | 610 | - |
| Ethylbenzene | 2.51E+05 | | | - | - | - | - | - | - | - | - | 430 | - | - | - |
| Methylethyl Ketone | NA | | | | | | | | 11 | - | - | - | - | - | 14 |
| Tetrachloroethene | 100 | | | 120 | 290 | 640 | 1100 | 230 | - | - | - | 88 | 1400 | 1500 | - |
| Trichloroethene | 540 | | | 110 | 220 | 260 | 420 | 43 | - | - | - | 120 | 890 | 520 | - |
| Toluene | 1.40E+06 | | | - | - | - | - | - | - | - | - | 2500 | 9.6 | - | - |
| 1,1,1-Trichloroethane | 3300000 | | | - | - | - | - | - | - | - | - | 490 | - | - | - |
| 1,1,2-Trichloroethane | 230 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Vinyl Chloride | 3300 | | | - | - | 39 | 35 | - | - | 18 | 41 | - | - | 230 | 67 |
| Xylenes (d) | NA | (e) | | - | - | | | - | - | - | - | 2200 | - | - | - |
| Semivolatile Organics in ug/kg | | | | | | | | | | | | | | | |
| Benz(a)anthracene | 220 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Chrysene | 250 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Acenaphthene | 7.00E+04 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Anthracene | 5.20E+07 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Fluoranthene | 3.70E+05 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Fluorene | 2.20E+06 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Phenanthrene | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Pyrene | 1.50E+07 | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Dibenzofuran | NA | | | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Petroleum Hydrocarbons in mg/kg | | | | | | | | | | | | | | | |
| TPH (f) | 2000 | (g) | | - | - | - | - | - | - | - | - | - | - | - | - |

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# TABLE 8b
## SWMU 20: DETECTED ANALYTES FOR PHASE II SOIL SAMPLES
### in ug/kg

| Analyte | PSL | | Boring ID: | 15C | 15D | 15D | 15D | 15D | 15D | 15D | 16C | 16C | 16C | 16C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID (a): | 15C-5 | 15D-5 | 15D-8 | 15D-18.5 | 15D-30 | 15D-36 | 15D-50dup | 16C-3 | 16C-4.5 | 16C-13.5 | 16C-35 |
| | | | Date Collected: | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 | Aug-89 |
| Volatile Organics in ug/kg | | | | | | | | | | | | | | |
| Acetone | NA | | | - | 15 | 39 | - | - | 9.5 | 8.6 | - | - | - | 8.1 |
| Carbon Disulfide | NA | | | - | - | - | - | - | - | - | - | - | - | - |
| 1,1-Dichloroethene | 2.00E+01 | | | - | - | - | - | - | - | - | - | - | - | - |
| 1,2-Dichloroethene (b) | 1.78E+05 | (c) | | - | - | - | 390 | 770 | - | - | - | - | - | - |
| Ethylbenzene | 2.51E+05 | | | - | - | - | - | - | - | - | - | - | - | - |
| Methylethyl Ketone | NA | | | - | - | 12 | - | - | - | - | - | - | - | - |
| Tetrachloroethene | 100 | | | - | - | - | - | - | - | - | - | 26 | 12 | - |
| Trichloroethene | 540 | | | - | - | - | 140 | 6.9 | - | - | 5.8 | 18 | 20 | - |
| Toluene | 1.40E+06 | | | - | - | - | - | - | - | - | - | - | - | - |
| 1,1,1-Trichloroethane | 3300000 | | | - | - | - | - | - | - | - | - | - | - | - |
| 1,1,2-Trichloroethane | 230 | | | - | - | - | - | - | - | - | - | - | - | - |
| Vinyl Chloride | 3300 | | | - | - | - | - | 49 | - | - | - | - | - | - |
| Xylenes (d) | NA | (e) | | - | - | - | - | - | - | - | - | - | - | - |
| Semivolatile Organics in ug/kg | | | | | | | | | | | | | | |
| Benz(a)anthracene | 220 | | | - | - | - | - | - | - | - | - | - | - | - |
| Chrysene | 250 | | | - | - | - | - | - | - | - | - | - | - | - |
| Acenaphthene | 7.00E+04 | | | - | - | - | - | - | - | - | - | - | - | - |
| Anthracene | 5.20E+07 | | | - | - | - | - | - | - | - | - | - | - | - |
| Fluoranthene | 3.70E+05 | | | - | - | - | - | - | - | - | - | - | - | - |
| Fluorene | 2.20E+06 | | | - | - | - | - | - | - | - | - | - | - | - |
| Phenanthrene | NA | | | - | - | - | - | - | - | - | - | - | - | - |
| Pyrene | 1.50E+07 | | | - | - | - | - | - | - | - | - | - | - | - |
| Dibenzofuran | NA | | | - | - | - | - | - | - | - | - | - | - | - |
| Total Petroleum Hydrocarbons in mg/kg | | | | | | | | | | | | | | |
| TPH (f) | 2000 | (g) | | 22 | - | - | - | - | - | - | - | - | - | - |

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# TABLE 9
## SWMU 20: BENZENE CONCENTRATIONS IN GROUNDWATER SAMPLES
## in ug/L

| Well | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 |
|---|---|---|---|---|---|---|---|---|
| MW-6B | - | 1.3 | - | - | - | - | - | - |
| MW-6C | 4.2 | 5.7 | 2.8 | 2.7 | - | 2.76 | 1.9 J | 1.7 |
| MW-8C | 14 | - | - | - | 15.8 | - | - | - |
| MW-9A | - | - | - | - | - | - | - | - |
| MW-9B | - | - | - | - | - | - | - | 1.2 |
| MW-9C | 1.7 | 2.5 | 1.7 | - | 1.5 | 1.4 | - | - |
| MW-9D | - | - | - | - | - | - | - | - |
| MW-10A | - | - | - | - | - | - | - | - |
| MW-10C | 1.3 | 1.1 | 1.1 | - | 1.4 | 1.2 | - | 1.3 |
| MW-11A | - | - | - | - | - | - | - | - |
| MW-12A | - | - | - | - | - | - | - | - |
| MW-13A | - | - | - | - | - | - | - | - |
| MW-13C | 3.9 | 3.3 | 3 | - | 2 | 2.3 | 1.2 | - |
| MW-14A | - | - | - | - | - | - | - | - |
| MW-14C | 2.8 | 4.6 | 2.5 | 1.2 | 1.4 | 1.3 | - | - |
| MW-14E | - | - | - | - | - | - | - | - |
| MW-15A | - | - | - | - | - | - | - | - |
| MW-15C | - | 5.2 | 5.2 | 5.4 | - | 4.3 | 2.9 J | 3.2 |
| MW-15D | - | - | - | - | - | - | - | - |
| MW-16A | 2 | - | 11 | 50 | 1.6 | 46 | 34 | 15 |
| MW-16C | 15 | 8.3 | 10 | 6.4 | 7.8 | 4.3 | 5.0 | 4.5 |
| MW-17A | 11 | - | - | - | 1.5 | - | nt | - |
| MW-17C | 5.6 | 2.7 | 3.7 | 2.4 | 2.1 | nt | - | nt |
| MW-17D | - | - | - | - | - | - | - | nt |
| MW-18A | - | - | - | - | - | - | - | nt |
| MW-18C | 1.5 | 1.4 | 1.5 | - | 1.1 | 1.3 | - | - |
| MW-18D | - | - | - | - | - | - | - | nt |
| MW-19A | - | - | - | - | - | - | - | nt |
| MW-19C | 2.2 | 1.8 | 1.8 | 1.3 | 1.2 | 1.4 | 1.3 | - |
| MW-19D | - | - | - | - | - | - | - | nt |
| MW-20A | - | - | - | - | - | - | - | nt |
| MW-20C | - | - | - | - | - | - | - | - |
| MW-20D | - | - | - | - | - | - | - | nt |

- not detected
nt not tested
J estimated value
[ ] analyte detected at concentration above preliminary screening level

DFT 001044

# TABLE 10
## SWMU 20: cis-1,2-DCE CONCENTRATIONS IN GROUNDWATER SAMPLES
in ug/L

| Well | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 |
|---|---|---|---|---|---|---|---|---|
| MW-6B | 67 | 9.9 | 70 | 50 | 72 | 92 | 64 | 27 |
| MW-6C | 1.1 | 180 J | - | - | - | - | - | - |
| MW-8C | 38 | - | 1.1 | - | 3.2 | - | - | - |
| MW-9A | 94 | 680 | 15.5 | 190 | 420 | 61 | 270 J | 100 |
| MW-9B | 940 J | 178 | 122 | 41 | 102 | 135 | 110 J | 100 |
| MW-9C | - | - | - | - | - | - | - | 1.1 |
| MW-9D | - | - | - | - | - | - | - | - |
| MW-10A | 29 | 6.9 | 33 | 21 | 11 | 14 | 14 | 36 |
| MW-10C | - | - | - | - | - | - | - | - |
| MW-11A | 2.8 | 2.3 | 2.1 | 1.1 | 1.5 | 1.6 | 1.3 J | 2.1 |
| MW-12A | 1.7 | 1.7 | 1.8 | 1.0 | 1.9 | 2.1 | 1.5 J | 2.2 |
| MW-13A | - | 1.2 | 1.3 | 1.2 | 1.2 | - | - | - |
| MW-13C | - | - | - | - | - | - | - | - |
| MW-14A | 4.9 | 3.7 | 7 | 3.2 | 3.8 | - | - | - |
| MW-14C | 26 | 22 | 6.2 | - | 1.2 | 2.8 | 1.6 | - |
| MW-14E | - | - | - | - | - | - | - | - |
| MW-15A | 16 | 6.4 | - | - | - | - | 5.0 J | 4.9 |
| MW-15C | 790 J | 91 | 53 | 28 | 1.0 | 2.5 | - | 1.1 |
| MW-15D | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - |
| MW-16A | 1 | 1 | 1 | 1 | 1 | 1.8 | 1.8 J | 2.6 |
| MW-16C | - | - | - | - | - | - | - | - |
| MW-17A | 2.3 | 3.8 | 4.1 | 4.3 | 2.3 | 2.1 | nt | 2 |
| MW-17C | - | - | - | - | - | nt | - | nt |
| MW-17D | - | - | - | - | - | nt | - | nt |
| MW-18A | - | - | - | - | - | - | - | nt |
| MW-18C | 1.8 | 2.8 | 1.9 | 2.1 | 1.3 | 1.6 | 1.4 J | - |
| MW-18D | 1.8 | - | - | - | - | - | - | nt |
| MW-19A | - | - | - | - | - | - | - | nt |
| MW-19C | 2.0 | 1.2 | 1.4 | - | 1.0 | - | 1.0 J | - |
| MW-19D | - | - | - | - | - | - | - | nt |
| MW-20A | - | - | - | - | - | - | - | nt |
| MW-20C | - | 1.5 | - | - | 1.3 | - | 1.1 J | 1.1 |
| MW-20D | - | - | - | - | - | - | - | nt |

| | |
|---|---|
| - | not detected |
| nt | not tested |
| J | estimated value |
| cis-1,2-DCE | cis-1,2-dichloroethene |

No preliminary screening level available for DCE.

DFT 001045

# TABLE 11
## SWMU 20: PCE CONCENTRATIONS IN GROUNDWATER SAMPLES
in ug/L

| Well | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 |
|---|---|---|---|---|---|---|---|---|
| MW-6B | 18.9 | 16.3 | 22.6 | 2.3 | 6 | 10.19 | 2.6 J | 2.4 |
| MW-6C | - | - | - | - | - | - | - | - |
| MW-8C | 7.8 | - | - | - | - | - | - | - |
| MW-9A | 39.4 | 121 | 5.1 | 38 | 40 | 36.6 | 12.65 | 16 |
| MW-9B | 31.3 | - | 6.74 | 3.6 | - | 6.62 | 1.18 | 2.1 |
| MW-9C | - | - | - | - | - | - | - | - |
| MW-9D | - | - | - | - | - | - | - | - |
| MW-10A | 72.5 | 86.4 | 38 | 21.5 | 16.6 | 21.63 | 30.3 | 11 |
| MW-10C | - | - | - | - | - | - | - | - |
| MW-11A | - | - | - | - | - | - | - | - |
| MW-12A | - | - | - | - | - | - | - | - |
| MW-13A | 1.6 | 1.3 | - | - | 1.2 | - | - | 1.6 |
| MW-13C | - | - | - | - | - | - | - | - |
| MW-14A | - | - | - | - | - | - | - | - |
| MW-14C | - | - | - | - | - | - | - | - |
| MW-14E | - | - | - | - | - | - | - | - |
| MW-15A | - | - | - | - | - | - | - | - |
| MW-15C | - | - | - | - | - | - | - | - |
| MW-15D | - | - | - | - | - | - | - | - |
| MW-16A | 1.64 | 1.03 | 1.3 | 2.3 | 2.2 | - | - | - |
| MW-16C | - | - | - | - | - | - | - | - |
| MW-17A | 2.6 | 2.4 | 2.5 | 2.1 | 2.6 | 4.15 | | - |
| MW-17C | - | - | - | - | - | nt | - | nt |
| MW-17D | - | - | - | - | - | - | - | nt |
| MW-18A | - | - | - | - | - | - | - | nt |
| MW-18C | - | - | - | - | - | - | - | - |
| MW-18D | - | - | - | - | - | - | - | nt |
| MW-19A | - | - | - | - | - | - | - | nt |
| MW-19C | - | - | - | - | - | - | - | - |
| MW-19D | - | - | - | - | - | - | - | nt |
| MW-20A | - | - | - | - | - | - | - | nt |
| MW-20C | - | - | - | - | - | - | - | - |
| MW-20D | - | - | - | - | - | - | - | nt |

| | |
|---|---|
| - | not detected |
| nt | not tested |
| J | estimated value |
| PCE | tetrachloroethene |
| [ ] | analyte detected at concentration above preliminary screening level |

DFT 001046

# TABLE 16
## AOC-01/02: VOC CONCENTRATIONS IN SOIL SAMPLES
## in ug/kg

| Sample ID: | BE (a) | SLABSW (a) | DG952W (a) | |
|---|---|---|---|---|
| Date Collected: | Oct-90 | Oct-90 | Oct-90 | PSL |
| Benzene | 130 | - | 22 | 220,000 |
| Ethylbenzene | - | - | 4 | 250,000 |
| Toluene | - | - | 20 | 1,400,000 |
| Xylenes [b] | 110 | 380 | 32 | NA |

(a) Soil samples collected from remaining soil at base of UST excavation (Landau 1990b)
(b) Undifferentiated xylene
PSL = preliminary screening level, see Table 3

DFT 001047

# TABLE 17
## AOC-01/02: DETECTED ANALYTES IN GROUNDWATER SAMPLES
in ug/L

| Analyte | Maximum Concentration (a) | Marine Water PSL | Fresh Water PSL |
|---|---|---|---|
| Metals | | | |
| Aluminum | 170 | na | na |
| Arsenic | 1.6 | 5 | 5 |
| Barium | 16 | na | na |
| Cadmium | 12 | 9 | 1 |
| Calcium | 17000 | na | na |
| Copper | 24 | 3.4 | 8.9 |
| Iron | 17000 | na | na |
| Magnesium | 9600 | na | na |
| Volatile Organics | | | |
| Toluene | 1.17 J | 200,000 | 200,000 |
| Xylenes (total) | 1.47 J | na | na |
| Total Petroleum Hydrocarbons | | | |
| Diesel-range | 2970 | 500 | 500 |

PSL = preliminary cleanup level, see Table 2

J = estimated value

na = not available

analyte detected at concentration above preliminary screening level

(a) Maximum concentration for groundwater sampling from 1998 to present

DFT 001048

# TABLE 19
## AOC-03/04: DETECTED ANALYTES IN GROUNDWATER SAMPLES
### in ug/L

| Analyte | Maximum Concentration | PSL |
|---|---|---|
| Volatile Organics | | |
| Acetone | 3.5 | na |
| cis-1,2-dichloroethene | 1.24 | na |
| Total Petroleum Hydrocarbons | | |
| Diesel-range | 2010 | 500 |

PSL = preliminary screening level, see Table 2
J = estimated value
na = not available
analyte detected at concentration above preliminary screening level

DFT 001049

# TABLE 20
## AOC-05: GROUNDWATER RESULTS FROM GEOPROBE SAMPLING

| | Gasoline-range Petroleum Hydrocarbons (mg/L) | Benzene (ug/L) | Toluene (ug/L) | Ethylbenzene (ug/L) | Total Xylenes (ug/L) |
|---|---|---|---|---|---|
| PSL [a] | 0.8 (b) | 71 | 200,000 | 29,000 | na |
| SB-7 Upper | 0.25 U | 5.9 | 1.0 U | 1.0 U | 7.3 |
| SB-7 Lower | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-8 Upper | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-8 Lower | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-9 Upper | 5.3 | 99 | 1.0 U | 33 | 153 |
| SB-9 Lower | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-10 Upper | 250 | 23 | 18000 | 4600 | 25000 |
| SB-10 Lower | 0.30 | 1.0 U | 7.9 | 4.4 | 26 |
| SB-11 Upper | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-11 Lower | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-12 Upper | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| SB-12 Lower | 0.25 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |

na = groundwater screening level not available
PSL = preliminary screening level, see Table 2
Analyte detected at concentration above the preliminary screening level
Groundwater samples collected in January 2001 from Geoprobe exploration, IT 2001

DFT 001050

# TABLE 21
## AOC-05: GROUNDWATER MONITORING RESULTS FOR JUNE 2001 SAMPLING EVENT
## in ug/L

| Well | Benzene | Toluene | Ethylbenzene | Xylenes (total) |
|---|---|---|---|---|
| PSL | 71 | 200,000 | 29,000 | na |
| BDC-102 | 5.33 J | 1 U | 1 U | 1.87 J |
| BDC-103 | 875 J | 12010 | 1985 J | 11430 |

PSL = preliminary screening level, see Table 2

J = estimated value

Analyte detected at concentration above the preliminary screening level

DFT 001051

APPENDIX A

# Summary of Soil and Groundwater Data for SWMUs and AOCs (Digital Format)

Over-sized page(s) removed and submitted in hard copy.

APPENDIX B

# Pump and Treat Remedial System Evaluation – SWMU 20, Landau Associates 2001

Landau Associates
Environmental and Geotechnical Services

# TECHNICAL MEMORANDUM

TO: Jim Bet & Carl Bach
The Boeing Company

FROM: Martin Powers and Jerry Ninteman

DATE June 11, 2001

**RE: PUMP AND TREAT REMEDIAL SYSTEM EVALUATION – SWMU 20**
**BOEING DEVELOPMENTAL CENTER**
**TUKWILA, WASHINGTON**

In accordance with our letter proposal dated January 5, 2001 we have completed Task 3 – Pump and Treat Remediation System Evaluation at the referenced site. In completing the task authorized, we examined the following information relative to the groundwater pump and treat system:

- Current and historical contaminant distribution (lateral and vertical) to evaluate system effectiveness in plume control and aquifer restoration. This task included preparation of volatile organic compound (VOC) concentration isopleth maps for perchloroethylene (PCE), trichloroethylene (TCE), cis-1,-2 dichloroethylene (cis-1,2-DCE), and vinyl chloride for A, B, C, and D zone monitoring wells for three different monitoring events (August 1989, January 1994, and December 2000).

- Capture zone of each extraction well within each of three depth intervals (i.e., A, B, and C Horizons) at current pumping rates. This task included preparation of one groundwater elevation contour map for the A, B, and C Horizons using data representative of non-pumping conditions and steady state pumping conditions in E-1 and E-2, and estimating the capture zone from these maps. The capture zone was compared to plume maps to evaluate plume containment.

- Appropriateness of current extraction well locations and screen depths.

- Appropriateness of alternate pumping rates or alternate pumping scenarios (e.g., cyclic pumping, or concurrent extraction from both wells) with respect to plume containment and aquifer restoration.

- Current mass removal rates, trends in mass removal, and total VOC mass removed to date.

- Natural attenuation mechanisms and effectiveness, including a comparison of current mass removal rates to potential natural attenuation rates.

In developing our conclusions for the evaluation, we reviewed data for dissolved-phase concentrations in groundwater monitoring wells located at the site (Table 1); groundwater elevation data based on historical groundwater level measurements and an elevation survey of the monitoring and extraction wells completed in February 2001 (Table 2); groundwater monitoring and extraction well construction details, as previously provided in the document entitled Groundwater Extraction and

Treatment System Assessment (Tetra Tech, August 1996) (Table 3); and VOC mass removal rates exhibited by the pump and treat system as reported by The Boeing Company (Boeing) (Table 4).

## BACKGROUND INFORMATION

Our review of the data indicates that a release of chlorinated hydrocarbons to the subsurface was initially discovered in 1989. The apparent source of the chlorinated hydrocarbons was the vapor degreaser sumps, which were in use at the facility from 1958 until 1984 and contained PCE and TCE. The presence of chlorinated hydrocarbons in the subsurface was detected during the implementation of structural improvements at the DC 9-101 building. In the spring of 1990, approximately 1,398 tons of impacted soil was removed and disposed at licensed disposal facilities. The initial groundwater sampling event was completed at the site in August 1989, after groundwater monitoring wells were installed to determine the extent of impact to the groundwater from the chlorinated hydrocarbons. Twenty-one (21) of the current groundwater monitoring wells (MW-6B, 6C, 7C, 8C, 9A, 9B, 9C, 9D, 10A, 10C, 11A, 12A, 13A, 13C, 14A, 14C, 15A, 15C, 15D, 16A, and 16C) were used for the collection of groundwater samples from 1989 to 1991. Thirteen additional groundwater monitoring wells (MW-14E, 17A, 17C, 17D, 18A, 18C, 18D, 19A, 19C, 19D, 20A, 20C, and 20D) were installed in February 1991 and one additional groundwater monitoring well (MW-21A) was installed in October 1992. The groundwater monitoring wells installed at the facility were constructed to permit evaluation of distinct layers (horizons) of the groundwater present beneath the site. The range of depths of the monitoring well screens relative to the horizon of groundwater targeted for assessment were as follows:

A Horizon Wells – Screen Depths Ranging from 6.5 to 21.5 ft below the ground surface (BGS).

B Horizon Wells – Screen Depths Ranging from 22.0 to 27.5 ft BGS.

C Horizon Wells – Screen Depths Ranging from 23.5 to 40.5 ft BGS.

D Horizon Wells – Screen Depths Ranging from 40.0 to 56.0 ft BGS.

E Horizon Well – Screen Depth Ranging from 77.0 to 82.0 ft BGS.

A, B, and C Horizon wells were intended to monitor three distinct layers of groundwater located in the shallow, unconfined aquifer beneath the site. The D Horizon wells were intended to evaluate the semi-confined layer of groundwater present beneath a discontinuous silt aquitard underlying the unconfined aquifer. The E Horizon well (MW-14E) was intended to monitor the water quality in a fully confined aquifer present beneath a massive marine silt deposit underlying the semi-confined aquifer. The

E Horizon well has not exhibited impact by chlorinated hydrocarbons in excess of laboratory detection limits since August 1997, therefore the E Horizon is not included in the evaluation contained herein.

Our assessment of the pump and treat system focuses on the chlorinated hydrocarbons PCE, TCE, cis-1,2-DCE, and vinyl chloride. These constituents are considered the primary constituents of interest (CoI) based on their concentration and frequency of detection in site monitoring wells. Data provided by Boeing indicate that two other constituents, benzene and naphthalene, are present in site groundwater at concentrations that exceed either Model Toxics Control Act (MTCA) Method A or Method B groundwater cleanup levels. However, these constituents are not considered CoI because, as of December 2000, the concentration of benzene and naphthalene exceed cleanup levels at only one well each. The December 2000 exceedances are limited to monitoring well MW-16A, which yielded a benzene concentration of 46 micrograms per liter (µg/L) compared to a Method A cleanup level of 5 µg/L, and MW-15A, which yielded a naphthalene concentration of 696 µg/L compared to a Method B cleanup level of 320 µg/L. (Comparison with MTCA cleanup levels is for screening purposes only; site-specific cleanup levels are being developed and will be included in the Site Summary Report.)

The groundwater pump and treat remediation system was installed in the fall of 1993 and began operation on March 7, 1994. The remediation system utilizes two wells (E-1 and E-2) for the extraction of impacted groundwater. E-1 was installed with a screened interval extending from approximately 23 to 38.3 ft BGS, which indicates that E-1 was capable of collecting groundwater from the A, B, and C Horizons of the shallow groundwater present beneath the site. E-1 remained in use as the sole recovery well at the site from March 4, 1994 to December 13, 1995. The second groundwater extraction well (E-2) was utilized for groundwater extraction beginning in July 1996. E-2 was constructed with well screen extending from approximately 22 to 32 ft BGS, which indicates that extraction of water from E-2 would also be within the A, B, and C Horizons of the groundwater beneath the site. Since July 1996, the extraction wells have been used alternately for extraction, with E-2 being operated for a majority of the time.

For the purpose of our evaluation, the data collected for the site was considered under two distinct scenarios prior to the activation of the remediation system and following the activation of the remediation system. Our evaluation of the data compiled for the site follows.

## CONTAMINANT DISTRIBUTION EVALUATION

Groundwater analytical data have been compiled at the site since 1989. Table 1 provides a summary of the analytical data for the primary CoI at the site. For the purpose of evaluating the distribution of chlorinated hydrocarbons over time, we have utilized the dissolved phase concentrations reported for August 1989, January 1994, and December 2000 to develop site maps showing CoI data for

the A Horizon (inclusive of the two B Horizon wells), C Horizon, and D Horizon groundwater. These site maps are presented on Figures 1A, 1-C, and 1-D through 4-A, 4-C, and 4D. The A, C, and D designation refers to the A (and B), C, and D Horizons, respectively. Figures were not prepared for the B Horizon because this horizon only contained two data points. Analytical data for PCE, TCE, cis-1,2-DCE, and vinyl chloride Figures 1 through 4, respectively.

Since the groundwater pump and treat system was not activated until March 1994, expansion or contraction of the dissolved phase plumes of CoI from August 1989 to January 1994 would be attributed to the natural attenuation of the chlorinated hydrocarbons. Natural attenuation includes non-destructive processes (adsorption, dispersion, advection, and volatilization) and destructive processes (biodegradation) to reduce the concentration and/or mass of contaminants in the groundwater. Expansion or contraction of the CoI plumes between January 1994 and December 2000 can be attributed to both natural attenuation processes and the mass removal of chlorinated hydrocarbons caused by the pump and treat system. It should be noted that the overall extent of the dissolved phase plumes (i.e., the 1 μg/L contour area) appears to increase significantly between 1989 and 1994. However, the increase in the estimated size of the plumes can be at least partially attributed to the fact that 14 groundwater monitoring wells were installed after August 1989, thus providing additional data points to more clearly estimate the plume's fringe areas.

**Data Evaluation - August 1989 to January 1994**

The evaluation of data for the period from August 1989 to January 1994 was completed based on the information provided on Figures 1 through 4. A comparison of August 1989 and January 1994 isopleth maps for the same constituent indicates that the lateral extent of dissolved phase PCE, TCE, and cis-1,2-DCE in excess of 100 μg/L decreased or did not change during this period in the A and C Horizons (the arbitrary cutoff concentration of 100 μg/L was used in this analysis as a representative indicator of the plume extent). None of the CoI exceeded 100 μg/L in the D Horizon in either 1989 or 1994. The extent of the 100 μg/L isopleth of dissolved phase vinyl chloride increased during this period. To quantify the change in area of the groundwater impacted by the CoI in excess of 100 μg/L, we estimated the area of the plumes with concentrations of CoI greater than 100 μg/L for the A and C Horizons. The estimated percentage of variation in the area of groundwater impacted by each CoI in excess of 100 μg/L from August 1989 to January 1994 was then quantified as shown in Table 5. As indicated in Table 5, the area of groundwater impacted by 100 μg/L of the CoI appeared to change from August 1989 to January 1994 as follows:

- PCE impact greater than 100 µg/L decreased by 12 percent in the A Horizon and 100 percent (to less than 100 µg/L) in the C Horizon

- TCE impact greater than 100 µg/L decreased by 8 percent in the A Horizon and 100 percent in the C Horizon

- cis-1,2-DCE impact greater than 100 µg/L decreased by 33 percent in the A Horizon and 79 percent in the C Horizon

- Vinyl chloride impact greater than 100 µg/L increased by 121 percent in the C Horizon; the area of the A Horizon containing vinyl chloride concentrations above 100 µg/L went from 0 square feet ($ft^2$) in 1989 to approximately 3100 $ft^2$ in 1994.

The data indicates that the effects of natural attenuation processes had a positive impact on the reduction of concentrations of CoI in the saturated zone, especially in the C Horizon. The increase of vinyl chloride concentrations and decrease in PCE and TCE concentrations is often observed in plumes in which reductive dechlorination processes are active. Reductive dechlorination is the primary biodegradation pathway for the more highly chlorinated hydrocarbons (e.g., PCE and TCE). After the PCE and TCE are sufficiently reduced, the biodegradation process often shifts to an alternative mechanism such as aerobic oxidation, iron reduction, methanogenesis, or cometabolism to continue the destruction of the less chlorinated compounds (e.g., cis-1,2-DCE and vinyl chloride).

**Data Evaluation - January 1994 to December 2000**

The evaluation of data for the period from January 1994 to December 2000 was completed based on the information provided on Figures 1 through 4. A comparison of January 1994 and December 2000 isopleth maps for the same constituent indicates that the lateral and vertical extent of dissolved phase PCE, TCE, cis-1,2 DCE, and vinyl chloride in excess of 100 µg/L decreased significantly during this period. To quantify the change in area of the groundwater impacted by the CoI in excess of 100 µg/L, we estimated the area of the plumes with concentrations of CoI greater than 100 µg/L for the A and C Horizons. The estimated percentage of variation in the area of groundwater impacted by each CoI in excess of 100 µg/L from January 1994 to December 2000 was then quantified as shown in Table 5. As indicated in Table 5, the area of groundwater impacted by 100 µg/L of the CoI appeared to change from January 1994 to December 2000 as follows:

- PCE impact greater than 100 ppb decreased by 100 percent in the A Horizon; PCE concentrations equal to or greater than 100 µg/L were not detected in the C Horizon in 1994 or 2000

- TCE impact greater than 100 ppb decreased by 100 percent in the A Horizon; TCE concentrations equal to or greater than 100 µg/L were not detected in the C Horizon in 1994 or 2000

- cis-1,2 DCE impact greater than 100 ppb decreased by 100 percent in the A Horizon and 100 percent in the C Horizon
- Vinyl chloride impact greater than 100 ppb decreased by 95 percent in the A Horizon and 100 percent in the C Horizon.

The data indicate that the effects of groundwater pump and treat and natural attenuation processes had a positive impact on the reduction of concentrations of CoI in the saturated zone and resulted in a greater reduction in plume extent, as defined by the 100 µg/L isopleth, as compared to the non-pumping period from 1989 to 1994. The long-term reduction of CoI concentrations could be verified by discontinuing pumping activities for at least 6 months and allowing the VOCs in the groundwater and soil system to equilibrate. At some sites, allowing the VOC distribution to return to equilibrium following interruption of pumping has caused a rebound in the VOC concentrations. This is especially true where a non-aqueous phase liquid (NAPL) source area is present.

## CAPTURE ZONE ANALYSIS

Capture zones for groundwater in the A, B, and C Horizons were estimated for the groundwater pump and treat system by preparing groundwater elevation contour maps under various pumping conditions. A groundwater elevation contour map representative of non-pumping conditions was also prepared to evaluate natural groundwater flow gradients and flow directions. A summary of the groundwater elevation data used in this analysis is provided in Table 2. The A, B, and C Horizon groundwater monitoring wells are screened within the same surficial aquifer and the groundwater extraction wells are screened in the A, B, and C Horizons. Where available, groundwater elevation data collected from the A Horizon wells was considered preferentially over B and C Horizon data in developing the groundwater elevation maps utilized for capture zone analysis, in order to minimize the effects of vertical gradients.

The entire groundwater extraction system was reported to be inactive from December 1995 until July 1996. The groundwater elevation data from the A, B, and C Horizons in February 1996 is presented on Figure 5 to represent the groundwater elevation (potentiometric) surface for the surficial aquifer beneath the site under non-pumping conditions. As shown on Figure 5, the natural (i.e., non-pumping) groundwater flow gradient and direction is non-uniform within the study area. Groundwater generally exhibits an overall west, southwesterly flow direction across the study area with the exception of the area to the northwest of extraction wells E1 and E2 which appears to exhibit an easterly flow direction. This flow reversal is caused by an anomalously high groundwater level in MW-19A and MW-19C. An overall west, southwesterly flow direction would be expected given that this is the direction toward the Duwamish Waterway.

Groundwater extraction well E-1 was used exclusively for groundwater extraction from March 1994 to December 1995. The groundwater elevation data from the A, B, and C Horizons in October 1995 is provided on Figure 6 to represent the potentiometric surface for the surficial aquifer under the influence of groundwater extraction from E-1 alone. Groundwater extraction well E-2 was used exclusively for groundwater extraction from March 1999 to December 2000. The groundwater elevation data from the A, B, and C Horizons in December 2000 is provided on Figure 7 to represent the potentiometric surface for the surficial aquifer under the influence of groundwater extraction from E-2 alone. The apparent effect on the groundwater flow direction created by the operation of the groundwater extraction wells is exhibited on Figures 6 and 7. Based on the altered groundwater flow direction caused by the operation of the extraction wells, the independent operation of each of the groundwater extraction wells is sufficient to limit plume migration. Each of the groundwater extraction wells appears to create a capture zone that encompasses the full extent of groundwater impacted by CoI in excess of 1 μg/L in the A, B, and C Horizons. The D Horizon groundwater was not evaluated because the extraction wells are not screened within the D Horizon and the data do not indicate that the groundwater is significantly impacted in the D Horizon.

## MASS REMOVAL RATE EVALUATION FOR PUMP AND TREAT SYSTEM

Boeing provided data related to the mass of contaminants removed by the groundwater pump and treat system. The mass removal data is summarized in Table 4. As indicated in Table 4, the pump and treat remediation system has removed approximately 80 lbs of total chlorinated hydrocarbons from the subsurface of the site from March 7, 1994 to September 21, 2000. The average daily mass removal rate for the groundwater pump and treat system was approximately 0.05 lbs per day (22 grams per day) during the period analyzed. The average daily mass removal rate does not take into consideration periods of time when the pump and treat system was offline (i.e., the average daily mass removal rate would be slightly higher if the total mass removed was divided only by the number of days in which the system was online). Of the 80 lbs of chlorinated hydrocarbons estimated to have been removed by the pump and treat system, approximately 70 lbs (88 percent of the total mass removed) were removed prior to 1999. During the past two years (January 1999 through September 2000) approximately 10 lbs (12 percent of the total mass removed) has been extracted by the pump and treat system. The total mass of chlorinated hydrocarbons extracted by the pump and treat system has been steadily declining since 1997 due to a decline in the concentration of CoI present in the groundwater recovered by the pump and treat remediation system (Figure 8).

The data observed relevant to mass removal is typical for groundwater pump and treat systems. During the initial stages of operation of a groundwater pump and treat system, the groundwater being

recovered for treatment has a relatively high concentration of dissolved phase CoI. However, as the operation of the groundwater pump and treat system continues, the concentration of dissolved phase CoI is limited by the rate at which the CoI become "desorbed" from the saturated zone soil particles. The concentration of dissolved phase CoI in the recovered groundwater is related to the amount of contact time between the soil particles and the groundwater to be recovered. The groundwater pump and treat system limits the contact time between the soil particles and the groundwater and reduces the mass of CoI that can transferred from the soil particles to the groundwater, thus resulting in lower dissolved phase contaminant concentrations. In an effort to increase the mass removal efficiency, the operation of pump and treat systems is often cycled to allow the groundwater to periodically equilibrate and cause "washing" of CoI from the soil matrix within the groundwater table. If the operation of the groundwater pump and treat remediation system is to continue, cyclic operation of the pumps on a weekly basis may improve the mass removal efficiency.

## NATURAL ATTENUATION EVALUATION

According to the United States Environmental Protection Agency (USEPA) – Office of Solid Waste and Emergency Response (OSWER), three lines of evidence can be used to verify natural attenuation of chlorinated hydrocarbons. The lines of evidence identified by OSWER Directive 9200.4-17 (1997) are as follows:

1. *Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. (In the case of a ground water plume, decreasing concentrations should not be solely the result of plume migration.)*

2. *Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels. For example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the rates of biological degradation processes occurring at the site.*

3. *Data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).*

The OSWER directive also states that "*Unless EPA or the implementing state agency determines that historical data (Number 1 above) are of sufficient quality and duration to support a decision to use monitored natural attenuation, EPA expects that data characterizing the nature and rates of natural attenuation processes at the site (Number 2 above) should be provided. Where the latter are also inadequate or inconclusive, data from microcosm studies (Number 3 above) may also be necessary.*

*In general, more supporting information may be required to demonstrate the efficacy of monitored natural attenuation ... at sites with contaminants that transform into more toxic and/or mobile forms than the parent contaminant."* This final statement is applicable to PCE, TCE, and cis-1,2 DCE ultimately degrading to vinyl chloride.

In consideration of the need to verify the first two lines of evidence listed above, the occurrence of natural attenuation may be evaluated at a site by performing the following steps:

**Step 1 – Evaluate the potential for natural attenuation to be effective at a site**

This step requires an evaluation of several data sets. The initial data set to be evaluated is the concentration of the CoI over time. If natural attenuation processes are to be considered as a viable remediation alternative, the concentration of the CoI should be decreasing over time primarily as a result of natural biodegradation processes. In sites impacted with PCE or TCE, the production of biodegradation breakdown products (cis-1,2-DCE and vinyl chloride) provide the most reliable indication that natural biodegradation processes are active at the site. A second set of data that must be considered in this step is the presence of potential receptors (e.g., potable water wells, surface water bodies, subsurface structures, etc.) located within the plume area. A third data set to be considered is the natural groundwater gradient and velocity exhibited by the impacted groundwater to assist in predicting if a potential receptor could be impacted in the future by the plume as it migrates before natural attenuation processes can effectively reduce concentrations to protect the receptor.

Sufficient CoI data have been collected at the site to indicate that the transformation of parent compounds PCE and TCE to breakdown products of cis-1,2-DCE and vinyl chloride occurs and that this attenuation process has resulted in a reduction in the concentration and extent of the CoI plumes at the site. In relation to the presence of potential receptors at the site and potential impact to potential receptors within the extent of the plume area and downgradient, the following conclusions have been derived:

- No potential receptors were identified within the plume area.
- The nearest downgradient potential receptor (The Duwamish Waterway) was identified to be approximately 500 ft west of the former source area of the plume. Groundwater analyses for CoI indicate that the dissolved-phase plume has not extended beyond 200 ft downgradient (west-southwest) from the source area.

It is likely that the reduction of the CoI plumes is due to a combination of the effects of natural attenuation and the groundwater pump and treat system. This decline can be qualitatively evaluated by comparing the plume maps presented on Figures 1 through 4.

**Step 2 –Identify the natural attenuation mechanisms at the site**

This step is completed after it has been determined that there is evidence that natural attenuation processes are likely having a positive impact on the reduction of the CoI plume. The key data to be evaluated during this step are geochemical parameters that may indicate the driving force behind biodegradation activity at the site. As stated earlier, reductive dechlorination processes appear to be ongoing at the site based on the reduction of PCE and TCE concentrations and the presence of cis-1,2-DCE and vinyl chloride. However, sufficient geochemical data has not been collected for the site to conclusively determine the actual mechanism(s) responsible for the reductive dechlorination processes. Reductive dechlorination has been demonstrated at other sites under nitrate and iron reducing conditions, but the most rapid biodegradation rates, affecting the widest range of chlorinated aliphatic hydrocarbons, occur under sulfate-reducing and methanogenic conditions (Bouwer, 1994).

In our experience, it is likely that reductive dechlorination at the site is occurring under methanogenic conditions because of the presence of vinyl chloride. Sites undergoing reductive dechlorination under sulfate-reducing conditions often do not progress beyond the degradation of TCE and subsequent formation of cis-1,2-DCE and therefore lack significant concentrations of vinyl chloride. Additional site geochemical data would be needed to demonstrate the actual reductive dechlorination process. Geochemical parameters that would be indicative of reductive dechlorination include a reduction in the concentration of sulfate or nitrate within the impacted area or an increase in the concentration of ferrous iron (iron II), methane, ethane/ethene or chloride ion in the impacted area.

Following the reduction of PCE and TCE, the continued biodegradation of the remaining CoI (cis-1,2-DCE and vinyl chloride) often is continued by oxidation-reduction mechanisms which are typically aerobic respiration, iron reduction, or methanogenesis. Evidence of these biodegradation processes would typically be confirmed by a depletion of dissolved oxygen within the impacted area or an increase of ferrous iron, methane, ethane/ethene or chloride ion within the impacted area.

In addition to the specific evidence referenced for biodegradation of PCE, TCE, cis-1,2-DCE, and vinyl chloride, there are conventional parameters that can indicate microbiological activity. These parameters include oxidation-reduction potential, alkalinity, conductivity, carbon dioxide concentration, temperature, and pH in groundwater. In addition, a sufficient carbon source must be present to continue the biodegradation process. The availability of carbon can be determined by analyzing the groundwater for total organic carbon (TOC) content.

**Step 3 –Estimate the attenuation rate of CoI for the site**

Following the completion of the initial two steps involved with the natural attenuation evaluation, it is often necessary to estimate the rate of attenuation of the CoI present in the subsurface. Estimating the

rate of attenuation may be simplistic (e.g., regression analysis to determine the attenuation rate observed due to natural processes) or more sophisticated (e.g., implementation of a three-dimensional groundwater model for the site). The goal of estimating the rate of attenuation is to predict whether cleanup level goals can be obtained within a reasonable timeframe and within an acceptable distance downgradient of the release area at identified "sentinel" wells. Accurate predictions of CoI concentrations in sentinel wells that are also protective of human health and the environment are key to gaining regulatory approval for the use of natural attenuation as a remediation method for the site.

Attenuation rates are typically calculated by observing the rate at which a contaminant concentration decreases with distance downgradient along a groundwater migration pathway. The data are typically fitted to a first order exponential decay equation and a regression analysis is performed to obtain the rate constant (for example, see USEPA 1998). Methods are available to separate the affects of non-biological processes (e.g., adsorption, dispersion, advection, and volatilization) from biological processes. Such an evaluation requires knowledge of the groundwater flow velocity and direction and contaminant concentration data from several monitoring points located along a common migration pathway. Because knowledge of these conditions does not exist for this site to the level needed to conduct such an evaluation, a modified evaluation was conducted with the objective of comparing the relative rate of contaminant concentration reduction for the non-pumping period (i.e., 1989 to 1994) to the relative rate of contaminant concentration reduction for the pumping period (i.e., 1994 to 2000). The evaluation consisted of calculating the rate at which CoI concentrations decreased with time at site monitoring wells during the non-pumping and pumping periods. The rate was obtained by plotting the natural logarithm of the concentration of specific contaminants (normalized to the starting concentration) versus time.

Separate graphs were prepared for select groundwater monitoring wells for the active pumping and non-pumping scenarios. Following the graphing of the contaminant concentration as described, a linear regression analysis was performed on each graph to determine the rate of contaminant reduction exhibited in each of the wells for the specific CoI. These graphs are presented in Attachment 1. A summary of the CoI reduction rate estimates is presented in Table 6. The calculated contaminant reduction rates consider the reduction in contaminant concentrations due to the combined affect of the non-destructive (advection, dispersion, etc.) and destructive (biodegradation) components of natural attenuation and, for the 1994 to 2000 period, the reduction caused by the operation of the pump and treat system.

The following conclusions were derived from information presented in Table 6, based on comparisons of the rate of contaminant reduction under non-pumping and pumping scenarios:

- The rate of PCE concentration reduction was greater in the non-pumping scenario in 6 out of 8 wells that could be compared
- The rate of TCE concentration reduction was greater in the non-pumping scenario in 6 out of 9 wells that could be compared
- The rate of cis-1,2 DCE concentration reduction was greater in the non-pumping scenario in 5 out of 10 wells that could be compared
- The rate of vinyl chloride concentration reduction was greater in the pumping scenario in 10 out of 10 wells that could be compared.

These results indicate that, with the exception of vinyl chloride, the rate of concentration reduction during non-pumping conditions was at least as great as the rate of concentration reduction during pumping conditions and in fact was significantly higher during non-pumping conditions for PCE and TCE. This trend is consistent with the expected trend given that the more highly oxidized chlorinated compounds (e.g., PCE and TCE) are more readily degraded under reductive dechlorination conditions.

The calculation of average concentration reduction rates for each CoI (see Table 6) allows an average half-life value to be calculated for each CoI. The half life is a term used to represent the amount of time necessary for the concentration of a compound to reach a concentration equal to one-half the concentrations measured at time zero. Therefore, the half life can be used to estimate how long it will take for the concentrations of CoI in the plume measured in December 2000 to decrease to concentrations equal to approximately one-half of the December 2000 concentrations, assuming the reduction rate does not change and CoI concentrations do not rebound after the pump and treat system is turned off. Based on this evaluation, natural attenuation processes (without the assistance of the pump and treat system) could remove 50 percent of the remaining PCE, TCE, and cis-1,2-DCE mass present in the saturated zone within the next 2 to 3 years. The production of vinyl chloride will continue to decline as concentrations of the parent compounds decline.

**Step 4 – Monitor site and validate attenuation rate estimates**

After an estimated attenuation rate for CoI is developed for a site, the predicted sentinel well concentrations must be validated by continuing to collect groundwater analytical data. Typically, the attenuation rate predictions are validated by collecting groundwater samples at sentinel wells to compare actual CoI concentrations to predicted CoI concentrations. In the event that a significant discrepancy is observed between the predicted and the actual CoI concentrations, it may be necessary to re-evaluate the attenuation rate at the site and collect additional biodegradation parameters. In the event that the predicted sentinel well concentrations are proven to be accurate over a period of time, typically 1 to 2 years, and it appears that potential receptors will not be impacted by the plume, closure may be

requested from the regulatory agency. The closure approval from the regulatory agency is often contingent upon the completion of an extended monitoring program that will provide additional data relevant to the effectiveness of natural attenuation in achieving site specific clean-up criteria. The length and frequency of the long term monitoring can often be negotiated with the regulatory agency.

## CONCLUSIONS AND RECOMMENDATIONS

The data presented and discussed herein lead to the following conclusions:

- Concentrations of PCE, TCE, and cis-1,2-DCE in groundwater steadily declined since groundwater monitoring began in August 1989 until January 1994, apparently due to the effects of natural attenuation.

- The production of breakdown products (cis-1,2-DCE and vinyl chloride) in conjunction with the decline in PCE and TCE concentrations under non-pumping conditions indicate that natural biodegradation processes (i.e., reductive dechlorination) are active at the site.

- The capture zone evaluation of the current pump and treat system indicates that it is effectively controlling plume migration.

- The influent concentration of the groundwater recovered by the pump and treat system has been declining significantly over the past 2 years. As of September 2000, approximately 88 percent of the total mass of CoI removed by the pump and treat remediation system was removed prior to 1999.

- The extent of the PCE, TCE, and cis-1,2-DCE plumes (as measured by the 100 μg/L isopleth) decreased more rapidly under pumping conditions in comparison to non-pumping conditions, however, the rate of PCE and TCE concentration reduction appeared to be greater under non-pumping conditions.

- During both pumping and non-pumping periods, the lateral extent of CoI greater than 1 μg/L was fully contained within site boundaries.

Based on the evidence provided in this memorandum documenting the effectiveness of natural attenuation at this site, combined with previous source control measures (soil excavation and pump and treat operation), lack of potential receptors, and historical data indicating a downgradient plume of limited extent, we recommend requesting approval from Ecology to shut down the pump and treat system and monitor groundwater over a minimum six month period to evaluate whether VOC concentrations rebound in site groundwater. Discontinuation of the groundwater pump and treat system is further supported by considering the significant amount of energy resources expended to operate the system (approximately 130 kilowatt-hours per day) for a minimal amount of VOCs currently being removed by the system (approximately 0.3 pounds per day based on January 2000 through September 2000). A technical memorandum outlining the proposed discontinuation of the pump and treat system and the subsequent groundwater monitoring schedule should be prepared and submitted to Ecology for approval. The pump

and treat system should remain at the site in a standby mode. The technical memorandum outlining the steps to be completed for shut down of the system should include a contingency plan for restarting the pump and treat system in the event that monitoring indicates that natural attenuation processes are not effective in maintaining acceptable concentrations within the site boundary. Following the six month period after system shut down, groundwater data should be evaluated to develop a final remedy for the site.

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APPENDIX B

# Pump and Treat Remedial System Evaluation – SWMU 20, Landau Associates 2001

Landau Associates
Environmental and Geotechnical Services

# TECHNICAL MEMORANDUM

TO: Jim Bet & Carl Bach
The Boeing Company

FROM: Martin Powers and Jerry Ninteman

DATE June 11, 2001

**RE: PUMP AND TREAT REMEDIAL SYSTEM EVALUATION – SWMU 20**
**BOEING DEVELOPMENTAL CENTER**
**TUKWILA, WASHINGTON**

In accordance with our letter proposal dated January 5, 2001 we have completed Task 3 – Pump and Treat Remediation System Evaluation at the referenced site. In completing the task authorized, we examined the following information relative to the groundwater pump and treat system:

- Current and historical contaminant distribution (lateral and vertical) to evaluate system effectiveness in plume control and aquifer restoration. This task included preparation of volatile organic compound (VOC) concentration isopleth maps for perchloroethylene (PCE), trichloroethylene (TCE), cis-1,-2 dichloroethylene (cis-1,2-DCE), and vinyl chloride for A, B, C, and D zone monitoring wells for three different monitoring events (August 1989, January 1994, and December 2000).

- Capture zone of each extraction well within each of three depth intervals (i.e., A, B, and C Horizons) at current pumping rates. This task included preparation of one groundwater elevation contour map for the A, B, and C Horizons using data representative of non-pumping conditions and steady state pumping conditions in E-1 and E-2, and estimating the capture zone from these maps. The capture zone was compared to plume maps to evaluate plume containment.

- Appropriateness of current extraction well locations and screen depths.

- Appropriateness of alternate pumping rates or alternate pumping scenarios (e.g., cyclic pumping, or concurrent extraction from both wells) with respect to plume containment and aquifer restoration.

- Current mass removal rates, trends in mass removal, and total VOC mass removed to date.

- Natural attenuation mechanisms and effectiveness, including a comparison of current mass removal rates to potential natural attenuation rates.

In developing our conclusions for the evaluation, we reviewed data for dissolved-phase concentrations in groundwater monitoring wells located at the site (Table 1); groundwater elevation data based on historical groundwater level measurements and an elevation survey of the monitoring and extraction wells completed in February 2001 (Table 2); groundwater monitoring and extraction well construction details, as previously provided in the document entitled Groundwater Extraction and

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Treatment System Assessment (Tetra Tech, August 1996) (Table 3); and VOC mass removal rates exhibited by the pump and treat system as reported by The Boeing Company (Boeing) (Table 4).

## BACKGROUND INFORMATION

Our review of the data indicates that a release of chlorinated hydrocarbons to the subsurface was initially discovered in 1989. The apparent source of the chlorinated hydrocarbons was the vapor degreaser sumps, which were in use at the facility from 1958 until 1984 and contained PCE and TCE. The presence of chlorinated hydrocarbons in the subsurface was detected during the implementation of structural improvements at the DC 9-101 building. In the spring of 1990, approximately 1,398 tons of impacted soil was removed and disposed at licensed disposal facilities. The initial groundwater sampling event was completed at the site in August 1989, after groundwater monitoring wells were installed to determine the extent of impact to the groundwater from the chlorinated hydrocarbons. Twenty-one (21) of the current groundwater monitoring wells (MW-6B, 6C, 7C, 8C, 9A, 9B, 9C, 9D, 10A, 10C, 11A, 12A, 13A, 13C, 14A, 14C, 15A, 15C, 15D, 16A, and 16C) were used for the collection of groundwater samples from 1989 to 1991. Thirteen additional groundwater monitoring wells (MW-14E, 17A, 17C, 17D, 18A, 18C, 18D, 19A, 19C, 19D, 20A, 20C, and 20D) were installed in February 1991 and one additional groundwater monitoring well (MW-21A) was installed in October 1992. The groundwater monitoring wells installed at the facility were constructed to permit evaluation of distinct layers (horizons) of the groundwater present beneath the site. The range of depths of the monitoring well screens relative to the horizon of groundwater targeted for assessment were as follows:

A Horizon Wells – Screen Depths Ranging from 6.5 to 21.5 ft below the ground surface (BGS).

B Horizon Wells – Screen Depths Ranging from 22.0 to 27.5 ft BGS.

C Horizon Wells – Screen Depths Ranging from 23.5 to 40.5 ft BGS.

D Horizon Wells – Screen Depths Ranging from 40.0 to 56.0 ft BGS.

E Horizon Well – Screen Depth Ranging from 77.0 to 82.0 ft BGS.

A, B, and C Horizon wells were intended to monitor three distinct layers of groundwater located in the shallow, unconfined aquifer beneath the site. The D Horizon wells were intended to evaluate the semi-confined layer of groundwater present beneath a discontinuous silt aquitard underlying the unconfined aquifer. The E Horizon well (MW-14E) was intended to monitor the water quality in a fully confined aquifer present beneath a massive marine silt deposit underlying the semi-confined aquifer. The

E Horizon well has not exhibited impact by chlorinated hydrocarbons in excess of laboratory detection limits since August 1997, therefore the E Horizon is not included in the evaluation contained herein.

Our assessment of the pump and treat system focuses on the chlorinated hydrocarbons PCE, TCE, cis-1,2-DCE, and vinyl chloride. These constituents are considered the primary constituents of interest (CoI) based on their concentration and frequency of detection in site monitoring wells. Data provided by Boeing indicate that two other constituents, benzene and naphthalene, are present in site groundwater at concentrations that exceed either Model Toxics Control Act (MTCA) Method A or Method B groundwater cleanup levels. However, these constituents are not considered CoI because, as of December 2000, the concentration of benzene and naphthalene exceed cleanup levels at only one well each. The December 2000 exceedances are limited to monitoring well MW-16A, which yielded a benzene concentration of 46 micrograms per liter (µg/L) compared to a Method A cleanup level of 5 µg/L, and MW-15A, which yielded a naphthalene concentration of 696 µg/L compared to a Method B cleanup level of 320 µg/L. (Comparison with MTCA cleanup levels is for screening purposes only; site-specific cleanup levels are being developed and will be included in the Site Summary Report.)

The groundwater pump and treat remediation system was installed in the fall of 1993 and began operation on March 7, 1994. The remediation system utilizes two wells (E-1 and E-2) for the extraction of impacted groundwater. E-1 was installed with a screened interval extending from approximately 23 to 38.3 ft BGS, which indicates that E-1 was capable of collecting groundwater from the A, B, and C Horizons of the shallow groundwater present beneath the site. E-1 remained in use as the sole recovery well at the site from March 4, 1994 to December 13, 1995. The second groundwater extraction well (E-2) was utilized for groundwater extraction beginning in July 1996. E-2 was constructed with well screen extending from approximately 22 to 32 ft BGS, which indicates that extraction of water from E-2 would also be within the A, B, and C Horizons of the groundwater beneath the site. Since July 1996, the extraction wells have been used alternately for extraction, with E-2 being operated for a majority of the time.

For the purpose of our evaluation, the data collected for the site was considered under two distinct scenarios prior to the activation of the remediation system and following the activation of the remediation system. Our evaluation of the data compiled for the site follows.

## CONTAMINANT DISTRIBUTION EVALUATION

Groundwater analytical data have been compiled at the site since 1989. Table 1 provides a summary of the analytical data for the primary CoI at the site. For the purpose of evaluating the distribution of chlorinated hydrocarbons over time, we have utilized the dissolved phase concentrations reported for August 1989, January 1994, and December 2000 to develop site maps showing CoI data for

the A Horizon (inclusive of the two B Horizon wells), C Horizon, and D Horizon groundwater. These site maps are presented on Figures 1A, 1-C, and 1-D through 4-A, 4-C, and 4D. The A, C, and D designation refers to the A (and B), C, and D Horizons, respectively. Figures were not prepared for the B Horizon because this horizon only contained two data points. Analytical data for PCE, TCE, cis-1,2-DCE, and vinyl chloride Figures 1 through 4, respectively.

Since the groundwater pump and treat system was not activated until March 1994, expansion or contraction of the dissolved phase plumes of CoI from August 1989 to January 1994 would be attributed to the natural attenuation of the chlorinated hydrocarbons. Natural attenuation includes non-destructive processes (adsorption, dispersion, advection, and volatilization) and destructive processes (biodegradation) to reduce the concentration and/or mass of contaminants in the groundwater. Expansion or contraction of the CoI plumes between January 1994 and December 2000 can be attributed to both natural attenuation processes and the mass removal of chlorinated hydrocarbons caused by the pump and treat system. It should be noted that the overall extent of the dissolved phase plumes (i.e., the 1 µg/L contour area) appears to increase significantly between 1989 and 1994. However, the increase in the estimated size of the plumes can be at least partially attributed to the fact that 14 groundwater monitoring wells were installed after August 1989, thus providing additional data points to more clearly estimate the plume's fringe areas.

**Data Evaluation - August 1989 to January 1994**

The evaluation of data for the period from August 1989 to January 1994 was completed based on the information provided on Figures 1 through 4. A comparison of August 1989 and January 1994 isopleth maps for the same constituent indicates that the lateral extent of dissolved phase PCE, TCE, and cis-1,2-DCE in excess of 100 µg/L decreased or did not change during this period in the A and C Horizons (the arbitrary cutoff concentration of 100 µg/L was used in this analysis as a representative indicator of the plume extent). None of the CoI exceeded 100 µg/L in the D Horizon in either 1989 or 1994. The extent of the 100 µg/L isopleth of dissolved phase vinyl chloride increased during this period. To quantify the change in area of the groundwater impacted by the CoI in excess of 100 µg/L, we estimated the area of the plumes with concentrations of CoI greater than 100 µg/L for the A and C Horizons. The estimated percentage of variation in the area of groundwater impacted by each CoI in excess of 100 µg/L from August 1989 to January 1994 was then quantified as shown in Table 5. As indicated in Table 5, the area of groundwater impacted by 100 µg/L of the CoI appeared to change from August 1989 to January 1994 as follows:

- PCE impact greater than 100 μg/L decreased by 12 percent in the A Horizon and 100 percent (to less than 100 μg/L) in the C Horizon

- TCE impact greater than 100 μg/L decreased by 8 percent in the A Horizon and 100 percent in the C Horizon

- cis-1,2-DCE impact greater than 100 μg/L decreased by 33 percent in the A Horizon and 79 percent in the C Horizon

- Vinyl chloride impact greater than 100 μg/L increased by 121 percent in the C Horizon; the area of the A Horizon containing vinyl chloride concentrations above 100 μg/L went from 0 square feet ($ft^2$) in 1989 to approximately 3100 $ft^2$ in 1994.

The data indicates that the effects of natural attenuation processes had a positive impact on the reduction of concentrations of CoI in the saturated zone, especially in the C Horizon. The increase of vinyl chloride concentrations and decrease in PCE and TCE concentrations is often observed in plumes in which reductive dechlorination processes are active. Reductive dechlorination is the primary biodegradation pathway for the more highly chlorinated hydrocarbons (e.g., PCE and TCE). After the PCE and TCE are sufficiently reduced, the biodegradation process often shifts to an alternative mechanism such as aerobic oxidation, iron reduction, methanogenesis, or cometabolism to continue the destruction of the less chlorinated compounds (e.g., cis-1,2-DCE and vinyl chloride).

**Data Evaluation - January 1994 to December 2000**

The evaluation of data for the period from January 1994 to December 2000 was completed based on the information provided on Figures 1 through 4. A comparison of January 1994 and December 2000 isopleth maps for the same constituent indicates that the lateral and vertical extent of dissolved phase PCE, TCE, cis-1,2 DCE, and vinyl chloride in excess of 100 μg/L decreased significantly during this period. To quantify the change in area of the groundwater impacted by the CoI in excess of 100 μg/L, we estimated the area of the plumes with concentrations of CoI greater than 100 μg/L for the A and C Horizons. The estimated percentage of variation in the area of groundwater impacted by each CoI in excess of 100 μg/L from January 1994 to December 2000 was then quantified as shown in Table 5. As indicated in Table 5, the area of groundwater impacted by 100 μg/L of the CoI appeared to change from January 1994 to December 2000 as follows:

- PCE impact greater than 100 ppb decreased by 100 percent in the A Horizon; PCE concentrations equal to or greater than 100 μg/L were not detected in the C Horizon in 1994 or 2000

- TCE impact greater than 100 ppb decreased by 100 percent in the A Horizon; TCE concentrations equal to or greater than 100 μg/L were not detected in the C Horizon in 1994 or 2000

Groundwater extraction well E-1 was used exclusively for groundwater extraction from March 1994 to December 1995. The groundwater elevation data from the A, B, and C Horizons in October 1995 is provided on Figure 6 to represent the potentiometric surface for the surficial aquifer under the influence of groundwater extraction from E-1 alone. Groundwater extraction well E-2 was used exclusively for groundwater extraction from March 1999 to December 2000. The groundwater elevation data from the A, B, and C Horizons in December 2000 is provided on Figure 7 to represent the potentiometric surface for the surficial aquifer under the influence of groundwater extraction from E-2 alone. The apparent effect on the groundwater flow direction created by the operation of the groundwater extraction wells is exhibited on Figures 6 and 7. Based on the altered groundwater flow direction caused by the operation of the extraction wells, the independent operation of each of the groundwater extraction wells is sufficient to limit plume migration. Each of the groundwater extraction wells appears to create a capture zone that encompasses the full extent of groundwater impacted by CoI in excess of 1 μg/L in the A, B, and C Horizons. The D Horizon groundwater was not evaluated because the extraction wells are not screened within the D Horizon and the data do not indicate that the groundwater is significantly impacted in the D Horizon.

## MASS REMOVAL RATE EVALUATION FOR PUMP AND TREAT SYSTEM

Boeing provided data related to the mass of contaminants removed by the groundwater pump and treat system. The mass removal data is summarized in Table 4. As indicated in Table 4, the pump and treat remediation system has removed approximately 80 lbs of total chlorinated hydrocarbons from the subsurface of the site from March 7, 1994 to September 21, 2000. The average daily mass removal rate for the groundwater pump and treat system was approximately 0.05 lbs per day (22 grams per day) during the period analyzed. The average daily mass removal rate does not take into consideration periods of time when the pump and treat system was offline (i.e., the average daily mass removal rate would be slightly higher if the total mass removed was divided only by the number of days in which the system was online). Of the 80 lbs of chlorinated hydrocarbons estimated to have been removed by the pump and treat system, approximately 70 lbs (88 percent of the total mass removed) were removed prior to 1999. During the past two years (January 1999 through September 2000) approximately 10 lbs (12 percent of the total mass removed) has been extracted by the pump and treat system. The total mass of chlorinated hydrocarbons extracted by the pump and treat system has been steadily declining since 1997 due to a decline in the concentration of CoI present in the groundwater recovered by the pump and treat remediation system (Figure 8).

The data observed relevant to mass removal is typical for groundwater pump and treat systems. During the initial stages of operation of a groundwater pump and treat system, the groundwater being

*In general, more supporting information may be required to demonstrate the efficacy of monitored natural attenuation ... at sites with contaminants that transform into more toxic and/or mobile forms than the parent contaminant."* This final statement is applicable to PCE, TCE, and cis-1,2 DCE ultimately degrading to vinyl chloride.

In consideration of the need to verify the first two lines of evidence listed above, the occurrence of natural attenuation may be evaluated at a site by performing the following steps:

**Step 1 – Evaluate the potential for natural attenuation to be effective at a site**

This step requires an evaluation of several data sets. The initial data set to be evaluated is the concentration of the CoI over time. If natural attenuation processes are to be considered as a viable remediation alternative, the concentration of the CoI should be decreasing over time primarily as a result of natural biodegradation processes. In sites impacted with PCE or TCE, the production of biodegradation breakdown products (cis-1,2-DCE and vinyl chloride) provide the most reliable indication that natural biodegradation processes are active at the site. A second set of data that must be considered in this step is the presence of potential receptors (e.g., potable water wells, surface water bodies, subsurface structures, etc.) located within the plume area. A third data set to be considered is the natural groundwater gradient and velocity exhibited by the impacted groundwater to assist in predicting if a potential receptor could be impacted in the future by the plume as it migrates before natural attenuation processes can effectively reduce concentrations to protect the receptor.

Sufficient CoI data have been collected at the site to indicate that the transformation of parent compounds PCE and TCE to breakdown products of cis-1,2-DCE and vinyl chloride occurs and that this attenuation process has resulted in a reduction in the concentration and extent of the CoI plumes at the site. In relation to the presence of potential receptors at the site and potential impact to potential receptors within the extent of the plume area and downgradient, the following conclusions have been derived:

- No potential receptors were identified within the plume area.
- The nearest downgradient potential receptor (The Duwamish Waterway) was identified to be approximately 500 ft west of the former source area of the plume. Groundwater analyses for CoI indicate that the dissolved-phase plume has not extended beyond 200 ft downgradient (west-southwest) from the source area.

It is likely that the reduction of the CoI plumes is due to a combination of the effects of natural attenuation and the groundwater pump and treat system. This decline can be qualitatively evaluated by comparing the plume maps presented on Figures 1 through 4.

**Step 2 –Identify the natural attenuation mechanisms at the site**

This step is completed after it has been determined that there is evidence that natural attenuation processes are likely having a positive impact on the reduction of the CoI plume. The key data to be evaluated during this step are geochemical parameters that may indicate the driving force behind biodegradation activity at the site. As stated earlier, reductive dechlorination processes appear to be ongoing at the site based on the reduction of PCE and TCE concentrations and the presence of cis-1,2-DCE and vinyl chloride. However, sufficient geochemical data has not been collected for the site to conclusively determine the actual mechanism(s) responsible for the reductive dechlorination processes. Reductive dechlorination has been demonstrated at other sites under nitrate and iron reducing conditions, but the most rapid biodegradation rates, affecting the widest range of chlorinated aliphatic hydrocarbons, occur under sulfate-reducing and methanogenic conditions (Bouwer, 1994).

In our experience, it is likely that reductive dechlorination at the site is occurring under methanogenic conditions because of the presence of vinyl chloride. Sites undergoing reductive dechlorination under sulfate-reducing conditions often do not progress beyond the degradation of TCE and subsequent formation of cis-1,2-DCE and therefore lack significant concentrations of vinyl chloride. Additional site geochemical data would be needed to demonstrate the actual reductive dechlorination process. Geochemical parameters that would be indicative of reductive dechlorination include a reduction in the concentration of sulfate or nitrate within the impacted area or an increase in the concentration of ferrous iron (iron II), methane, ethane/ethene or chloride ion in the impacted area.

Following the reduction of PCE and TCE, the continued biodegradation of the remaining CoI (cis-1,2-DCE and vinyl chloride) often is continued by oxidation-reduction mechanisms which are typically aerobic respiration, iron reduction, or methanogenesis. Evidence of these biodegradation processes would typically be confirmed by a depletion of dissolved oxygen within the impacted area or an increase of ferrous iron, methane, ethane/ethene or chloride ion within the impacted area.

In addition to the specific evidence referenced for biodegradation of PCE, TCE, cis-1,2-DCE, and vinyl chloride, there are conventional parameters that can indicate microbiological activity. These parameters include oxidation-reduction potential, alkalinity, conductivity, carbon dioxide concentration, temperature, and pH in groundwater. In addition, a sufficient carbon source must be present to continue the biodegradation process. The availability of carbon can be determined by analyzing the groundwater for total organic carbon (TOC) content.

**Step 3 –Estimate the attenuation rate of CoI for the site**

Following the completion of the initial two steps involved with the natural attenuation evaluation, it is often necessary to estimate the rate of attenuation of the CoI present in the subsurface. Estimating the

rate of attenuation may be simplistic (e.g., regression analysis to determine the attenuation rate observed due to natural processes) or more sophisticated (e.g., implementation of a three-dimensional groundwater model for the site). The goal of estimating the rate of attenuation is to predict whether cleanup level goals can be obtained within a reasonable timeframe and within an acceptable distance downgradient of the release area at identified "sentinel" wells. Accurate predictions of CoI concentrations in sentinel wells that are also protective of human health and the environment are key to gaining regulatory approval for the use of natural attenuation as a remediation method for the site.

Attenuation rates are typically calculated by observing the rate at which a contaminant concentration decreases with distance downgradient along a groundwater migration pathway. The data are typically fitted to a first order exponential decay equation and a regression analysis is performed to obtain the rate constant (for example, see USEPA 1998). Methods are available to separate the affects of non-biological processes (e.g., adsorption, dispersion, advection, and volatilization) from biological processes. Such an evaluation requires knowledge of the groundwater flow velocity and direction and contaminant concentration data from several monitoring points located along a common migration pathway. Because knowledge of these conditions does not exist for this site to the level needed to conduct such an evaluation, a modified evaluation was conducted with the objective of comparing the relative rate of contaminant concentration reduction for the non-pumping period (i.e., 1989 to 1994) to the relative rate of contaminant concentration reduction for the pumping period (i.e., 1994 to 2000). The evaluation consisted of calculating the rate at which CoI concentrations decreased with time at site monitoring wells during the non-pumping and pumping periods. The rate was obtained by plotting the natural logarithm of the concentration of specific contaminants (normalized to the starting concentration) versus time.

Separate graphs were prepared for select groundwater monitoring wells for the active pumping and non-pumping scenarios. Following the graphing of the contaminant concentration as described, a linear regression analysis was performed on each graph to determine the rate of contaminant reduction exhibited in each of the wells for the specific CoI. These graphs are presented in Attachment 1. A summary of the CoI reduction rate estimates is presented in Table 6. The calculated contaminant reduction rates consider the reduction in contaminant concentrations due to the combined affect of the non-destructive (advection, dispersion, etc.) and destructive (biodegradation) components of natural attenuation and, for the 1994 to 2000 period, the reduction caused by the operation of the pump and treat system.

The following conclusions were derived from information presented in Table 6, based on comparisons of the rate of contaminant reduction under non-pumping and pumping scenarios:

- The rate of PCE concentration reduction was greater in the non-pumping scenario in 6 out of 8 wells that could be compared
- The rate of TCE concentration reduction was greater in the non-pumping scenario in 6 out of 9 wells that could be compared
- The rate of cis-1,2 DCE concentration reduction was greater in the non-pumping scenario in 5 out of 10 wells that could be compared
- The rate of vinyl chloride concentration reduction was greater in the pumping scenario in 10 out of 10 wells that could be compared.

These results indicate that, with the exception of vinyl chloride, the rate of concentration reduction during non-pumping conditions was at least as great as the rate of concentration reduction during pumping conditions and in fact was significantly higher during non-pumping conditions for PCE and TCE. This trend is consistent with the expected trend given that the more highly oxidized chlorinated compounds (e.g., PCE and TCE) are more readily degraded under reductive dechlorination conditions.

The calculation of average concentration reduction rates for each CoI (see Table 6) allows an average half-life value to be calculated for each CoI. The half life is a term used to represent the amount of time necessary for the concentration of a compound to reach a concentration equal to one-half the concentrations measured at time zero. Therefore, the half life can be used to estimate how long it will take for the concentrations of CoI in the plume measured in December 2000 to decrease to concentrations equal to approximately one-half of the December 2000 concentrations, assuming the reduction rate does not change and CoI concentrations do not rebound after the pump and treat system is turned off. Based on this evaluation, natural attenuation processes (without the assistance of the pump and treat system) could remove 50 percent of the remaining PCE, TCE, and cis-1,2-DCE mass present in the saturated zone within the next 2 to 3 years. The production of vinyl chloride will continue to decline as concentrations of the parent compounds decline.

**Step 4 – Monitor site and validate attenuation rate estimates**

After an estimated attenuation rate for CoI is developed for a site, the predicted sentinel well concentrations must be validated by continuing to collect groundwater analytical data. Typically, the attenuation rate predictions are validated by collecting groundwater samples at sentinel wells to compare actual CoI concentrations to predicted CoI concentrations. In the event that a significant discrepancy is observed between the predicted and the actual CoI concentrations, it may be necessary to re-evaluate the attenuation rate at the site and collect additional biodegradation parameters. In the event that the predicted sentinel well concentrations are proven to be accurate over a period of time, typically 1 to 2 years, and it appears that potential receptors will not be impacted by the plume, closure may be

requested from the regulatory agency. The closure approval from the regulatory agency is often contingent upon the completion of an extended monitoring program that will provide additional data relevant to the effectiveness of natural attenuation in achieving site specific clean-up criteria. The length and frequency of the long term monitoring can often be negotiated with the regulatory agency.

## CONCLUSIONS AND RECOMMENDATIONS

The data presented and discussed herein lead to the following conclusions:

- Concentrations of PCE, TCE, and cis-1,2-DCE in groundwater steadily declined since groundwater monitoring began in August 1989 until January 1994, apparently due to the effects of natural attenuation.

- The production of breakdown products (cis-1,2-DCE and vinyl chloride) in conjunction with the decline in PCE and TCE concentrations under non-pumping conditions indicate that natural biodegradation processes (i.e., reductive dechlorination) are active at the site.

- The capture zone evaluation of the current pump and treat system indicates that it is effectively controlling plume migration.

- The influent concentration of the groundwater recovered by the pump and treat system has been declining significantly over the past 2 years. As of September 2000, approximately 88 percent of the total mass of CoI removed by the pump and treat remediation system was removed prior to 1999.

- The extent of the PCE, TCE, and cis-1,2-DCE plumes (as measured by the 100 μg/L isopleth) decreased more rapidly under pumping conditions in comparison to non-pumping conditions, however, the rate of PCE and TCE concentration reduction appeared to be greater under non-pumping conditions.

- During both pumping and non-pumping periods, the lateral extent of CoI greater than 1 μg/L was fully contained within site boundaries.

Based on the evidence provided in this memorandum documenting the effectiveness of natural attenuation at this site, combined with previous source control measures (soil excavation and pump and treat operation), lack of potential receptors, and historical data indicating a downgradient plume of limited extent, we recommend requesting approval from Ecology to shut down the pump and treat system and monitor groundwater over a minimum six month period to evaluate whether VOC concentrations rebound in site groundwater. Discontinuation of the groundwater pump and treat system is further supported by considering the significant amount of energy resources expended to operate the system (approximately 130 kilowatt-hours per day) for a minimal amount of VOCs currently being removed by the system (approximately 0.3 pounds per day based on January 2000 through September 2000). A technical memorandum outlining the proposed discontinuation of the pump and treat system and the subsequent groundwater monitoring schedule should be prepared and submitted to Ecology for approval. The pump

and treat system should remain at the site in a standby mode. The technical memorandum outlining the steps to be completed for shut down of the system should include a contingency plan for restarting the pump and treat system in the event that monitoring indicates that natural attenuation processes are not effective in maintaining acceptable concentrations within the site boundary. Following the six month period after system shut down, groundwater data should be evaluated to develop a final remedy for the site.

## REFERENCES


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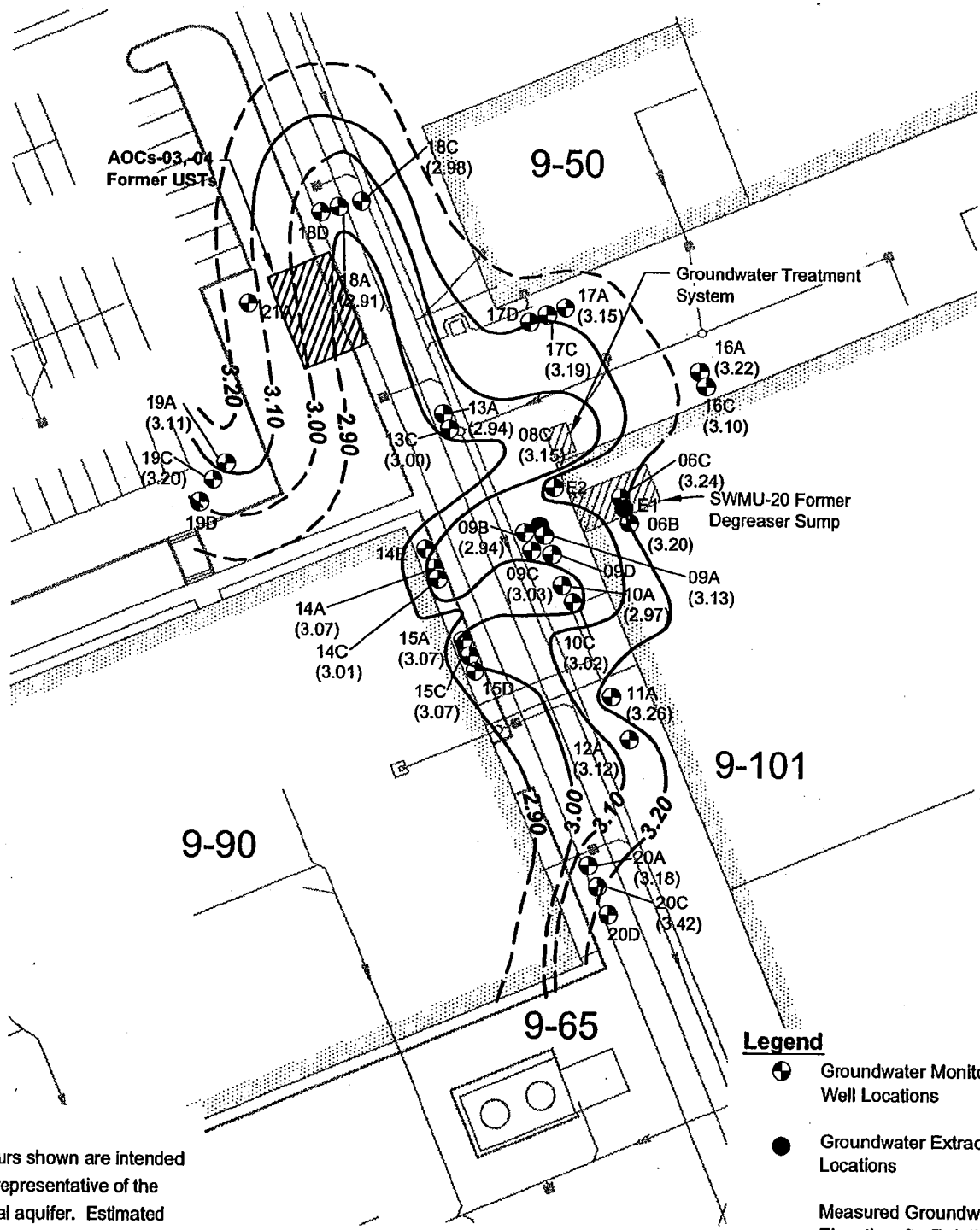
USEPA. 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater.* EPA/600/R-98/128. September.

USEPA. 1997. Office of Solid Waste and Emergency Response. *Draft Interim Final OSWER Monitored Natural Attenuation Policy.* OSWER Directive 9200.4-17. December 1.




**Note**

Contours shown are intended to be representative of the surficial aquifer. Estimated contour locations are weighted toward data collected in "A Horizon" wells.

**February 1996**

0 60 120

Scale in Feet

**Legend**

- Groundwater Monitoring Well Locations
- Groundwater Extraction Well Locations
- (3.42) Measured Groundwater Elevation, ft - Relative to NGVD29
- *3.20* Estimated Groundwater Elevation Contour, ft - Relative to NGVD29

*Adapted from: Boeing Facilities; Duane Hartman and Associates, 2001*

Boeing/Developmental Center | T:\025\093\010\Figs1.dwg (A) "Figure 5" 6/11/2001

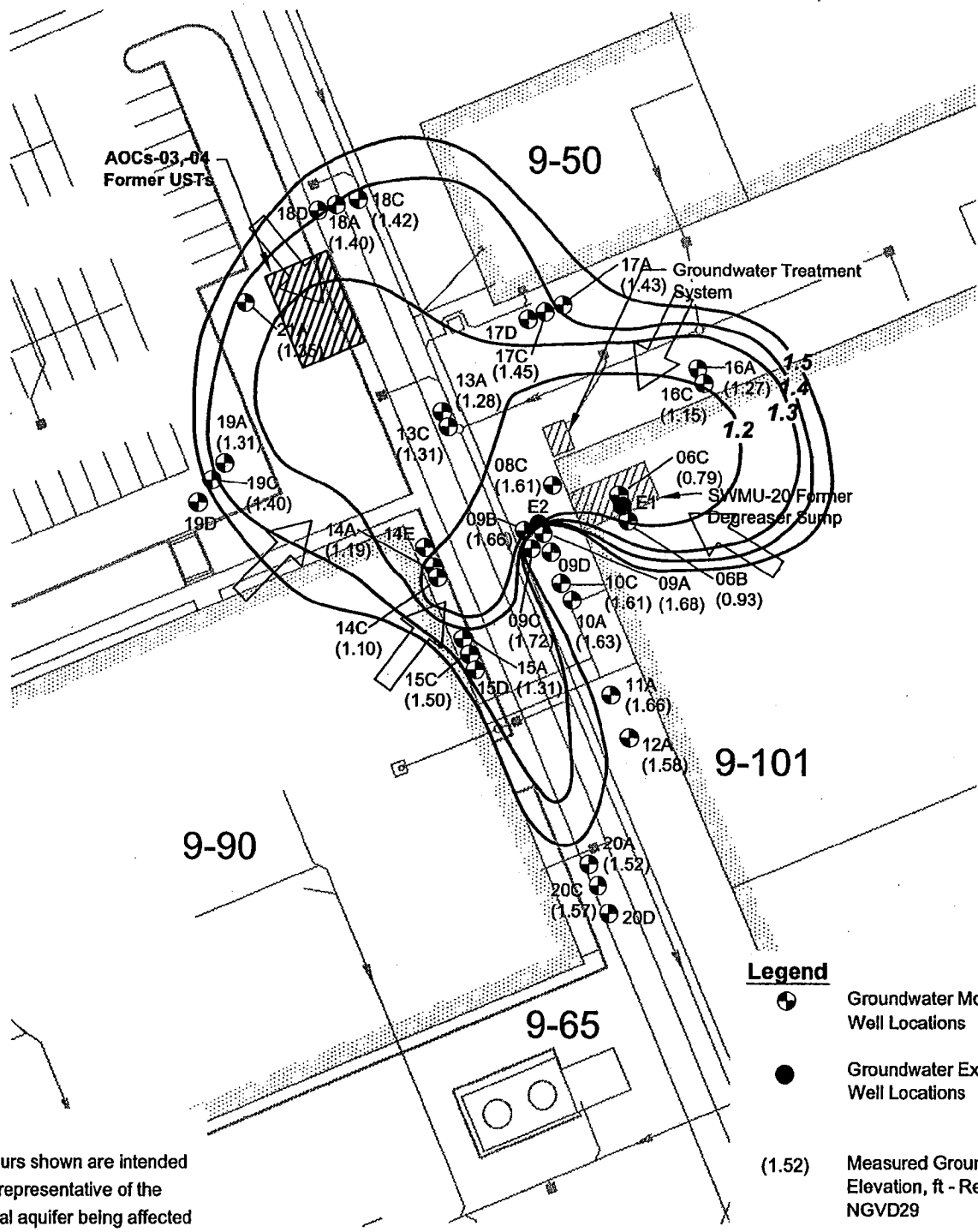
Landau Associates

Boeing Developmental Center
Tukwila, Washington

**Groundwater Potentiometric Map**
**Non-Pumping Scenario**

Figure 5

DFT 001094




**Legend**

- Groundwater Monitoring Well Locations
- Groundwater Extraction Well Locations
- (1.52) Measured Groundwater Elevation, ft - Relative to NGVD29
- — 1.5 — Estimated Groundwater Elevation Contour, ft - Relative to NGVD29
- Inferred Groundwater Flow Direction

**Note**

Contours shown are intended to be representative of the surficial aquifer being affected by the remedial system. Contours are weighted toward data collected in "A Horizon" wells.

**October 1995**

0 60 120

Scale in Feet

*Adapted from: Boeing Facilities; Duane Hartman and Associates, 2001*

Boeing/Developmental Center | T:\025\093\010\Figs1.dwg (A) "Figure 6" 6/11/2001

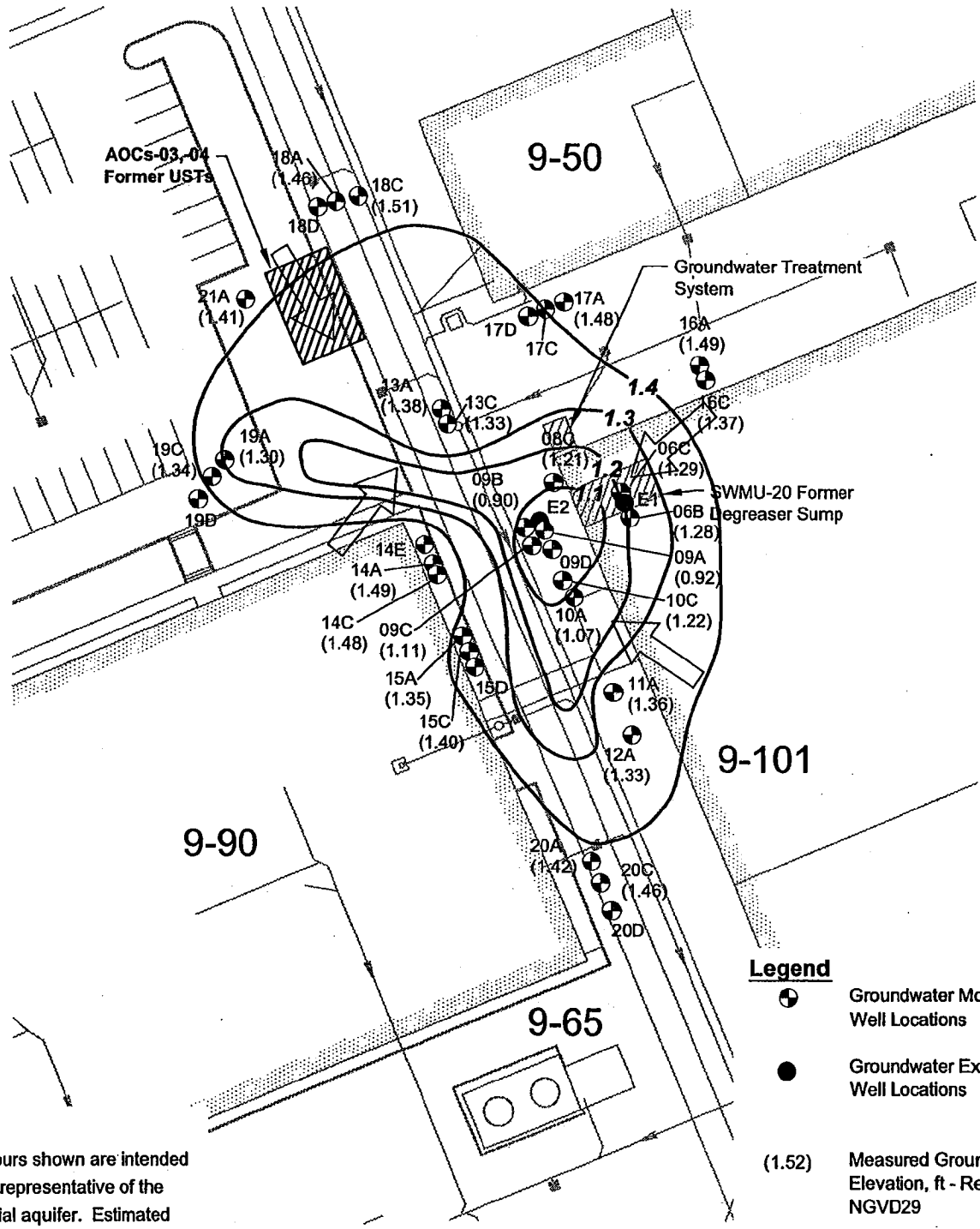
Landau Associates

Boeing Developmental Center
Tukwila, Washington

**Groundwater Potentiometric Map**
**Active Pumping - E-1**

Figure
6

DFT 001095




**Legend**

- Groundwater Monitoring Well Locations
- Groundwater Extraction Well Locations
- (1.52) Measured Groundwater Elevation, ft - Relative to NGVD29
- *1.5* Estimated Groundwater Elevation Contour, ft - Relative to NGVD29
- Inferred Groundwater Flow Direction

**Note**

Contours shown are intended to be representative of the surficial aquifer. Estimated contour locations are weighted toward data collected in "A Horizon" wells.

**December 2000**

0 60 120

Scale in Feet

*Adapted from: Boeing Facilities; Duane Hartman and Associates, 2001*

Boeing/Developmental Center | T:\025\093\010\Figs1.dwg (A) "Figure 7" 6/11/2001

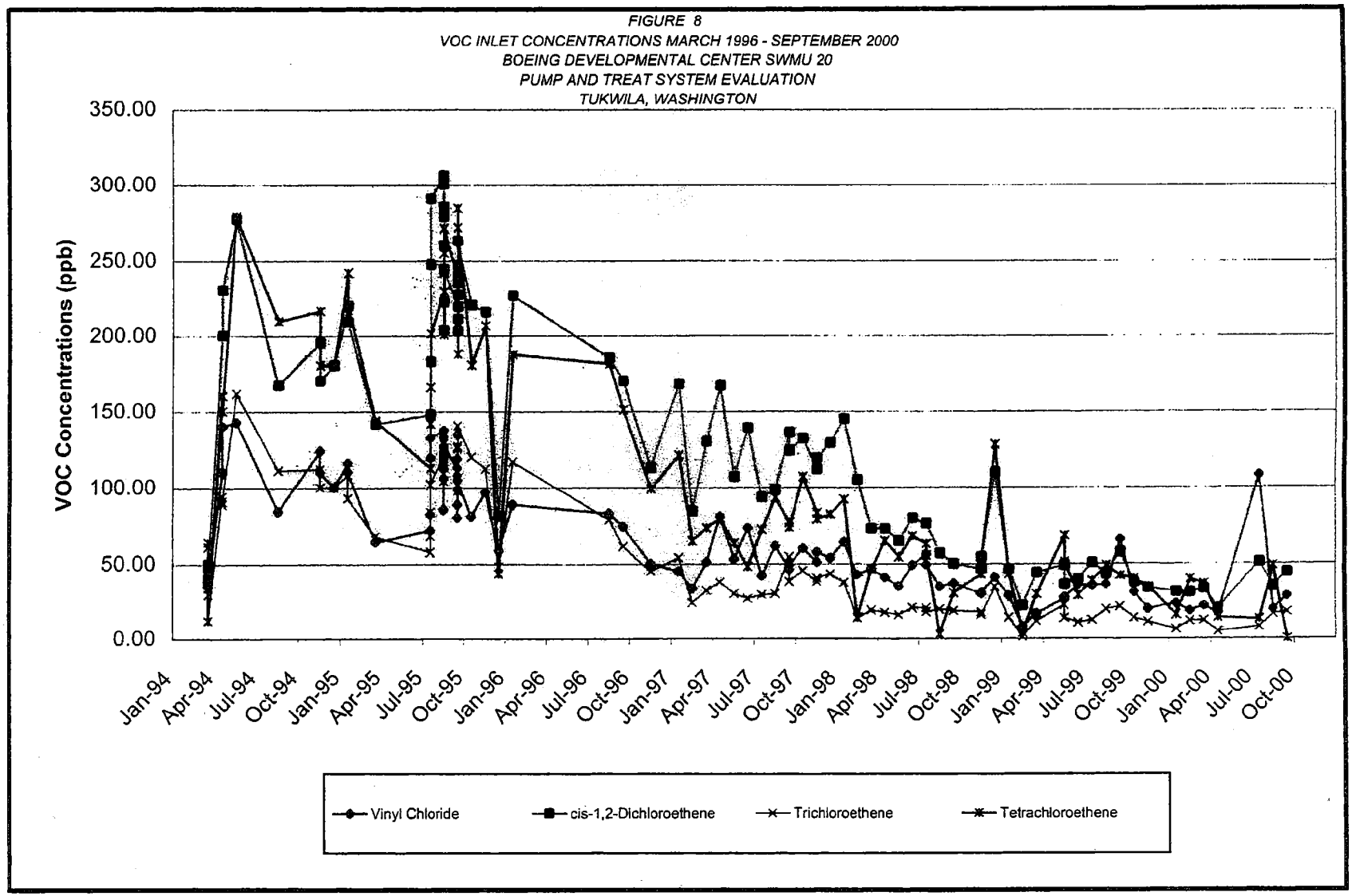
Landau Associates

Boeing Developmental Center
Tukwila, Washington

**Groundwater Potentiometric Map**
**Active Pumping - E-2**

Figure
7

DFT 001096




DFT 001097

Landau Associates

| Boeing Developmental Center<br>Tukwila, Washington | **VOC Inlet Concentrations** | Figure<br>8 |
|---|---|---|

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**Tetrachloroethene** *ug/l*

| | Aug-89 | Feb-91 | Jun-93 | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 93 | 2000 | 48 | 27 | 5.87 | 14.4 | 9.62 J | 26.18 | 13.7 | 14.3 | 21.5 | 21.3 | 17 | 16.9 | 18.9 | 16.3 | 22.6 | 2.3 | 6 | 10.19 |
| 06C | 4.5 | 54 | ND | 22 | <1.00 | <10.00 | <10.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 |
| 08C | 150 | 95 | 8 | 16 | <1.00 | <5.00 | <5.00 | <3.33 | <10.00 | 13.5 | <5.00 | <4.00 | <4.00 | <4.00 | 7.8 | <5.00 | <1.00 | <2.00 | <2.00 | <2.00 |
| 09A | 2400 | 1200 | 370 | 420 | 2568.3 | 1589 | 1970 | 785.7 | 114 | 272 | 98 | 76 | 96.9 | 56.6 | 39.4 | 94 | 5.1 | 38 | 40 | 36.6 |
| 09B | 10000 | 670 | 300 | 820 | 1972.7 | 668.1 | 1266 | 934.6 | 78.9 | 75.9 | 44.3 | 35 | 10.9 | 21.5 | 31.3 | <10.00 | 6.74 | 3.6 | <2.00 | 6.62 |
| 09C | 64 | 18 | ND | ND | 11.32 | <5.00 | <10.00 | 1.24 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 09D | ND | ND | ND | 8.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | 700 | 550 | | 180 | 635.8 | 754 E | 468.85 | 242.1 | 114 | 342 | 67.5 | 77.8 | 76.5 | 70.3 | 72.5 | 86.4 | 38 | 21.5 | 16.6 | 21.63 |
| 10C | 2.4 | 12 | | 6.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 11A | ND | ND | | 5.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 12A | ND | ND | | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13A | 5.3 | ND | | 10 | 4.17 | <5.00 | <5.00 | 6.82 | 3 | 2.1 | 3.2 | 2.1 | 1.7 | 1.5 | 1.6 | 1.3 | <1.00 | <1.00 | 1.2 | <1.00 |
| 13C | 1.1 | 5.1 | | 5.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14A | 220 | 74 | | 410 | 4.42 | <5.00 | 133.57 | 96.06 | 11.2 | <5.00 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14C | 120 | 1.2 | | 7.2 | 9.02 | 10.53 | 8.64 J | 5.44 | 6.1 | <1.00 | <10.00 | <10.00 | <10.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14E | | 0.5 | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | 2.2 | ND | | 11 | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 |
| 15C | 13 | 1.1 | | 13 | <1.00 | <33.30 | <5.00 | <1.00 | 1.1 | <1.00 | <2.00 | <10.00 | <10.00 | <10.00 | <3.33 | <1.00 | <2.00 | <2.00 | <1.00 | <1.00 |
| 15D | 2.6 | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | ND | 1.8 | | 1.6 | 1.10 | <5.00 | <5.00 | <1.00 | 1.7 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 | 1.64 | 1.03 | 1.3 | 2.3 | 2.2 | <1.00 |
| 16C | ND | ND | | ND | <1.00 | <5.00 | <10.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17A | ND | | | 36 | 1.39 | <5.00 | <5.00 | 1.55 | <1.00 | 1.3 | 2.7 | 1.90 J | 2.2 | <1.00 | 2.6 | 2.4 | 2.5 | 2.1 | 2.6 | 4.15 |
| 17C | ND | | | 36 | <1.00 | <5.00 | <5.00 | <1.00 | 1.6 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 17D | ND | | | 46 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | | ND | | 5.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | | ND | | 4.6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18D | | ND | | 4.6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | | 0.5 | | 6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | | ND | | 6.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19D | | ND | | 9.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | | ND | ND | 3.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | | ND | ND | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20D | | ND | ND | 4.3 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | | | 4.6 | NA | NA | NA | NA | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

DFT 001098

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**Trichloroethene** *ug/l*

| | Aug-89 | Feb-91 | Jun-93 | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 28 | 810 | 10 | 4.2 | 3.57 | 6.00 J | <5.00 | 7.37 | 3.5 | 2.5 | 4.9 | 4.7 | 4.6 | 6.5 | 3.5 | 2.6 | 4.54 | 2.2 | 4.7 | 8.71 |
| 06C | 7.2 | 21 | ND | 1.6 | <1.00 | 31.36 | <10.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 91.6 | <2.00 | <1.00 | <1.00 | <1.00 |
| 08C | 68 | 36 | 13 | 21 | 3.16 | <5.00 | <5.00 | <3.33 | <10.00 | 26.2 | <5.00 | <4.00 | <4.00 | <4.00 | 26.6 | <5.00 | <1.00 | <2.00 | <2.00 | <2.00 |
| 09A | 510 | 7400 | 1200 | 500 | 1796.5 | 1507 | 2318 | 1160 | 90.8 | 191 | 49.3 | 51.1 | 69.2 | 56.4 | 15.4 | 77 | 3.5 | 35 | 23 | 24.3 |
| 09B | 160 | 720 | 140 | 160 | 1463 | 524.7 | 1206 | 554 | 58.6 | 35.2 | 28.7 | 31.5 | 4.9 | 15.4 | 20.65 | <10.00 | 7.5 | 4.8 | 2.6 | 11.2 |
| 09C | 1200 | 97 | 70 | ND | 19.41 | <5.00 | <10.00 | 3.54 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 09D | ND | ND | ND | 2.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | 210 | 270 | | 120 | 333.23 | 411 E | 268.41 | 115.3 | 56.7 | 128 | 28.4 | 38.2 | 36.6 | 48.8 | 23.8 | 33.9 | 19.2 | 14 | 8.3 | 13.11 |
| 10C | ND | 13 | | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 11A | 15 | 13 | | 7 | 2.41 | <5.00 | <5.00 | 2.54 | 1.9 | 1 | <1.00 | <1.00 | 1.2 | 1.6 | <1.00 | 1.03 | <1.00 | <1.00 | <1.00 | <1.00 |
| 12A | 5.6 | 2.5 | | 5.5 | 1.13 | <5.00 | <5.00 | <1.00 | 1.7 | 1.2 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13A | 8.5 | 5.4 | | 31 | 12.23 | <5.00 | 9.57 J | 16.52 | 3.4 | 3.4 | 2 | 1.5 | 2.9 | 3 | 1.1 | 1.7 | 1.8 | 2.3 | 2.4 | 2.12 |
| 13C | ND | 9.2 | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14A | 130 | 66 | | 600 | 6.25 | <5.00 | 151.58 | 146.72 | 84.1 | 2.8 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14C | 78 | 2.3 | | 6.6 | 14.41 | 21.93 | 13.33 | 7.61 | 12.5 | <1.00 | <10.00 | <10.00 | <10.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14E | | 4.3 | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | 21 | ND | | 7.5 | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 |
| 15C | 22 | 4.7 | | 12 | <1.00 | <33.30 | <5.00 | <1.00 | 7.5 | <1.00 | <2.00 | 12 | <10.00 | <10.00 | <3.33 | <1.00 | <2.00 | <2.00 | <1.00 | <1.00 |
| 15D | ND | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | 5.1 | 5.8 | | 4.4 | 5.02 | <5.00 | <5.00 | 2.57 | 4 | 2.1 | 2.6 | 2 | 1.9 | <1.00 | <1.00 | <1.00 | 1.01 | 1.4 | 1.2 | 1.08 |
| 16C | ND | 1.3 | | ND | <1.00 | <5.00 | <10.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17A | | 3.7 | | 7.2 | 17.42 | 17.04 | <5.00 | 7.28 | <1.00 | 9.8 | 17.5 | 4.9 | 18 | 2 | <1.00 | 12.4 | 11.1 | 11.5 | 6.6 | 13.99 |
| 17C | | ND | | 2.1 | <1.00 | <5.00 | <5.00 | <1.00 | 14.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 17D | | ND | | 2.3 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | | 1.5 | | 1.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | | 1.9 | 0.8 | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | | 3.1 | 1.7 | 1.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20D | | ND | ND | 1.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | | | | NA | NA | NA | NA | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

DFT 001099

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**cis-1,2-Dichloroethene** *ug/l*

| | Aug-89 | Feb-91 | Jun-93 | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 23 | 710 | 25 | 23 | 43.71 | 53.75 | 29.45 | 58.31 | 46.3 | 30.5 | 37.4 | 60.9 | 61.8 | 76.4 | 66.7 | 9.9 | 70.1 | 49.7 | 71.5 | 91.77 |
| 06C | 230 | 28 | 6.7 | 7.9 | 14.57 | 99.09 | <10.00 | 1.01 | 107 | 1.9 | 3.1 | 22.1 | 28.3 | 12.3 | 1.1 | 181 E | <2.00 | <1.00 | <1.00 | <1.00 |
| 08C | 120 | 38 | 1.9 | 44 | 14.95 | <5.00 | 5.55 J | 8 | 1.1 | 37.6 | <5.00 | 37.3 | 46.1 | 42.3 | 38.4 | <5.00 | 1.1 | <2.00 | 3.2 | <2.00 |
| 09A | 440 | 15000 | 620 | 2500 | 5790.9 | 3286 | 7484 | 6143 | 443 | 816 | 520 | 258 | 206.E | 199 | 94.3 | 680 | 15.5 | 187 | 421 | 60.75 |
| 09B | 150 | 2100 | 210 | 940 | 5010.35 | 1307 E | 3407 E | 1521 | 207 | 142 | 164 E | 510 | 35.1 | 111 | 939 E | 178 | 122.04 | 41.2 | 102.4 | 135.2 |
| 09C | 1200 | 360 | 680 | 520 | 431.66 | 159.69 | 70 | 33.67 | 29.8 | 1.6 | 4.6 | 2.6 | 2 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 09D | 0.9 | 2.1 | ND | 5.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | 150 | 228 | | 470 | 421.26 | 297 E | 249.16 | 159.2 | 90.1 | 17.8 | 29 | 66.1 | 58.5 | 74.1 | 29.3 | 6.9 | 33.3 | 20.6 | 10.6 | 14.14 |
| 10C | 4.3 | ND | | 14 | 1.93 | <5.00 | <5.00 | 1.01 | <1.00 | <1.00 | f | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 11A | 63 | 43 | | 54 | 15.86 | 10.82 | 7.17 J | 10.27 | 9.3 | 6.4 | 4.9 | 6.6 | 6.1 | 4.2 | 2.8 | 2.3 | 2.1 | 1.1 | 1.5 | 1.55 |
| 12A | 13 | 4.2 | | 20 | 2.30 | 17.5 | <5.00 | 1.09 | 9.5 | 6.6 | <1.00 | 6.1 | 3.7 | 3 | 1.7 | 1.7 | 1.8 | 1.03 | 1.9 | 2.07 |
| 13A | 1.6 | ND | | 8.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.6 | <1.00 | <1.00 | 1.2 | 1.3 | 1.2 | 1.2 | <1.00 |
| 13C | 190 | 40 | | 16 | 1.14 | <5.00 | <5.00 | <1.00 | 1.3 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14A | 340 | 92 | | 590 | 15.50 | 9.83 J | 294.36 | 115.94 | 249 | 114 | 6.4 | 24.2 | 18.3 | 9.5 | 4.9 | 3.7 | 7 | 3.2 | 3.8 | <1.00 |
| 14C | 220 | 9.0 | | 110 | 187.91 | 1017.82 | 237.4 | 70.06 | 326 | 211 | 183 | 163 | 136 | 82.7 | 25.6 | 21.7 | 6.2 | <1.00 | 1.2 | 2.83 |
| 14E | | 9.3 | | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | 1800 | 6.8 | | 9.1 | 3.29 | <5.00 | <5.00 | <5.00 | 3.6 | 3.5 | 4.5 | 5 | 5.5 | 5.5 | 15.65 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 |
| 15C | 260 | 69 | | 92 | 69.14 | 640.52 | 93.62 | 1.47 | 463 | 532 | 187 | 1470 | 1100 | 719 | 785 E | 90.5 | 53.2 | 28.4 | 1.01 | 2.53 |
| 15D | 5.7 | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | 1.8 | 5.6 | | 5.5 | 12.63 | 5.38 J | <5.00 | 25.39 | 12 | 3.2 | 6.2 | 2.4 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.76 |
| 16C | 8.1 | 3.2 | | 14 | 11.83 | 6.24 J | <10.00 | 5.66 | 2.6 | 1.6 | 1.6 | 1.13 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17A | | 2.8 | | 4.3 | 1.38 | <5.00 | <5.00 | 1.09 | <1.00 | 1.4 | 1.2 | 2.90 J | 4.13 | <1.00 | 2.3 | 3.8 | 4.1 | 4.3 | 2.3 | 2.1 |
| 17C | | ND | | 5.3 | <1.00 | <5.00 | <5.00 | 1.19 | 1.6 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 17D | | ND | | 1.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | | ND | | 1.3 | 2.02 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | 1.8 | 2.8 | 1.9 | 2.1 | 1.3 | 1.59 |
| 18D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | | 1.4 | | 2.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | | ND | | 1.7 | 1.17 | <5.00 | <5.00 | 1.37 | 1.3 | <1.00 | <1.00 | 1.2 | 1.2 | 1.2 | 2 | 1.2 | 1.4 | <1.00 | 1.03 | <1.00 |
| 19D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | | 3.9 | 20 | 16 | 7.34 | 6.06 J | <5.00 | 2.46 | 2.5 | 2.1 | 1.9 | 1.6 | <1.00 | <1.00 | <1.00 | 1.5 | <1.00 | <1.00 | 1.3 | <1.00 |
| 20D | | ND | ND | 1.8 | 2.22 | <5.00 | <5.00 | 46.38 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | | | | NA | NA | NA | NA | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

DFT 001100

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**Vinyl Chloride** *ug/l*

| | Aug-89 | Feb-91 | Jun-93 | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 4.7 | ND | 74 | 13 | 36.53 | 31.8 | 52.29 | 44.78 | 54.5 | 49.4 | 63.7 | 88.7 | 55 | 62.7 | 46.3 | 4.2 | 48.4 | 25.9 | 8 | 21.58 |
| 06C | 1.6 | ND | 26 | 30 | 20.89 | 34.09 | 38.34 | 22.06 | 164 | 12 | 18.3 | 50.3 | 39.5 | 26.1 | 6 | 54.6 | 4.4 | <1.00 | <1.00 | <1.00 |
| 08C | 14 | 25 | ND | 130 | 42.13 | 32.69 | 35.33 | 35.96 | 129 | 41.2 | 201 | 488 | 256 | 210 | 20.6 | <5.00 | 49.7 | 21.4 | 2.4 | <2.00 |
| 09A | 26 | 2000 | 350 | 240 | 917.05 | 449 | 1385 | 844.9 | 124 | 228 | 80.9 | 185 | 127 | 135 | 83.8 | 425 | 14 | 278 | 499 | 17.95 |
| 09B | 23 | 830 | 87 | 140 | 648.6 | 175.6 | 836 | 228.2 | 104 | 62.6 | 41.7 | 270 | 20.9 | 50.7 | 439.56 | 132 | 152.36 | 66.6 | 82.6 | 146.7 |
| 09C | 110 | 130 | 82 | 190 | 233.79 | 185 E | 71.74 | 50.13 | 106 | 19.4 | 59.8 | 147 | 102.5 | 87.8 | 1.1 | <1.00 | 59 | 16.4 | <1.00 | <1.00 |
| 09D | 0.5 | ND | ND | ND | 1.37 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | 4.0 | 54 | | 120 | 116.25 | 16.12 | 31.6 | 651.2 | 80.9 | 16.7 | 48.2 | 33.4 | 9.8 | 8.8 | 8.7 | 1.3 | 12.1 | 3.5 | 3 | 3.32 |
| 10C | 8.3 | ND | | 39 | 28.29 | 33.16 | 40.41 | 18.69 | 11.6 | 10.1 | 9 | <1.00 | 4.3 | 3.8 | 1.7 | 1.6 | 2.8 | 1.4 | 2.1 | <1.00 |
| 11A | 7.2 | 13 | | 39 | 26.80 | 8.37 J | 12.14 | 14.04 | 3.8 | 1.8 | <1.00 | <1.00 | <1.00 | 3.4 | <1.00 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 |
| 12A | 3.2 | ND | | 14 | <1.00 | 17.16 | <5.00 | <1.00 | 2.9 | 8.6 | <1.00 | 9.4 | 6.7 | 1.1 | 1.3 | <1.00 | 2.7 | 1.06 | <1.00 | <1.00 |
| 13A | ND | ND | | 12 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13C | 240 | 220 | | 760 | 3.03 | <5.00 | 15.24 | 11.48 | 3.6 | 1.9 | 2.5 | 2.2 | <1.00 | <1.00 | 1 | 1.6 | 1.8 | <1.00 | <1.00 | <1.00 |
| 14A | 24 | 28 | | 170 | 11.38 | 30.32 | 44.4 | 36.4 | 339 | 232 | 162 | 270 | 158 | 70 | 29.1 | 13.74 | 58.2 | 20.9 | 19.7 | <1.00 |
| 14C | 46 | 98 | | 120 | 103.49 | 1587.3 | 1477 | 134.78 | 414 | 175 | 1296 | 307 | 148 | 144 | 39.4 | 56.4 | 30.2 | <1.00 | <1.00 | 4.67 |
| 14E | | ND | | 10 | 1.43 | <5.00 | <5.00 | <1.00 | 1.3 | <1.00 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | 7.7 | 12 | | 16 | 13.84 | 31.2 | 54.62 | 19.45 | 19.4 | 23 | 20.4 | 23.5 | 17.4 | 18.6 | 61.61 | 17.2 | 2.9 | 37 | 16 | <10.00 |
| 15C | 19 | 16 | | 38 | 38.79 | 142.38 | 69.81 | 5.12 | 104 | 220 | 69 | 598 | 519 | 500 | 772 E | 194 E | 121.2 | 49.2 | 1.4 | 21.32 |
| 15D | 210 | 190 | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 8.6 | 5.2 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | ND | 8.9 | | 6 | 9.18 | <5.00 | <5.00 | 8.42 | 4.4 | <1.00 | <1.00 | 2.2 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16C | 4 | 3.4 | | 15 | 23.46 | 38.59 | 45.16 | 31.71 | 20.8 | 11.8 | 11.3 | 9.1 | 3 | <1.00 | 1.4 | <1.00 | 1.9 | <1.00 | <1.00 | <1.00 |
| 17A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17C | | ND | | 10 | 2.32 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 17D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | | ND | | 5.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | | ND | 28 | 47 | 20.12 | 12.63 | 13.77 | 8.32 | 6.7 | 3.4 | 3.3 | 3.4 | <1.00 | <1.00 | 1.6 | 1.8 | <1.00 | 1.9 | <1.00 | 1.06 |
| 20D | | ND | ND | ND | 6.98 | <5.00 | <5.00 | 31.12 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | | | | NA | NA | NA | NA | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

DFT 001101

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**Benzene** ***ug/l***

| | Aug-89 | Feb-91 | Jun-93 | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | ND | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 |
| 06C | 0.4 | ND | ND | ND | 8.64 | 230.09 | 29.96 | 13.7 | 5.6 | 2.9 | 3.4 | 4.6 | 4.1 | 4.2 | 4.2 | 5.7 | 2.8 | 2.7 | <1.00 | 2.76 |
| 08C | ND | ND | ND | ND | 225.74 | 135.58 | 104.73 | 104.6 | 31.8 | 121 | 27.5 | 6.1 | <4.00 | <4.00 | 13.6 | <5.00 | <1.00 | <2.00 | 15.8 | <2.00 |
| 09A | 0.5 | ND | ND | ND | <1.00 | <5.00 | <500.00 | <50.00 | <3.33 | <10.00 | <4.00 | <5.00 | <1.00 | <4.00 | <1.00 | <10.00 | <1.00 | <10.00 | <10.00 | <5.00 |
| 09B | ND | ND | ND | ND | 19.76 | <33.30 | <50.00 | <10.00 | 2.5 | <1.00 | <1.00 | 7.5 | 3.1 | 3.3 | <3.33 | <10.00 | <2.00 | <2.00 | <2.00 | <2.00 |
| 09C | 0.5 | ND | ND | ND | <1.00 | <5.00 | <10.00 | <1.00 | 9.6 | 2.4 | 6.3 | 9.3 | 4.8 | 3.6 | 1.7 | 2.5 | 1.7 | <1.00 | 1.5 | 1.36 |
| 09D | ND | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | ND | 3.5 | | ND | <1.00 | <5.00 | <50.00 | <10.00 | <1.00 | <3.33 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10C | 0.8 | ND | | ND | 1.15 | <5.00 | <5.00 | 1.33 | 1.4 | 1.4 | 1.5 | 1.4 | 1.2 | 1.3 | 1.3 | 1.1 | 1.1 | <1.00 | 1.4 | 1.23 |
| 11A | ND | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 12A | ND | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13A | ND | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13C | ND | 0.6 | | ND | 4.88 | 69.66 | 33.56 | 25.76 | 75 | 34.1 | 36.5 | 20.5 | 7.6 | 6.8 | 3.9 | 3.3 | 3 | <1.00 | 2 | 2.31 |
| 14A | ND | ND | | ND | <1.00 | <5.00 | <20.00 | <1.00 | <10.00 | <5.00 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14C | 13 | ND | | ND | <1.00 | <5.00 | <5.00 | 26.44 | 22 | 11.7 | <10.00 | <10.00 | <10.00 | 4.3 | 2.8 | 4.64 | 2.5 | 1.2 | 1.4 | 1.33 |
| 14E | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | ND | ND | | ND | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 |
| 15C | ND | ND | | ND | <1.00 | <33.30 | <5.00 | <1.00 | <3.33 | <1.00 | <2.00 | <10.00 | <10.00 | <10.00 | <3.33 | 5.2 | 5.2 | 5.4 | <1.00 | 4.28 |
| 15D | ND | ND | | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | ND | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 2 | <1.00 | 10.9 | 49.8 | 1.6 | 46.03 |
| 16C | ND | ND | | ND | <1.00 | <5.00 | <10.00 | <1.00 | 3.3 | 31.2 | 11.3 | 14.4 | 18.8 | 1.7 | 15 | 8.3 | 10 | 6.4 | 7.8 | 4.33 |
| 17A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | 78.8 | 2.7 | <1.00 | <1.00 | <1.00 | <1.00 | 11.2 | <1.00 | <1.00 | <1.00 | 1.5 | <1.00 |
| 17C | | ND | | ND | 142.64 | 73.23 | 34.26 | 92.46 | 40.6 | 22.5 | 36.6 | 4.7 | 21.8 | 8.53 | 5.6 | 2.7 | 3.7 | 2.4 | 2.1 | NA |
| 17D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | | 18 | | 14 | 8.77 | 5.28 J | <5.00 | 5.79 | 5.4 | 3.1 | 3.6 | 4 | 2.9 | 2.7 | 1.5 | 1.4 | 1.5 | <1.00 | 1.1 | 1.26 |
| 18D | | ND | | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | | ND | | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | | ND | | 61 | 17.57 | 13.44 | 7.14 J | 10.46 | 6.8 | 5.6 | 6.8 | 6.2 | 3.4 | 2.9 | 2.2 | 1.8 | 1.8 | 1.3 | 1.2 | 1.43 |
| 19D | | ND | | 3.9 | 3.60 | <5.00 | <5.00 | 2.42 | 2.2 | 1.6 | 1.9 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | | 0.7 | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | 1.1 | <1.00 | 1.1 | 1.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20D | | ND | ND | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | | | | NA | NA | NA | NA | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

DFT 001102

# TABLE 1 SUMMARY OF GROUNDWATER ANALYTICAL DATA
## BOEING DEVELOPMENTAL CENTER
## DC 9-101 SWMU 20
## PUMP AND TREAT EVALUATION
## TUKWILA, WASHINGTON

**Naphthalene** *ug/l*

| | Aug-89 | Feb-91 | Jun-93 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | NA | NA | NA | NA | NA | NA | <1.00 | 2.8 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.4 | <1.00 | <1.00 | <1.00 | <1.00 |
| 06C | NA | NA | NA | NA | NA | NA | 29.26 | 10.4 | 9.1 | 8.8 | 7.2 | <1.00 | 18.4 | 3 | 25.1 | 3.4 | <1.00 | 7.7 | 44.97 |
| 08C | NA | NA | NA | NA | NA | NA | 351.9 | 401 | 155 | 370 | 234 | 118 | 292 | 600 E | 38.6 | 230 | 137 | 109.2 | 174.1 |
| 09A | NA | NA | NA | NA | NA | NA | <50.00 | <3.33 | <10.00 | <4.00 | <5.00 | <1.00 | 7 | <1.00 | <10.00 | <1.00 | <10.00 | <10.00 | 8.65 |
| 09B | NA | NA | NA | NA | NA | NA | <10.00 | <2.00 | <1.00 | <1.00 | 13.8 | 22.4 | <2.00 | <3.33 | <10.00 | 3.4 | 4.6 | <2.00 | 11.2 |
| 09C | NA | NA | NA | NA | NA | NA | <1.00 | 1.2 | <1.00 | 8.8 | 6.5 | <1.00 | 25 | <1.00 | <1.00 | 9.9 | 6.8 | <1.00 | 1.67 |
| 09D | NA | NA | NA | NA | NA | NA | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10A | NA | NA | NA | NA | NA | NA | <10.00 | 4.2 | <3.33 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 10C | NA | NA | NA | NA | NA | NA | 14.27 | 30.5 | 6.3 | 56.1 | 6.4 | 7.6 | 5.8 | 2.8 | <1.00 | 3.8 | 4.7 | 2.7 | 5.77 |
| 11A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 5.1 | <1.00 |
| 12A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 13C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 14A | NA | NA | NA | NA | NA | NA | <1.00 | <10.00 | <5.00 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | 150 | 4.8 | 235 | 113.23 |
| 14C | NA | NA | NA | NA | NA | NA | <2.00 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 | 11.8 | 7.2 | 6.5 | 6.3 | 7.3 | 17.2 | 8.7 |
| 14E | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 15A | NA | NA | NA | NA | NA | NA | 423.67 | 239 | 152 | 247 | 136 | 67.3 | 465 E | 1721 E | 916 | 58.9 | 561 | 797 | 695.6 |
| 15C | NA | NA | NA | NA | NA | NA | <1.00 | 1 | <1.00 | 4.4 | <10.00 | <10.00 | <10.00 | <3.33 | 4.8 | <2.00 | <2.00 | 29.8 | <1.00 |
| 15D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 16C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17A | NA | NA | NA | NA | NA | NA | <1.00 | 62 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 17C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | 26.6 | <1.00 | 0.6 | 37.3 | 106 | <1.00 | <1.00 | 31.9 | 16.6 | 13.7 | NA |
| 17D | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NA |
| 18A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 18C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | <1.00 |
| 18D | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 19D | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20C | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 20D | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| 21A | NA | NA | NA | NA | NA | NA | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |

NA = Constituent was not analyzed.

ND = Constituent was not detected in laboratory analysis.

DFT 001103

Table 2
Groundwater Elevation Data
Boeing Developmental Center
DC 9-101 Building SWMU 20
Pump and Treat Evaluation
Tukwila, Washington

## DEVELOPMENTAL CENTER WATER LEVEL MEASUREMENTS

| | | | | December 2000 (2) | | October 1995 (3) | | February 1996 (4) | |
|---|---|---|---|---|---|---|---|---|---|
| Well Location / Bldg. | Well ID No. | Well Depth | Top of Well Casing Elev. (1) (NGVD29) | Depth to Water | Water Elevation | Depth to Water | Water Elevation | Depth to Water | Water Elevation |
| 9-101-bldg. | MW-6B | 27.2 | 14.83 | 13.55 | 1.28 | 13.90 | 0.93 | 11.63 | 3.20 |
| 9-101-bldg. | MW-6C | 40.55 | 14.99 | 13.7 | 1.29 | 14.20 | 0.79 | 11.75 | 3.24 |
| 9-101-bldg. | MW-8C | 40.2 | 14.92 | 13.71 | 1.21 | 13.31 | 1.61 | 11.77 | 3.15 |
| 9-101-bldg. | MW-9A | 21.3 | 14.64 | 13.72 | 0.92 | 12.96 | 1.68 | 11.51 | 3.13 |
| 9-101-bldg. | MW-9B | 26.9 | 14.72 | 13.82 | 0.90 | 13.06 | 1.66 | 11.78 | 2.94 |
| 9-101-bldg. | MW-9C | 38.8 | 14.68 | 13.57 | 1.11 | 12.96 | 1.72 | 11.65 | 3.03 |
| 9-101-bldg. | MW-9D | 56 | 14.66 | 13.03 | 1.63 | 13.03 | 1.63 | 11.60 | 3.06 |
| 9-101-bldg. | MW-10A | 20.2 | 14.69 | 13.62 | 1.07 | 13.08 | 1.61 | 11.72 | 2.97 |
| 9-101-bldg. | MW-10C | 40.4 | 14.62 | 13.4 | 1.22 | 12.99 | 1.63 | 11.60 | 3.02 |
| 9-101-bldg. | MW-11A | 19.9 | 14.88 | 13.52 | 1.36 | 13.22 | 1.66 | 11.62 | 3.26 |
| 9-101-bldg. | MW-12A | 20.2 | 14.83 | 13.5 | 1.33 | 13.25 | 1.58 | 11.71 | 3.12 |
| 9-101-bldg. | MW-13A | 19.37 | 14.14 | 12.76 | 1.38 | 12.86 | 1.28 | 11.20 | 2.94 |
| 9-101-bldg. | MW-13C | 35.62 | 14.02 | 12.69 | 1.33 | 12.71 | 1.31 | 11.02 | 3.00 |
| 9-101-bldg. | MW-14A | 19 | 14.47 | 12.98 | 1.49 | 13.28 | 1.19 | 11.40 | 3.07 |
| 9-101-bldg. | MW-14C | 33.3 | 13.97 | 12.49 | 1.48 | 12.87 | 1.10 | 10.96 | 3.01 |
| 9-101-bldg. | MW-14E | 82.1 | 14.18 | 7.44 | 6.74 | 8.36 | 5.82 | 7.25 | 6.93 |
| 9-101-bldg. | MW-15A | 20.7 | 14.17 | 12.82 | 1.35 | 12.86 | 1.31 | 11.10 | 3.07 |
| 9-101-bldg. | MW-15C | 34.35 | 14.17 | 12.77 | 1.40 | 12.67 | 1.50 | 11.10 | 3.07 |
| 9-101-bldg. | MW-15D | 51.8 | 14.41 | 12.9 | 1.51 | nm | nm | nm | nm |
| 9-101-bldg. | MW-16A | 20.55 | 14.99 | 13.5 | 1.49 | 13.72 | 1.27 | 11.77 | 3.22 |
| 9-101-bldg. | MW-16C | 38.3 | 15.04 | 13.67 | 1.37 | 13.89 | 1.15 | 11.94 | 3.10 |
| 9-101-bldg. | MW-17A | 19 | 14.8 | 13.32 | 1.48 | 13.37 | 1.43 | 11.65 | 3.15 |
| 9-101-bldg. | MW-17C | 35 | 14.85 | nm | nm | 13.40 | 1.45 | 11.66 | 3.19 |
| 9-101-bldg. | MW-17D | 52.5 | 14.87 | nm | nm | 13.44 | 1.43 | 11.81 | 3.06 |
| 9-101-bldg. | MW-18A | 20.02 | 14.3 | 12.84 | 1.46 | 12.90 | 1.40 | 11.39 | 2.91 |
| 9-101-bldg. | MW-18C | 34.55 | 14.63 | 13.12 | 1.51 | 13.21 | 1.42 | 11.65 | 2.98 |
| 9-101-bldg. | MW-18D | 52.85 | 14.26 | 12.85 | 1.41 | 12.87 | 1.39 | 11.39 | 2.87 |
| 9-101-bldg. | MW-19A | 16.86 | 12.23 | 10.93 | 1.30 | 10.92 | 1.31 | 9.12 | 3.11 |
| 9-101-bldg. | MW-19C | 33.92 | 12.23 | 10.89 | 1.34 | 10.83 | 1.40 | 9.03 | 3.20 |
| 9-101-bldg. | MW-19D | 51.86 | 12.23 | 10.9 | 1.33 | 10.96 | 1.27 | 9.38 | 2.85 |
| 9-101-bldg. | MW-20A | 19.34 | 14.31 | 12.89 | 1.42 | 12.79 | 1.52 | 11.13 | 3.18 |
| 9-101-bldg. | MW-20C | 35.32 | 14.15 | 12.69 | 1.46 | 12.58 | 1.57 | 10.73 | 3.42 |
| 9-101-bldg. | MW-20D | 50.15 | 14.43 | 12.87 | 1.56 | 12.98 | 1.45 | 11.05 | 3.38 |
| 9-101/9-50 bldg. | MW-21A | 19.9 | 14.45 | 13.04 | 1.41 | 13.10 | 1.35 | nm | nm |

na - not available
nm - not measured
* Surface Elevation
Depth to Water measurements taken from top of well casing

1) Elevations from February 2001 survey
2) Data collected during period when extraction well E-2 was operating alone.
3) Data collected during period when extraction well E-1 was operating alone.
4) Data collected during non-pumping conditions.

# Table 3
## Monitoring Well Construction Details
## Boeing Developmental Center
## DC 9-101 Building SWMU 20
## Pump and Treat Evaluation
## Tukwila, Washington

| *Monitoring Well Number* | *Well Diameter & Const.* | *Top of Well Screen (Feet BGS)* | *Bottom of Well Screen (Feet BGS)* |
|---|---|---|---|
| MW-6B | 2" FGRP | 22.0 | 27.5 |
| MW-6C | 2" FGRP | 30.0 | 40.5 |
| MW-8C | 2" FGRP | 30.0 | 40.5 |
| MW-9A | 2" FGRP | 11.0 | 21.5 |
| MW-9B | 2" FGRP | 22.0 | 27.0 |
| MW-9C | 2" FGRP | 29.0 | 39.5 |
| MW-9D | 2" FGRP | 41.0 | 56.0 |
| MW-10A | 2" PVC-40 | 15.0 | 20.0 |
| MW-10C | 2" PVC-40 | 30.0 | 40.5 |
| MW-11A | 2" PVC-40 | 9.5 | 20.0 |
| MW-12A | 2" PVC-40 | 10.0 | 20.5 |
| MW-13A | 2" PVC-40 | 9.5 | 20.0 |
| MW-13C | 2" PVC-40 | 25.5 | 36.0 |
| MW-14A | 2" PVC-40 | 9.0 | 19.5 |
| MW-14C | 2" PVC-40 | 23.5 | 34.0 |
| MW-14E | 2" PVC-40 | 77.0 | 82.0 |
| MW-15A | 2" PVC-40 | 11.0 | 21.5 |
| MW-15C | 2" PVC-40 | 24.5 | 35.0 |
| MW-15D | 2" PVC-40 | 41.5 | 52.0 |
| MW-16A | 2" PVC-40 | 10.0 | 20.5 |
| MW-16C | 2" PVC-40 | 28.0 | 38.5 |
| MW-17A | 2" PVC-40 | 9.5 | 19.5 |
| MW-17C | 2" PVC-40 | 24.4 | 34.4 |
| MW-17D | 2" PVC-40 | 42.0 | 52.0 |
| MW-18A | 2" PVC-40 | 11.5 | 21.5 |
| MW-18C | 2" PVC-40 | 26.0 | 36.0 |
| MW-18D | 2" PVC-40 | 46.5 | 56.5 |
| MW-19A | 2" PVC-40 | 6.5 | 16.5 |
| MW-19C | 2" PVC-40 | 24.5 | 34.5 |
| MW-19D | 2" PVC-40 | 41.5 | 51.5 |
| MW-20A | 2" PVC-40 | 8.5 | 18.5 |
| MW-20C | 2" PVC-40 | 24.5 | 34.5 |
| MW-20D | 2" PVC-40 | 40.0 | 50.0 |
| MW-21A | 2" PVC-40 | 10.0 | 20.0 |
| E-1 | | 23.0 | 38.3 |
| E-2 | | 22.0 | 32.0 |

PVC = polyvinyl chloride

FGRP = fiberglass reinforced plastic

# DEVELOPMENTAL CENTER 9-101 PUMP TREAT SYSTEM
## EXTRACTION SAMPLING SUMMARY

**Table 4**
**Mass Removal Rate Summary**
**March 1994 to September 2000**
**Boeing Developmental Center**
**DC 9-101 Building SWMU 20**
**Pump and Treat Evaluation**
**Tukwila, Washington**

| *Year - 1994* | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 2,804,508 | 10616218.24 | | | | |
| *Extraction Well E-1* | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed through 9/00 | Cumulative Percentage of Total Mass Removed through 9/00 |
| *Vinyl Chloride* | 103.02 | 1093.63 | 2.4 | 2.4 | | |
| *cis-1,2-Dichloroethene* | 177.45 | 1883.86 | 4.2 | 4.2 | | |
| *Trichloroethene* | 99.74 | 1058.88 | 2.3 | 2.3 | | |
| *Tetrachloroethene* | 179.00 | 1900.29 | 4.2 | 4.2 | | |
| *Total VOCs* | | | 13.1 | 13.1 | 16.33% | 16.33% |

| *Year - 1995* | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 3,463,865 | 13112156.14 | | | | |
| *Extraction Well E-1* | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed | Cumulative Percentage of Total Mass Removed |
| *Vinyl Chloride* | 94.65 | 1241.07 | 2.7 | 5.1 | | |
| *cis-1,2-Dichloroethene* | 199.58 | 2616.97 | 5.8 | 9.9 | | |
| *Trichloroethene* | 96.45 | 1264.71 | 2.8 | 5.1 | | |
| *Tetrachloroethene* | 185.62 | 2433.93 | 5.4 | 9.6 | | |
| *Total VOCs* | | | 16.7 | 29.7 | 20.79% | 37.12% |

| *Year - 1996* | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 3,197,278 | 12103014.51 | | | | |
| *Extraction Well E-1 (1/96-2/96) E-2 (7/96-12/96)* | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed | Cumulative Percentage of Total Mass Removed |
| *Vinyl Chloride* | 71.04 | 859.77 | 1.9 | 7.0 | | |
| *cis-1,2-Dichloroethene* | 155.17 | 1878.05 | 4.1 | 14.1 | | |
| *Trichloroethene* | 70.17 | 849.22 | 1.9 | 7.0 | | |
| *Tetrachloroethene* | 132.24 | 1600.48 | 3.5 | 13.1 | | |
| *Total VOCs* | | | 11.4 | 41.2 | 14.27% | 51.39% |

DFT 001106

# Table 5
## Estimated Change of Plume Area (100 ppb isopleth)
## Boeing Developmental Center
## DC9-101 Building SWMU

| Groundwater Horizon | Col | Area of 100 ug/L Isopleth (1) ($ft^2$) 1989 | 1994 | 1989-1994 Percent Change | Area of 100 ug/L Isopleth (1) ($ft^2$) 1994 | 2000 | 1994-2000 Percent Change |
|---|---|---|---|---|---|---|---|
| A | Vinyl Chloride | 0 | 3131 | NA | 3131 | 161 | -95% |
| A | cis-1,2- DCE | 7766 | 5173 | -33% | 5173 | 0 | -100% |
| A | TCE | 4195 | 3864 | -8% | 3864 | 0 | -100% |
| A | PCE | 3767 | 3306 | -12% | 3306 | 0 | -100% |
| C | Vinyl Chloride | 2754 | 6078 | 121% | 6078 | 0 | -100% |
| C | cis-1,2- DCE | 7968 | 1647 | -79% | 1647 | 0 | -100% |
| C | TCE | 1349 | 0 | -100% | 0 | 0 | NA |
| C | PCE | 1976 | 0 | -100% | 0 | 0 | NA |

(1) See Figures 1 through 8

# DEVELOPMENTAL CENTER 9-101 PUMP TREAT SYSTEM
## EXTRACTION SAMPLING SUMMARY

| Year - 1997 | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 6,957,692 | 26337730.79 | | | | |
| Extraction Well E-2 | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed | Cumulative Percentage of Total Mass Removed |
| Vinyl Chloride | 54.72 | 1441.11 | 3.2 | 10.2 | | |
| cis-1,2-Dichloroethene | 124.53 | 3279.71 | 7.2 | 21.3 | | |
| Trichloroethene | 36.65 | 965.28 | 2.1 | 9.1 | | |
| Tetrachloroethene | 80.18 | 2111.63 | 4.7 | 17.7 | | |
| Total VOCs | | | 17.2 | 58.4 | 21.45% | 72.84% |

| Year - 1998 | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 7,249,888 | 27443813.03 | | | | |
| Extraction Well E-2 (1/98-7/98, 12/98) E-1 (8/98-11/98) | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed | Cumulative Percentage of Total Mass Removed |
| Vinyl Chloride | 42.05 | 1154.13 | 2.5 | 12.8 | | |
| cis-1,2-Dichloroethene | 77.99 | 2140.27 | 4.7 | 26.0 | | |
| Trichloroethene | 21.00 | 576.43 | 1.3 | 10.4 | | |
| Tetrachloroethene | 54.72 | 1501.75 | 3.3 | 21.1 | | |
| Total VOCs | | | 11.8 | 70.2 | 14.78% | 87.63% |

| Year - 1999 | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 6,441,513 | 24383780.61 | | | | |
| Extraction Well E-1 (1/99-3/99) E-2 (4/99-12/99) | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed through 9/00 | Cumulative Percentage of Total Mass Removed through 9/00 |
| Vinyl Chloride | 30.56 | 745.19 | 1.6 | 14.4 | | |
| cis-1,2-Dichloroethene | 41.93 | 1022.46 | 2.3 | 28.3 | | |
| Trichloroethene | 13.64 | 332.55 | 0.7 | 11.1 | | |
| Tetrachloroethene | 37.06 | 903.66 | 2.0 | 23.0 | | |
| Total VOCs | | | 6.6 | 76.8 | 8.26% | 95.89% |

| Year - 2000 | Total Gallons Removed During Year | Total Liters Removed During Year | | | | |
|---|---|---|---|---|---|---|
| | 3,782,562 | 14318555.59 | | | | |
| Extraction Well E-2 (1/00-9/00) | Average Concentration of Groundwater Extracted, ug/L | Mass of Constituent Removed During Year, grams | Mass of Constituent Removed During Year, Pounds | Cumulative Mass Removed, Pounds | Percentage of Total Mass Removed | Cumulative Percentage of Total Mass Removed |
| Vinyl Chloride | 33.84 | 484.58 | 1.1 | 15.5 | | |
| cis-1,2-Dichloroethene | 35.24 | 504.63 | 1.1 | 29.4 | | |
| Trichloroethene | 11.16 | 159.75 | 0.4 | 11.5 | | |
| Tetrachloroethene | 24.09 | 344.87 | 0.8 | 23.8 | | |
| Total VOCs | | | 3.3 | 80.1 | 4.11% | 100.00% |

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# Table 6
## Contaminant Reduction Estimates Using Linear Regression Analysis
## Boeing Developmental Center SWMU 20

**PCE Data**

| Well ID | Active Pumping Reduction Rate (1/year) | Inactive Pumping Reduction Rate (1/year) |
|---|---|---|
| MW-6B | -0.0373 | -0.744 |
| MW-8C | -0.3592 | -0.9189 |
| MW-9A | -0.2835 | -0.6405 |
| MW-9B | -0.4479 | -0.8307 |
| MW-9C | NA | -1.2685 |
| MW-10A | -0.2049 | -0.6791 |
| MW-14A | -0.4122 | 0.3113 |
| MW-14C | -0.0837 | -1.4067 |
| MW-15A | NA | 1.6094 |
| MW-15C | -2.4696 | 0 |
| Mean | -0.5373 | -0.4568 |
| Median | -0.3592 | -0.7116 |

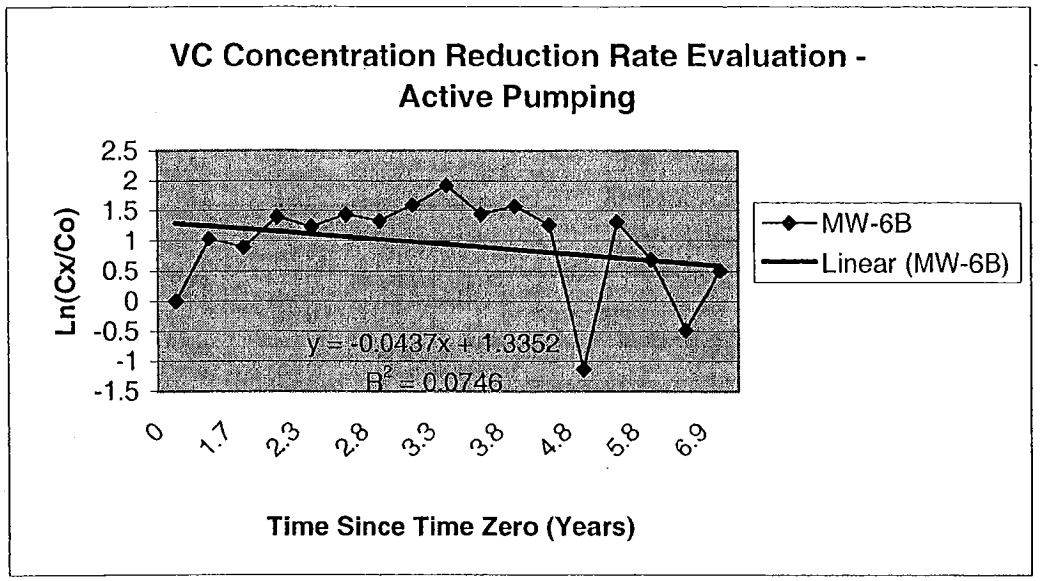
**TCE Data**

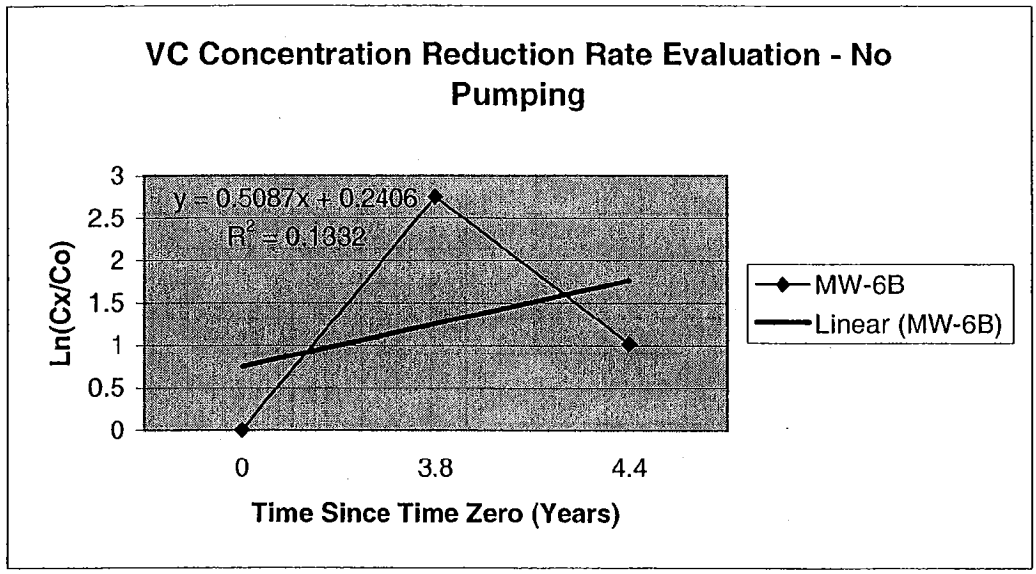
| Well ID | Active Pumping Reduction Rate (1/year) | Inactive Pumping Reduction Rate (1/year) |
|---|---|---|
| MW-6B | 0.0054 | -1.0086 |
| MW-8C | 0.2824 | -0.4544 |
| MW-9A | -0.3138 | -0.1879 |
| MW-9B | -0.3752 | -0.1638 |
| MW-9C | -0.0012 | -1.4208 |
| MW-10A | -0.2063 | -0.2798 |
| MW-14A | -0.5449 | 0.7647 |
| MW-14C | 0.0223 | -1.2348 |
| MW-15A | NA | -0.3089 |
| MW-15C | 0 | -0.3031 |
| Mean | -0.1257 | -0.4597 |
| Median | -0.0012 | -0.3060 |

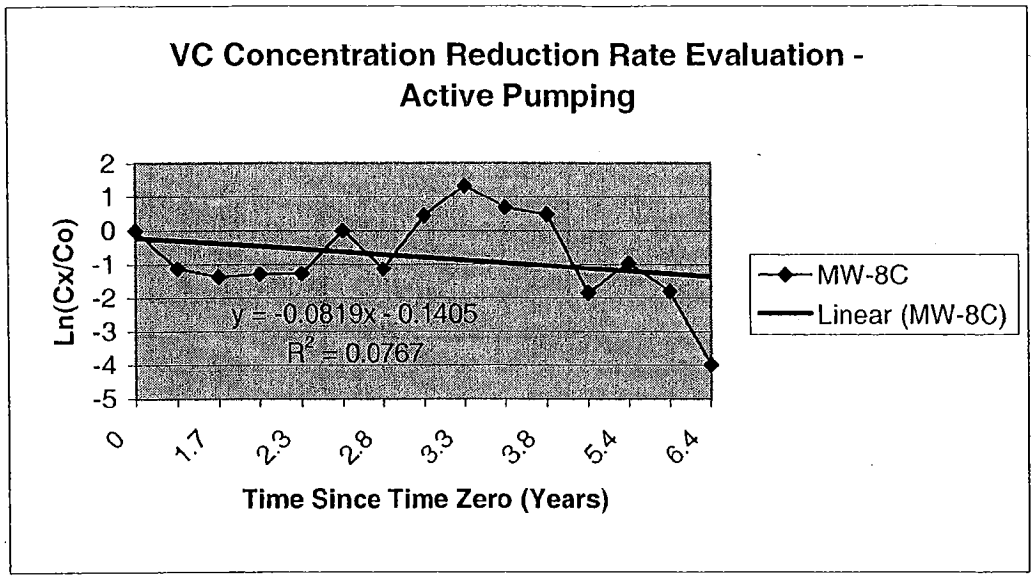
DFT 001109

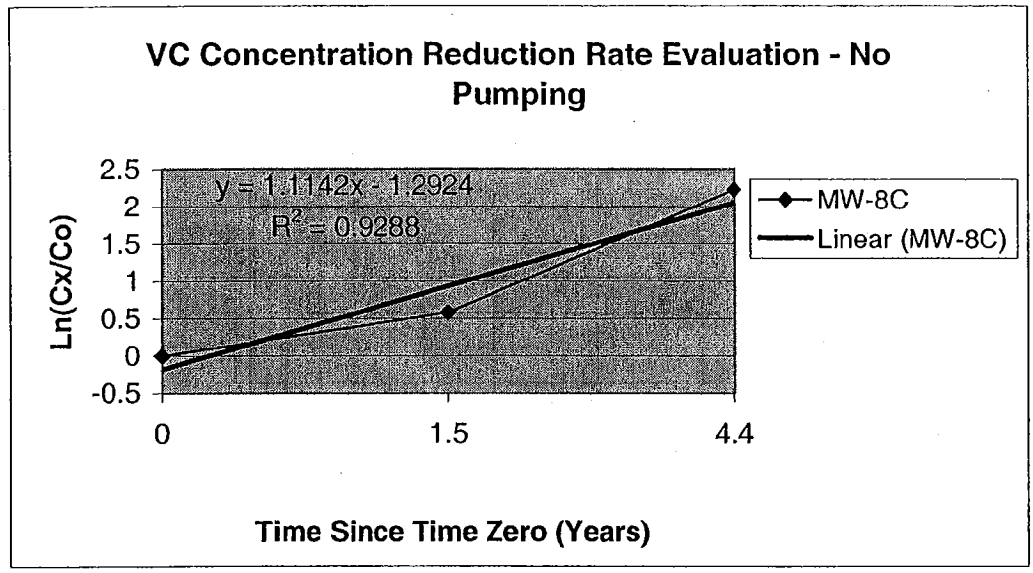
ATTACHMENT 1

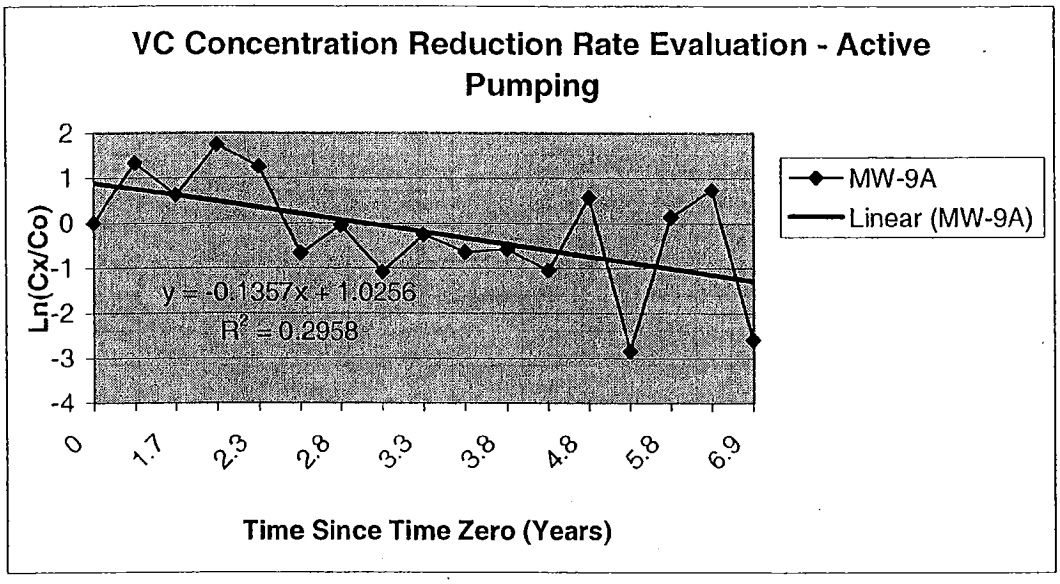
# Concentration Reduction Rate Evaluations

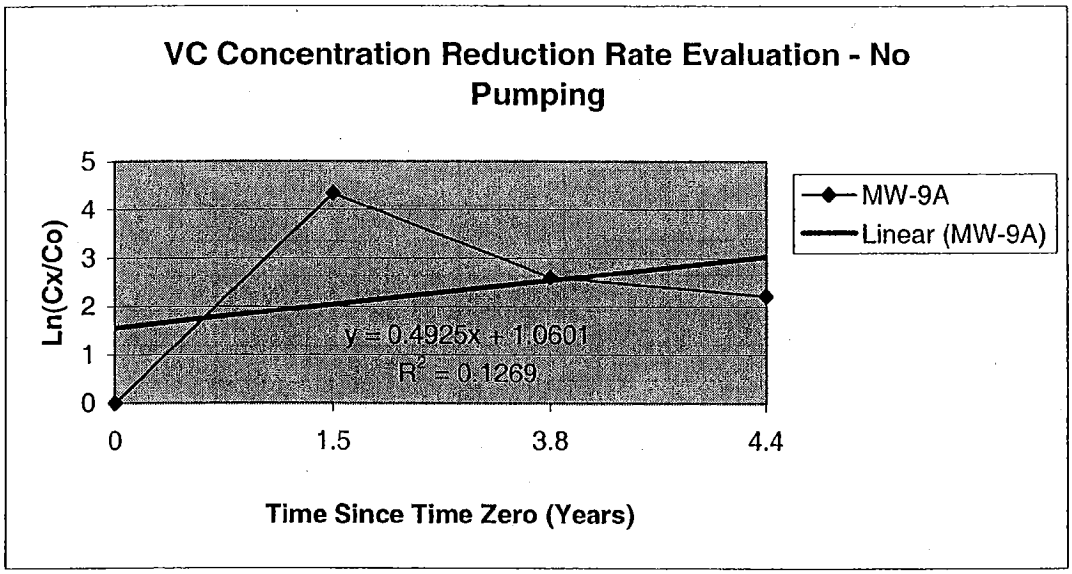

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
y = -0.0437x + 1.3352
R² = 0.0746
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

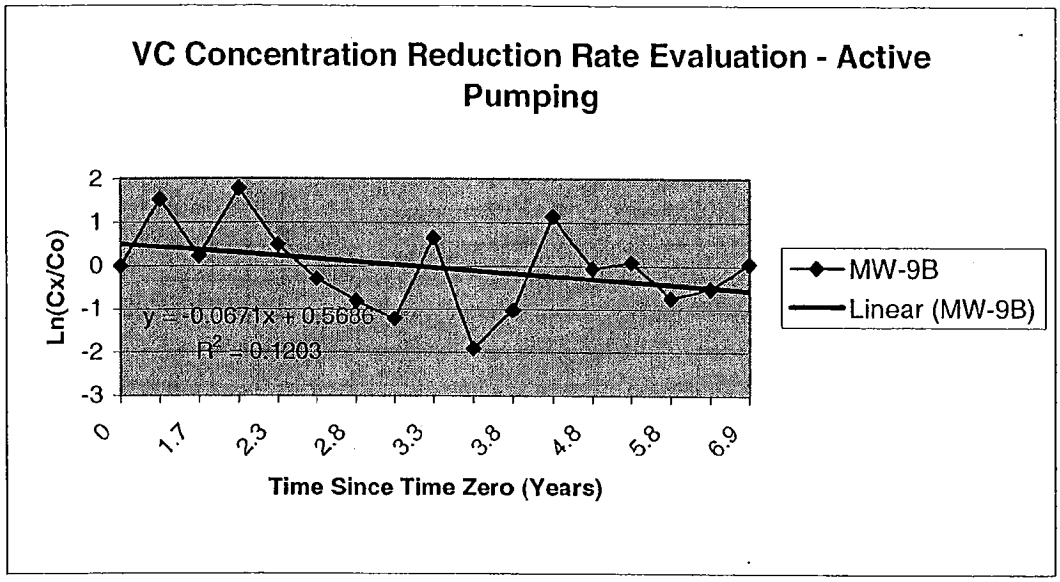

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
3
2.5
2
1.5
1
0.5
0
y = 0.5087x + 0.2406
R² = 0.1332
0
3.8
4.4
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

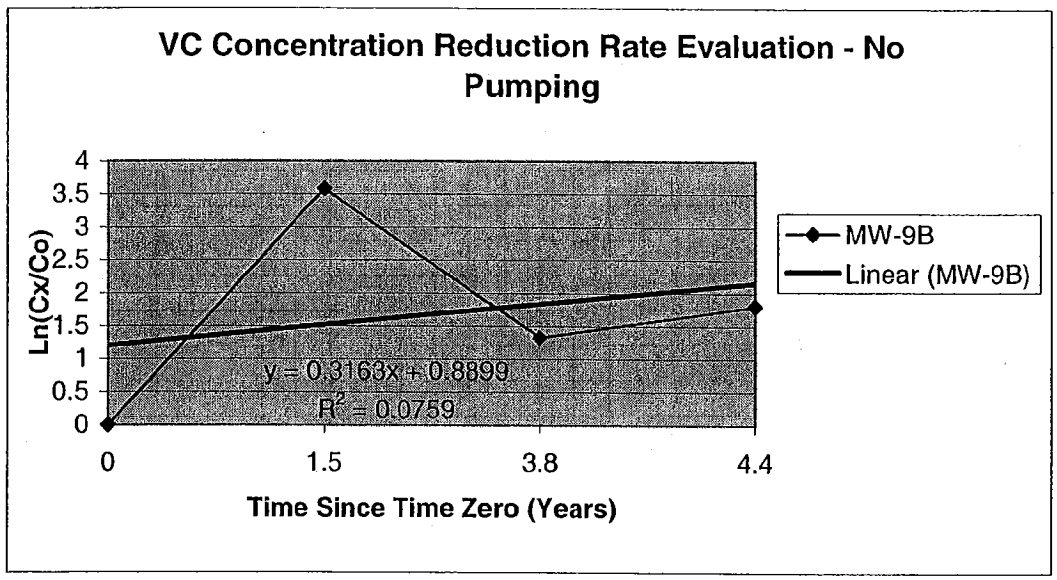

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
-4
-5
y = -0.0819x - 0.1405
R² = 0.0767
0
1.7
2.3
2.8
3.3
3.8
5.4
6.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

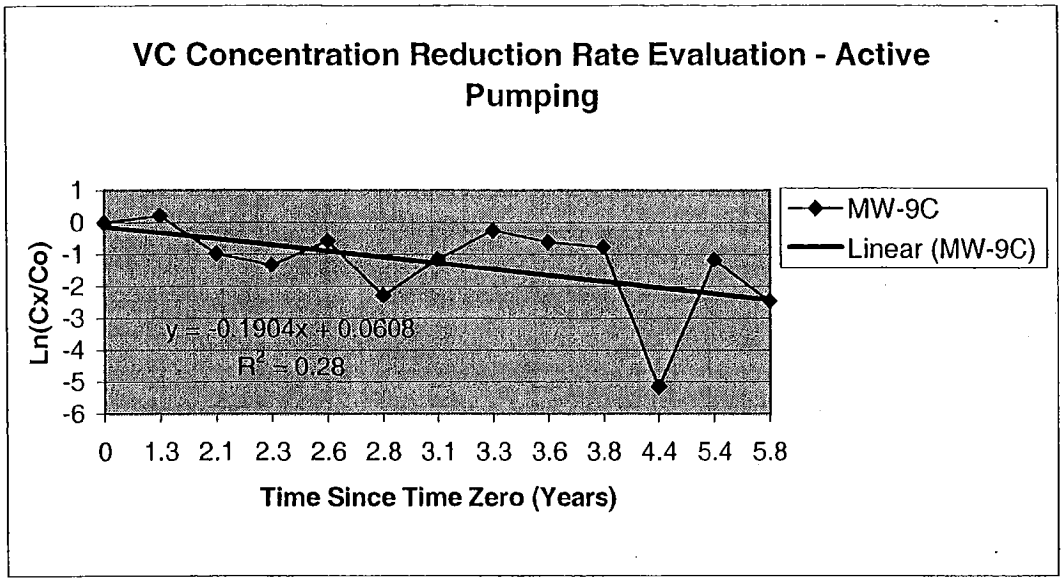

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
2.5
2
1.5
1
0.5
0
-0.5
y = 1.1142x - 1.2924
R² = 0.9288
0
1.5
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

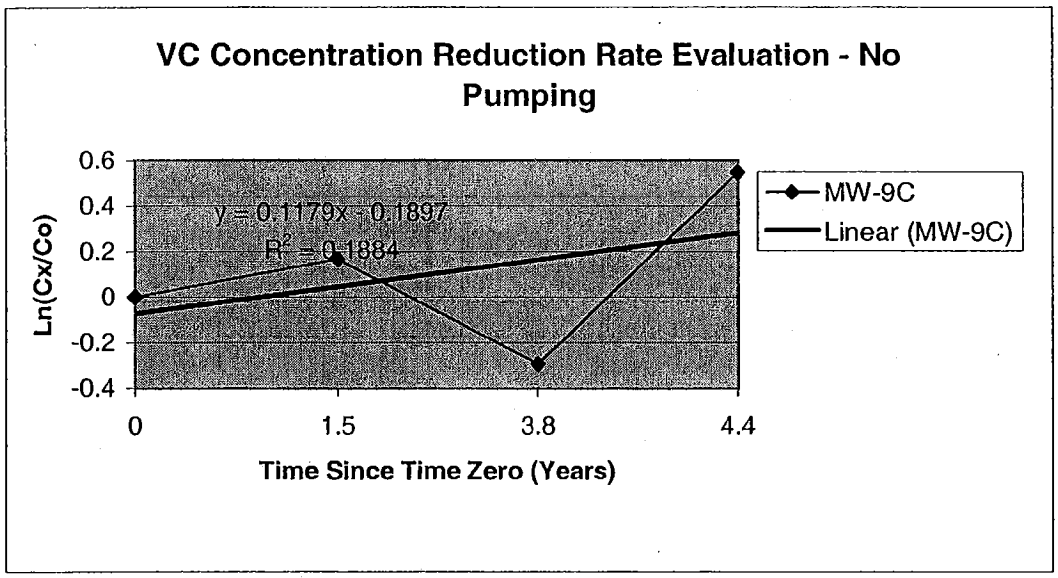

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
-4
y = -0.1357x + 1.0256
R² = 0.2958
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

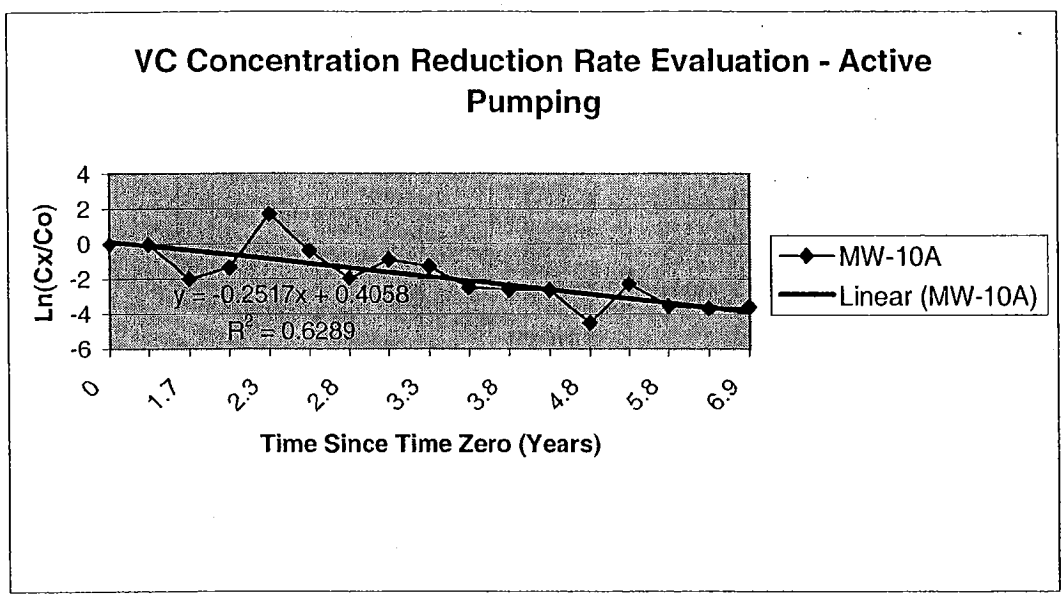

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
5
4
3
2
1
0
y = 0.4925x + 1.0601
R² = 0.1269
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

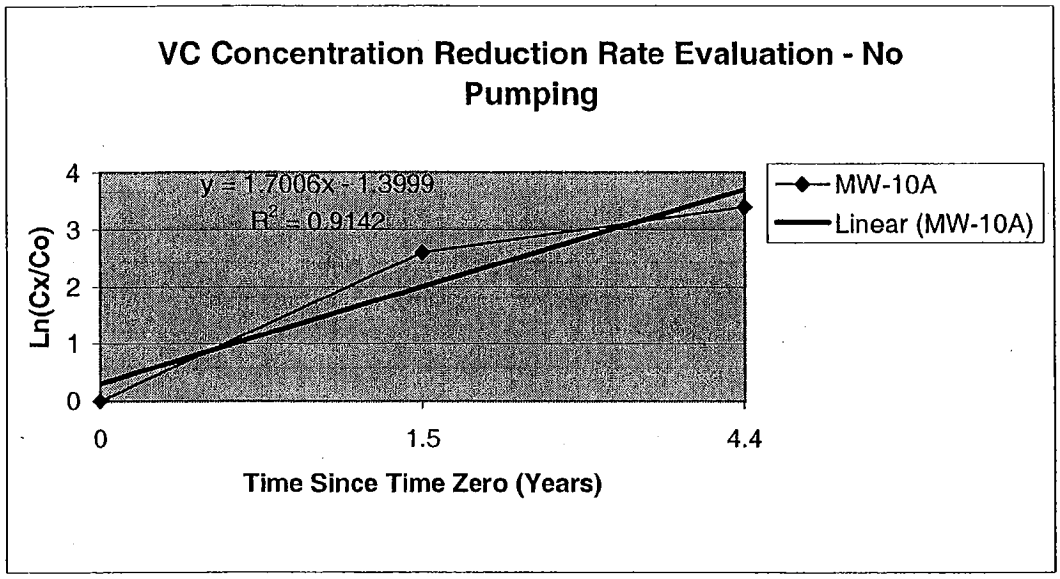

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
y = -0.0671x + 0.5686
R² = 0.1203
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

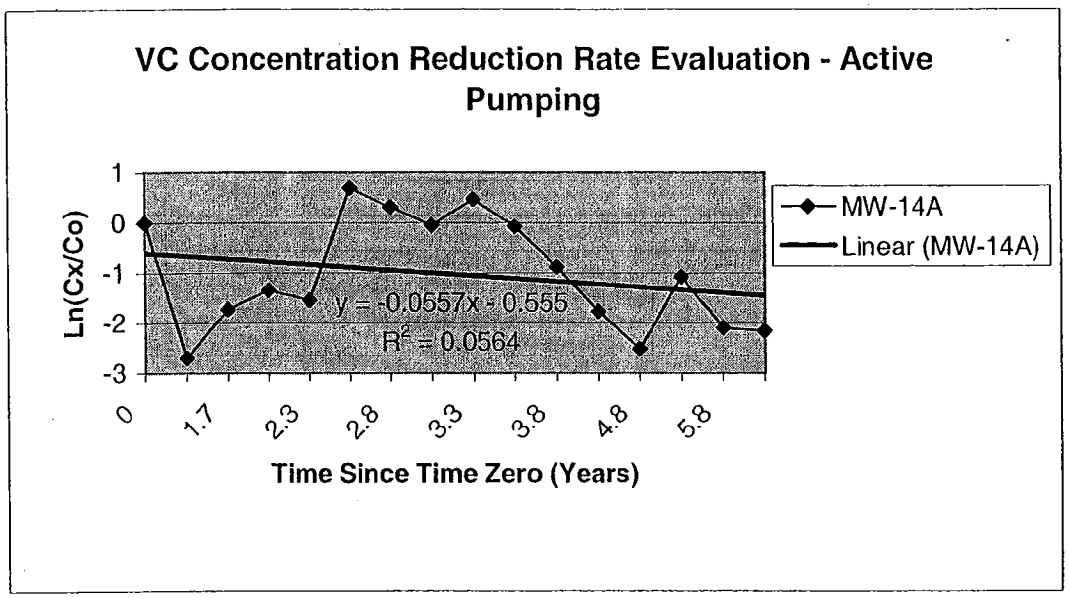

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
4
3.5
3
2.5
2
1.5
1
0.5
0
y = 0.3163x + 0.8899
R² = 0.0759
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

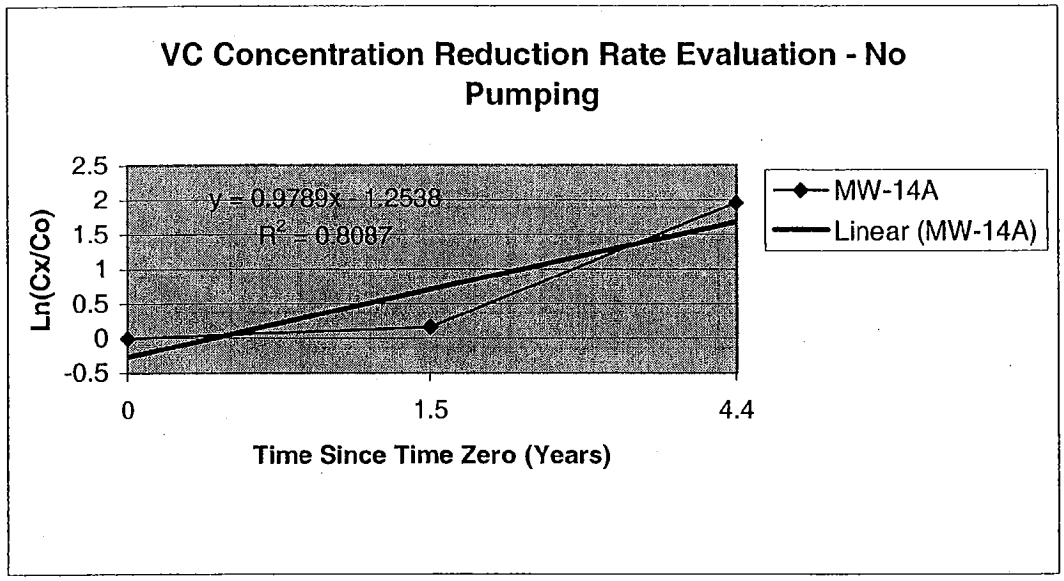

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
1
0
-1
-2
-3
-4
-5
-6
y = -0.1904x + 0.0608
R² = 0.28
0
1.3
2.1
2.3
2.6
2.8
3.1
3.3
3.6
3.8
4.4
5.4
5.8
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

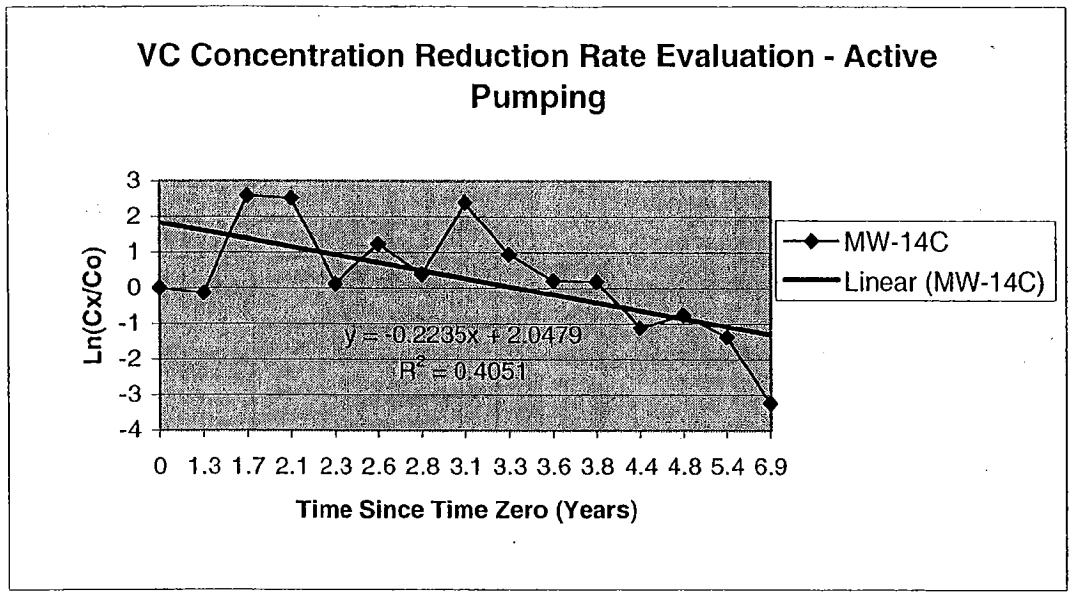

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0.6
0.4
0.2
0
-0.2
-0.4
y = 0.1179x - 0.1897
R² = 0.1884
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

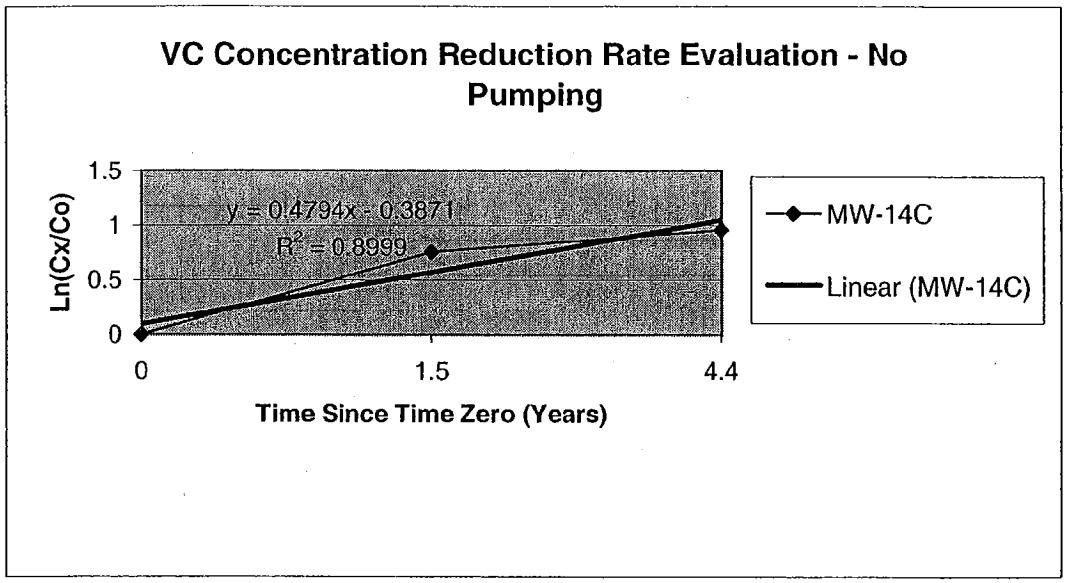

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
4
2
0
-2
-4
-6
y = -0.2517x + 0.4058
R² = 0.6289
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

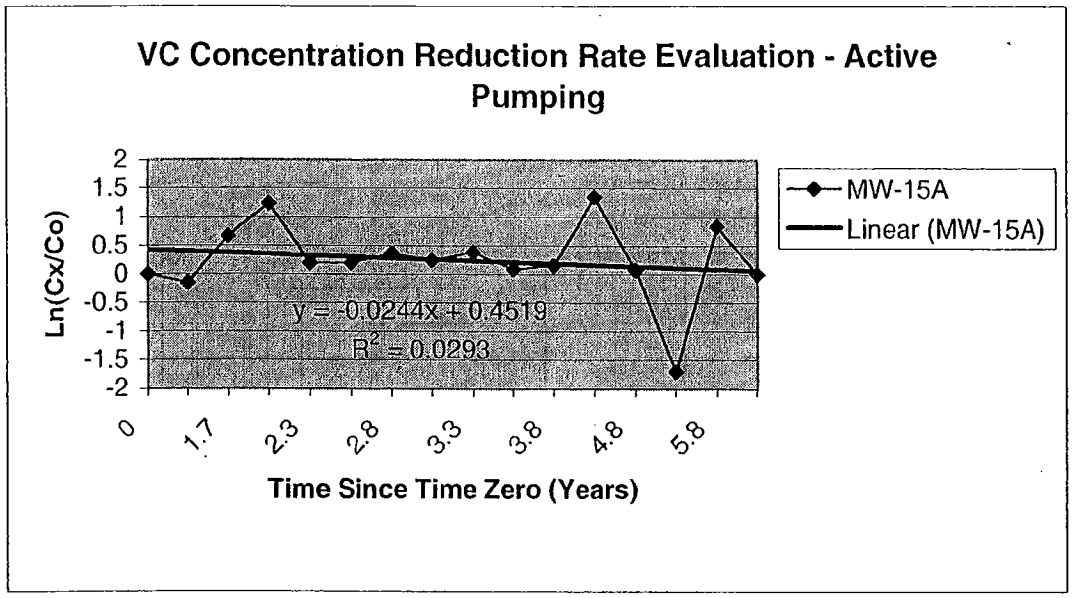

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
4
3
2
1
0
y = 1.7006x - 1.3999
R² = 0.9142
0
1.5
4.4
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

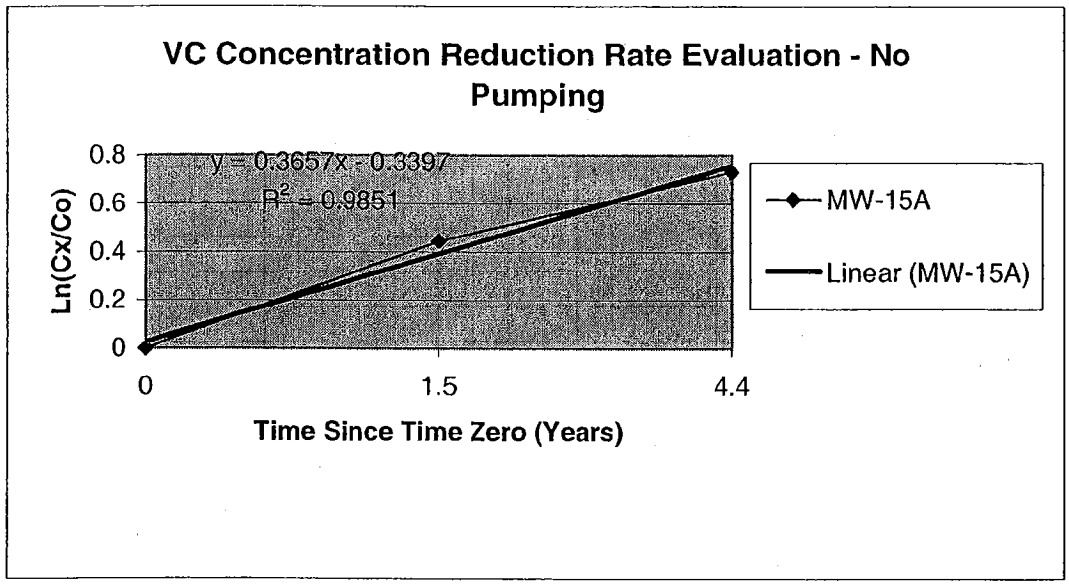

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
1
0
-1
-2
-3
y = -0.0557x - 0.555
R² = 0.0564
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

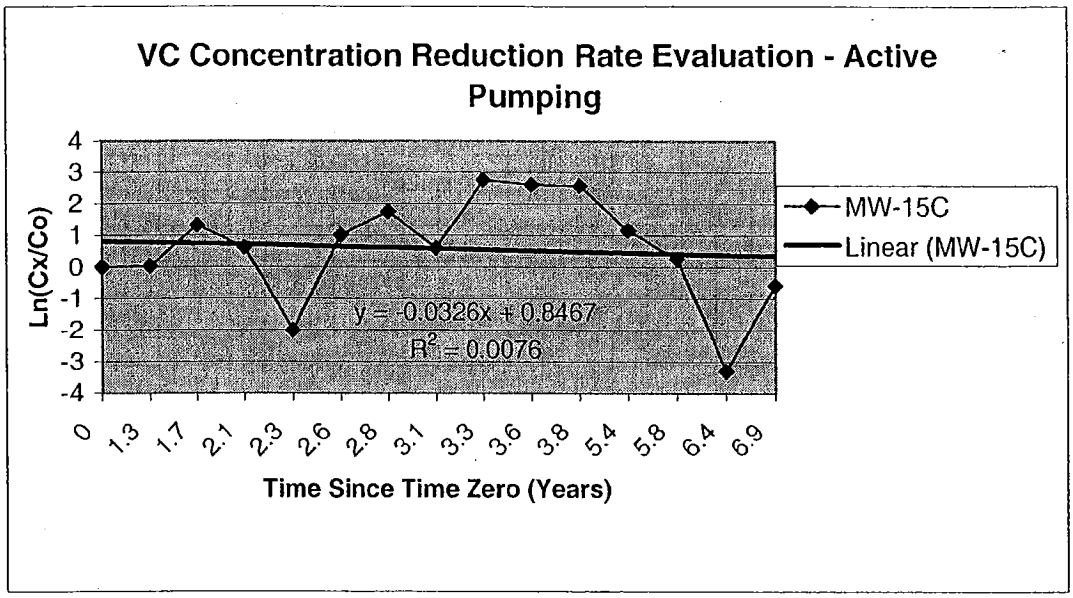

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
2.5
2
1.5
1
0.5
0
-0.5
y = 0.9789x - 1.2538
R² = 0.8087
0
1.5
4.4
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

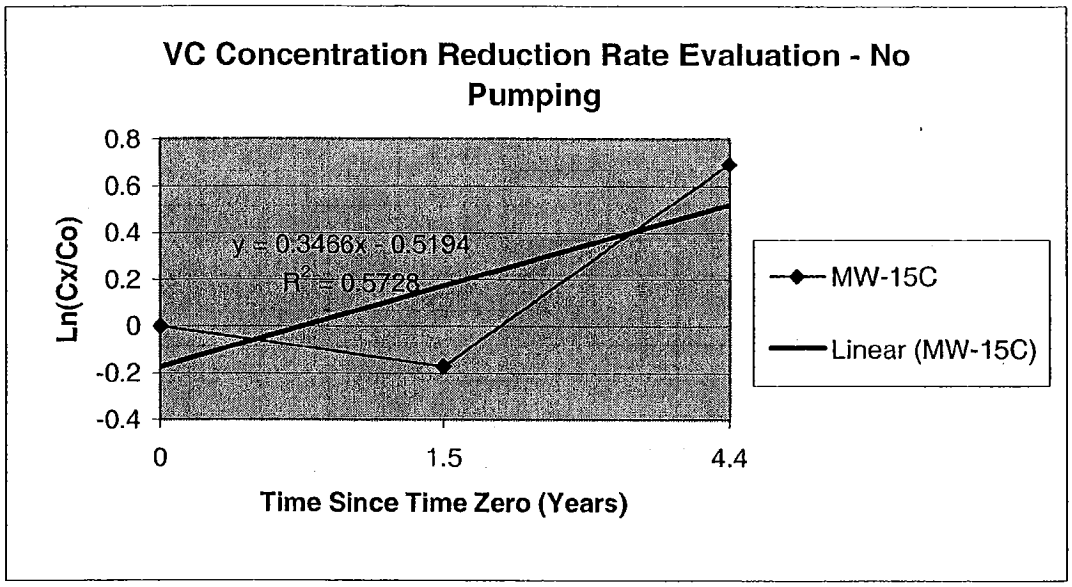

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
3
2
1
0
-1
-2
-3
-4
y = -0.2235x + 2.0479
R² = 0.4051
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 6.9
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)

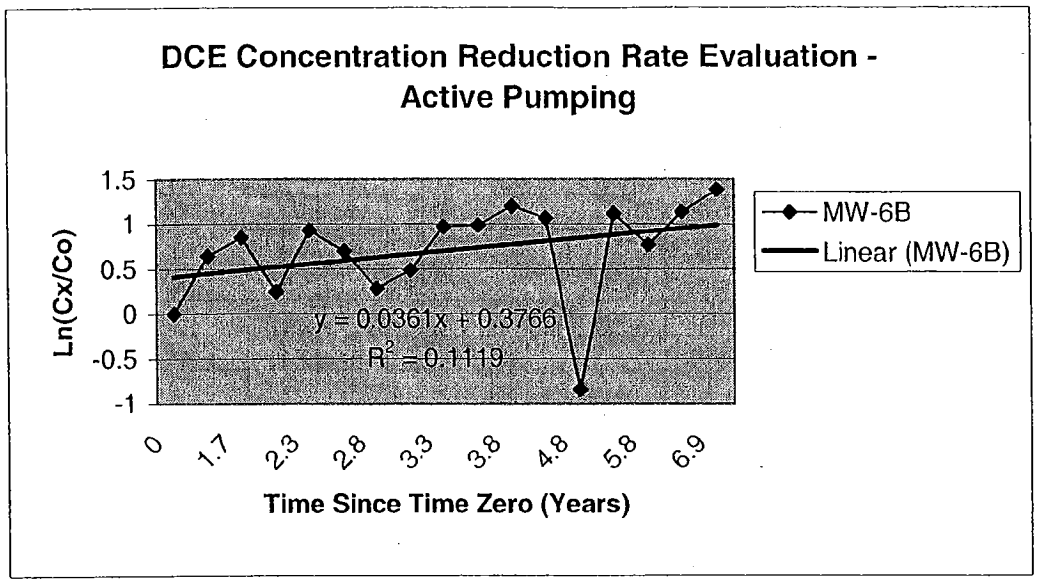

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
1.5
1
0.5
0
y = 0.4794x - 0.3871
R² = 0.8999
0
1.5
4.4
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)

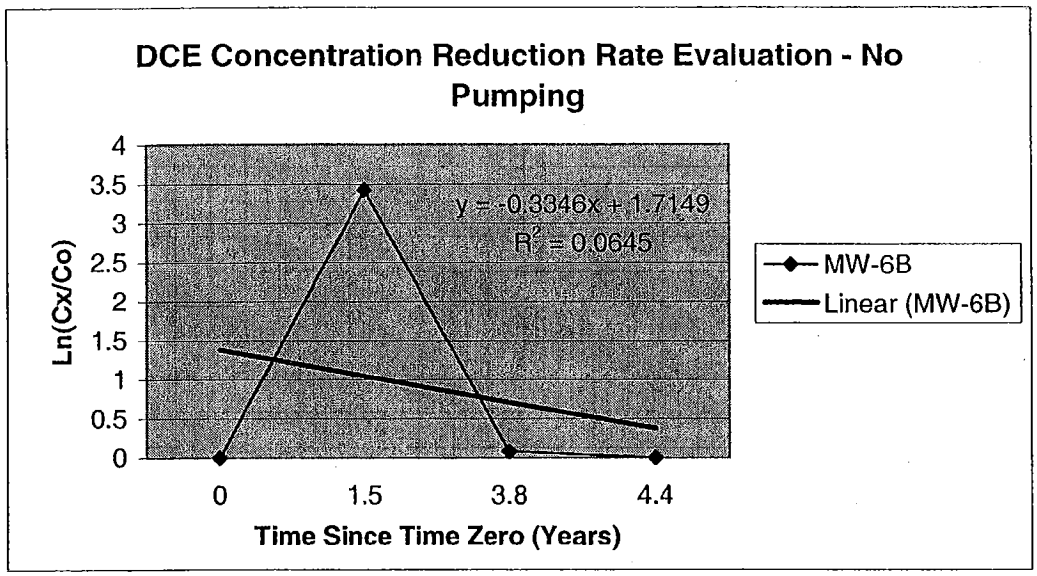

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
y = -0.0244x + 0.4519
R² = 0.0293
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
Time Since Time Zero (Years)
MW-15A
Linear (MW-15A)

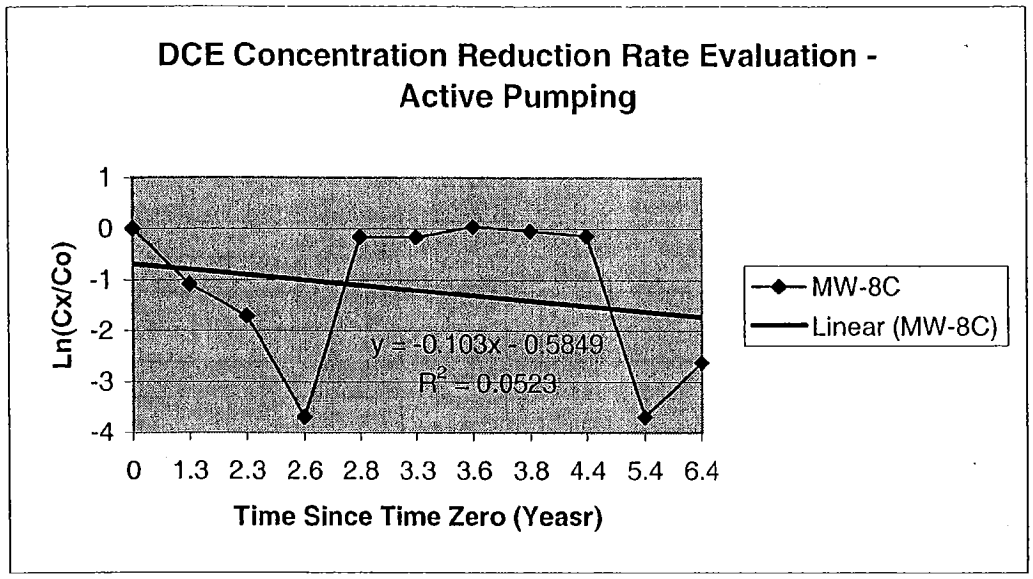

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0.8
0.6
0.4
0.2
0
y = 0.3657x - 0.3397
R² = 0.9851
0
1.5
4.4
Time Since Time Zero (Years)
MW-15A
Linear (MW-15A)

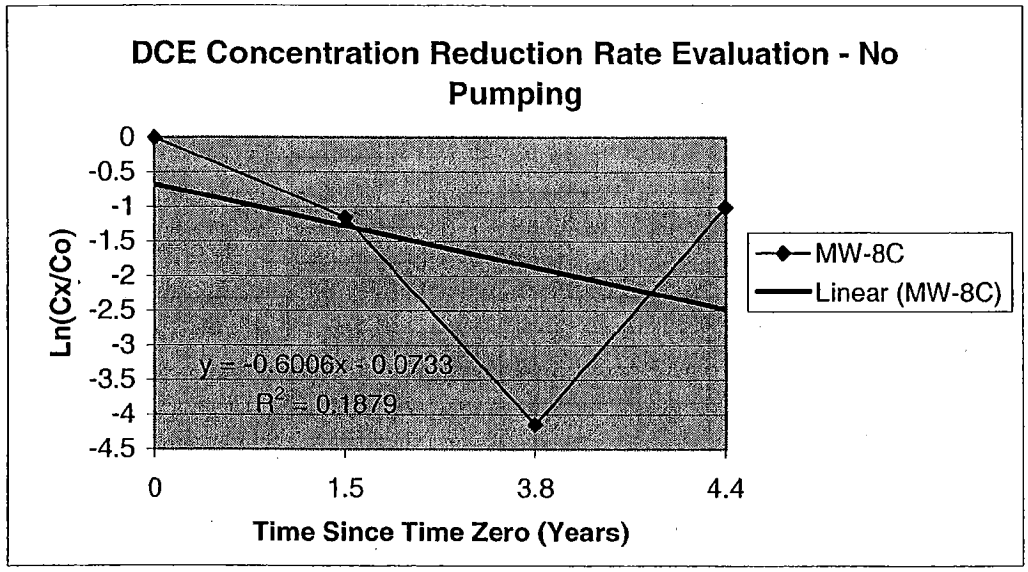

VC Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
4
3
2
1
0
-1
-2
-3
-4
y = -0.0326x + 0.8467
R² = 0.0076
0
1.3
1.7
2.1
2.3
2.6
2.8
3.1
3.3
3.6
3.8
5.4
5.8
6.4
6.9
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)

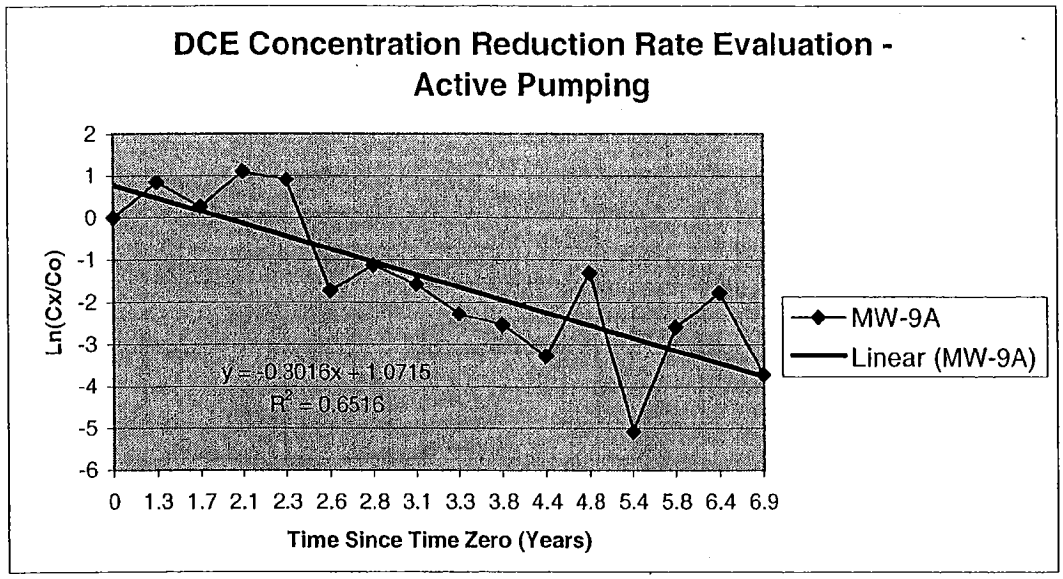

VC Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
y = 0.3466x - 0.5194
R² = 0.5728
0
1.5
4.4
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)

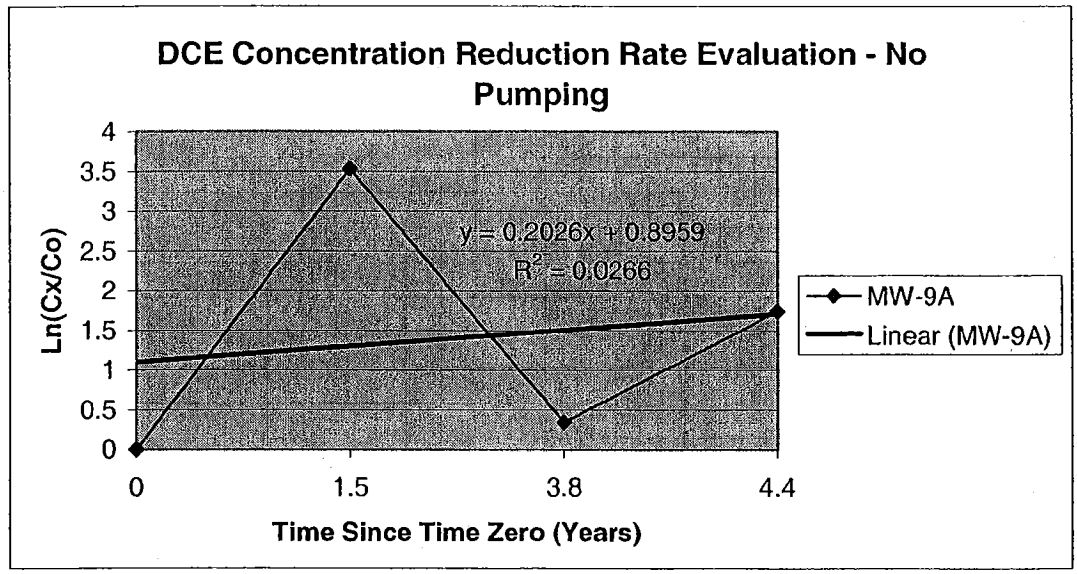

DCE Concentration Reduction Rate Evaluation - Active Pumping
1.5
1
0.5
0
-0.5
-1
Ln(Cx/Co)
y = 0.0361x + 0.3766
R² = 0.1119
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

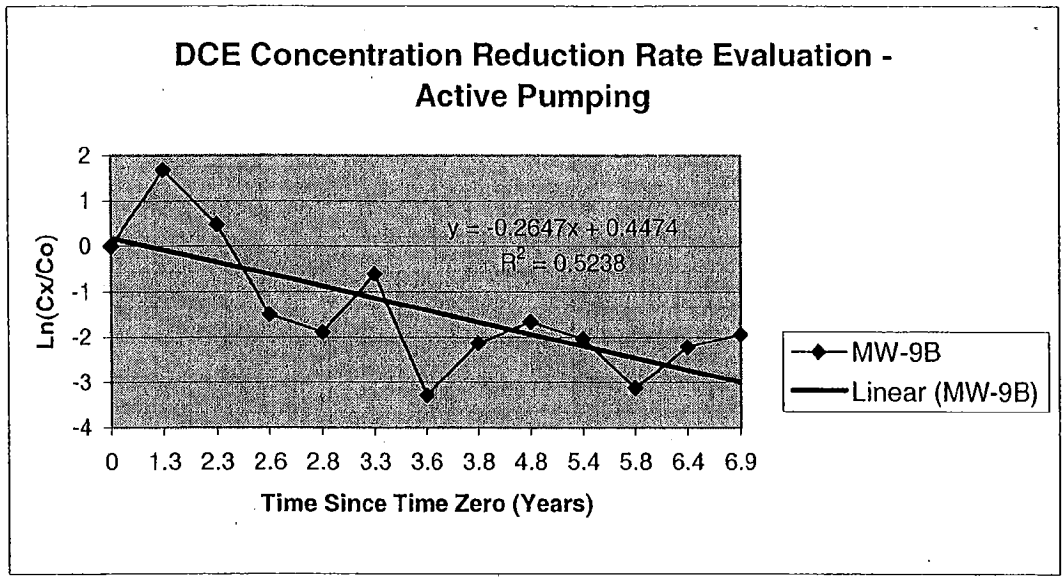

DCE Concentration Reduction Rate Evaluation - No Pumping
4
3.5
3
2.5
2
1.5
1
0.5
0
Ln(Cx/Co)
y = -0.3346x + 1.7149
R² = 0.0645
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

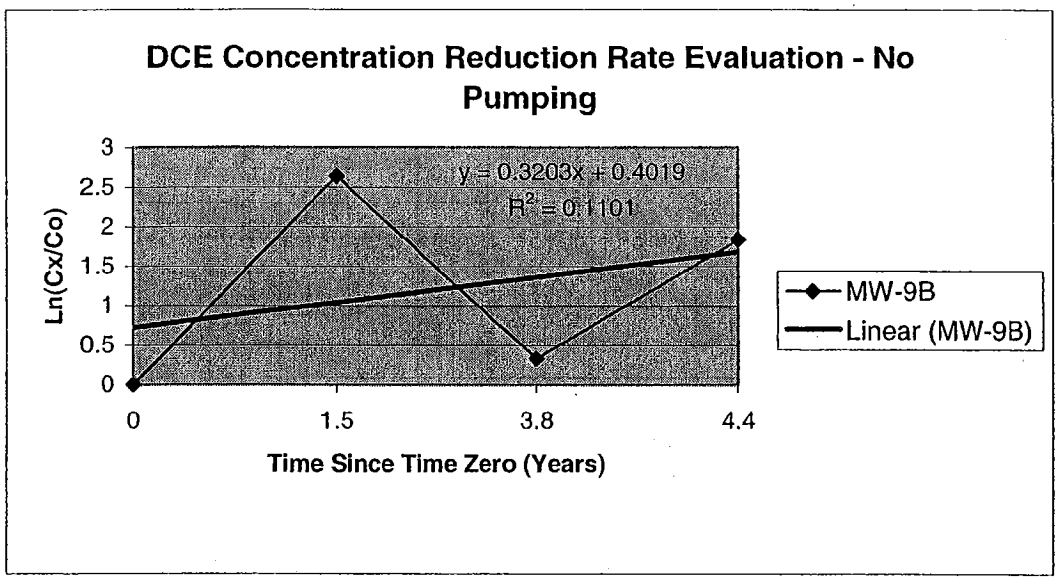

DCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
1
0
-1
-2
-3
-4
y = -0.103x - 0.5849
R2 = 0.0523
0
1.3
2.3
2.6
2.8
3.3
3.6
3.8
4.4
5.4
6.4
Time Since Time Zero (Yeasr)
MW-8C
Linear (MW-8C)

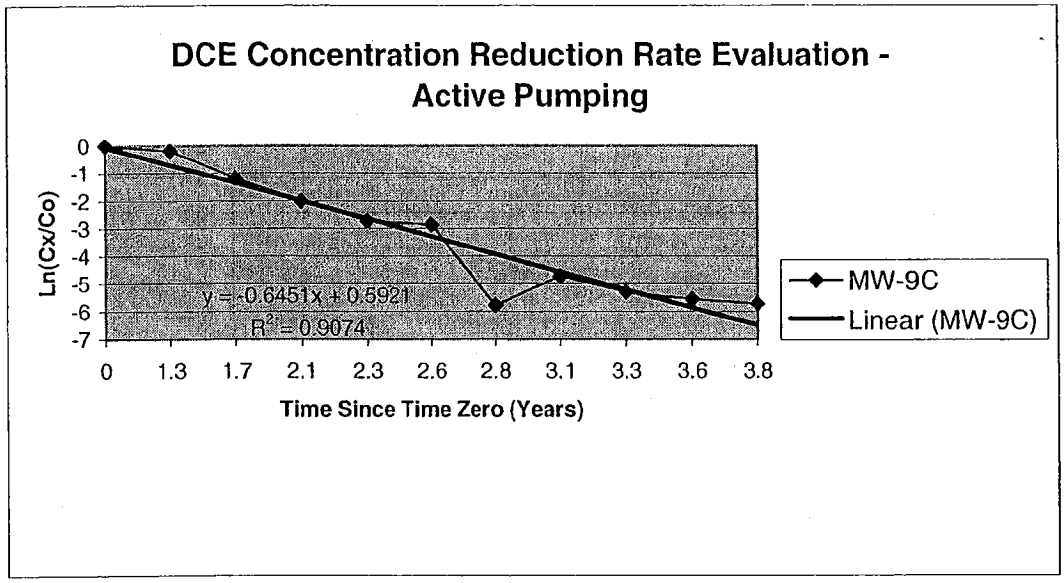

DCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
y = -0.6006x - 0.0733
R2 = 0.1879
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

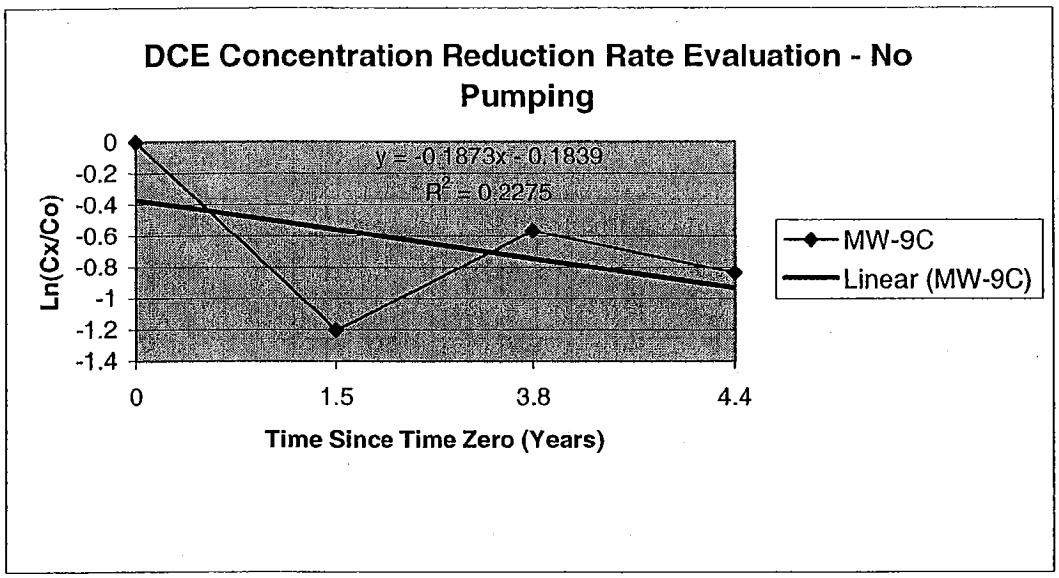

DCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
-4
-5
-6
y = -0.3016x + 1.0715
R² = 0.6516
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.8 4.4 4.8 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

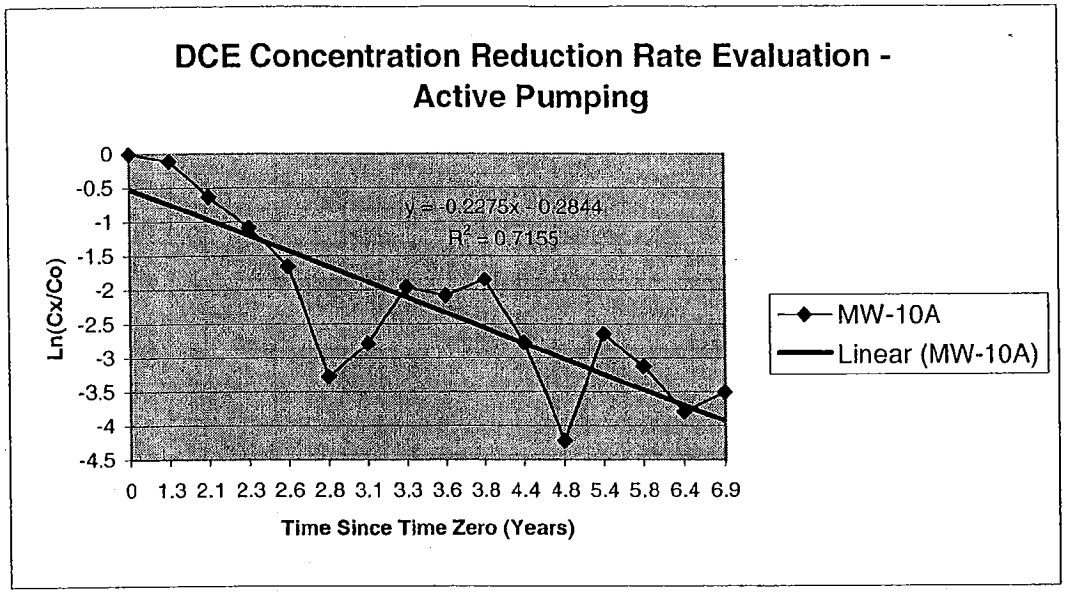

DCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
4
3.5
3
2.5
2
1.5
1
0.5
0
y = 0.2026x + 0.8959
R² = 0.0266
0 1.5 3.8 4.4
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

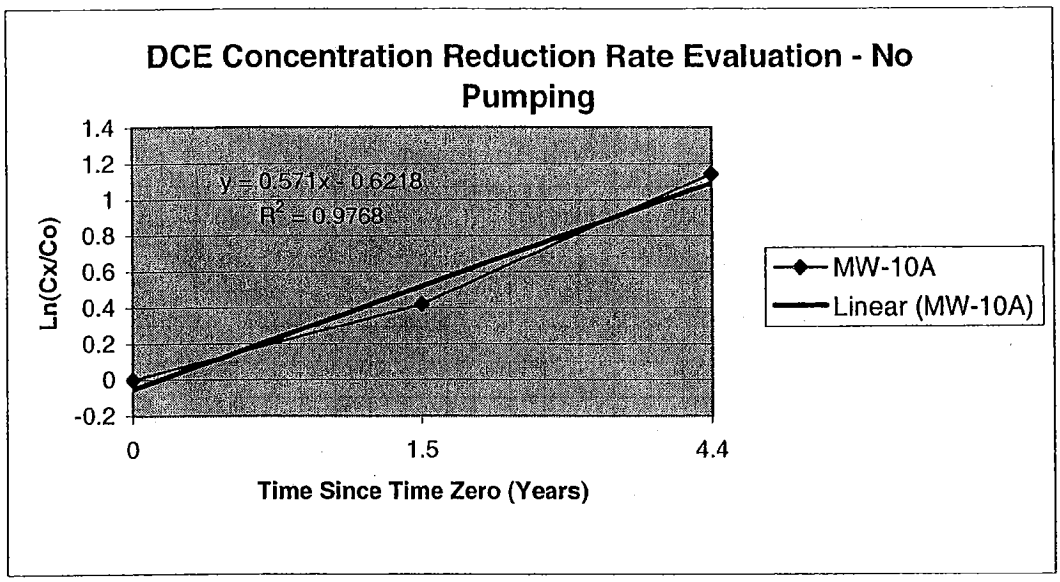

DCE Concentration Reduction Rate Evaluation - Active Pumping
y = -0.2647x + 0.4474
R² = 0.5238
Ln(Cx/Co)
2
1
0
-1
-2
-3
-4
0
1.3
2.3
2.6
2.8
3.3
3.6
3.8
4.8
5.4
5.8
6.4
6.9
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

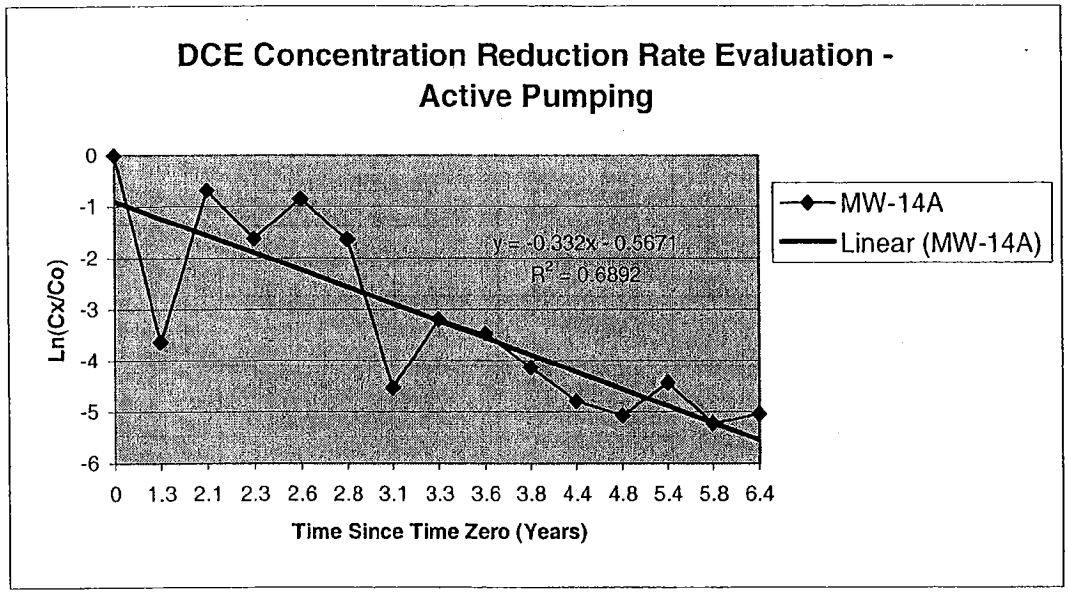

DCE Concentration Reduction Rate Evaluation - No Pumping
y = 0.3203x + 0.4019
R² = 0.1101
Ln(Cx/Co)
3
2.5
2
1.5
1
0.5
0
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

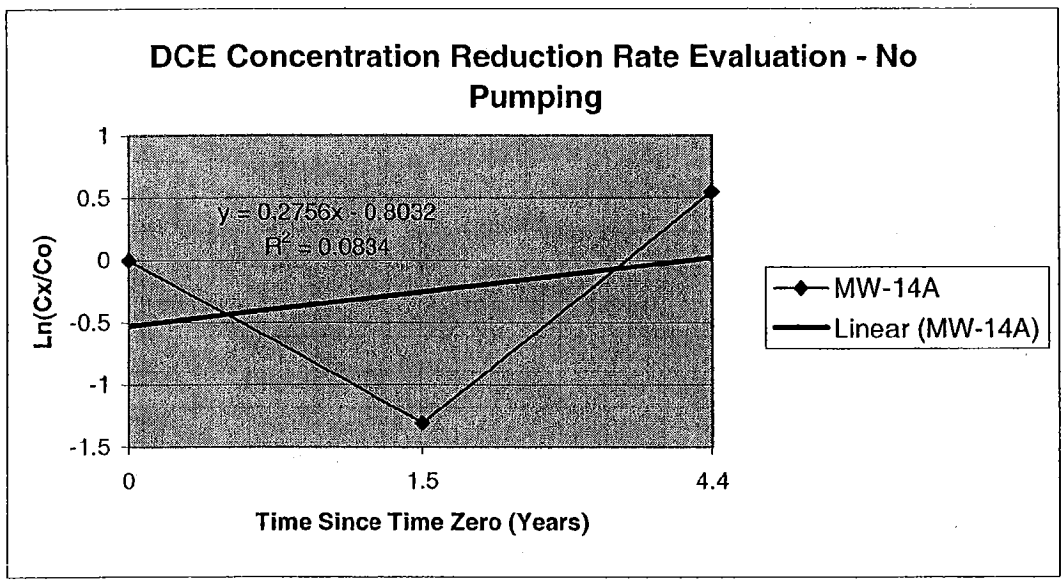

DCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
0
-1
-2
-3
-4
-5
-6
-7
y = -0.6451x + 0.5921
R² = 0.9074
0
1.3
1.7
2.1
2.3
2.6
2.8
3.1
3.3
3.6
3.8
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

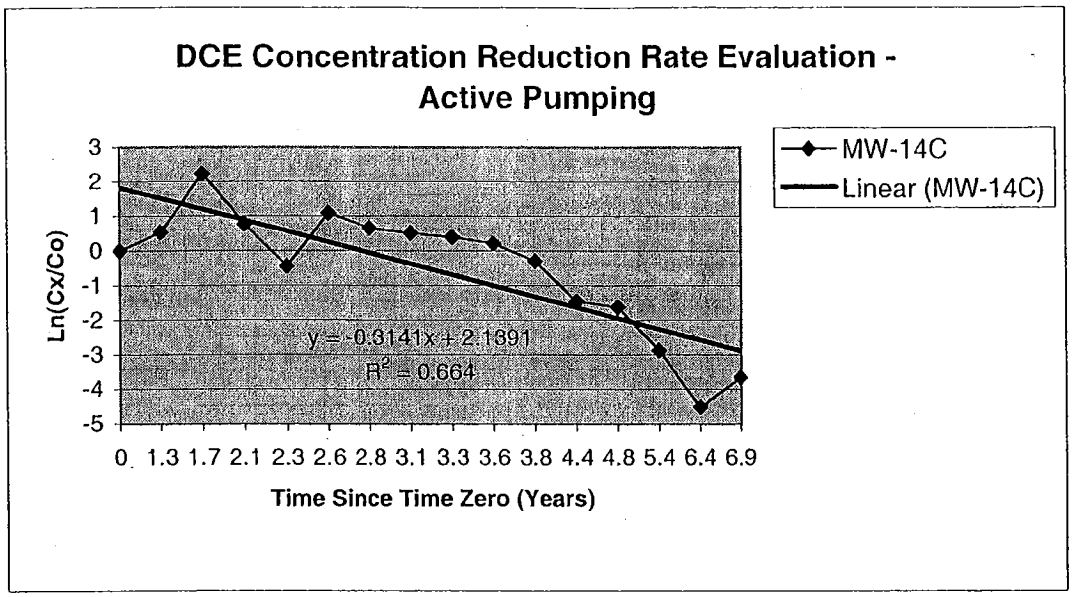

DCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
y = -0.1873x - 0.1839
R² = 0.2275
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

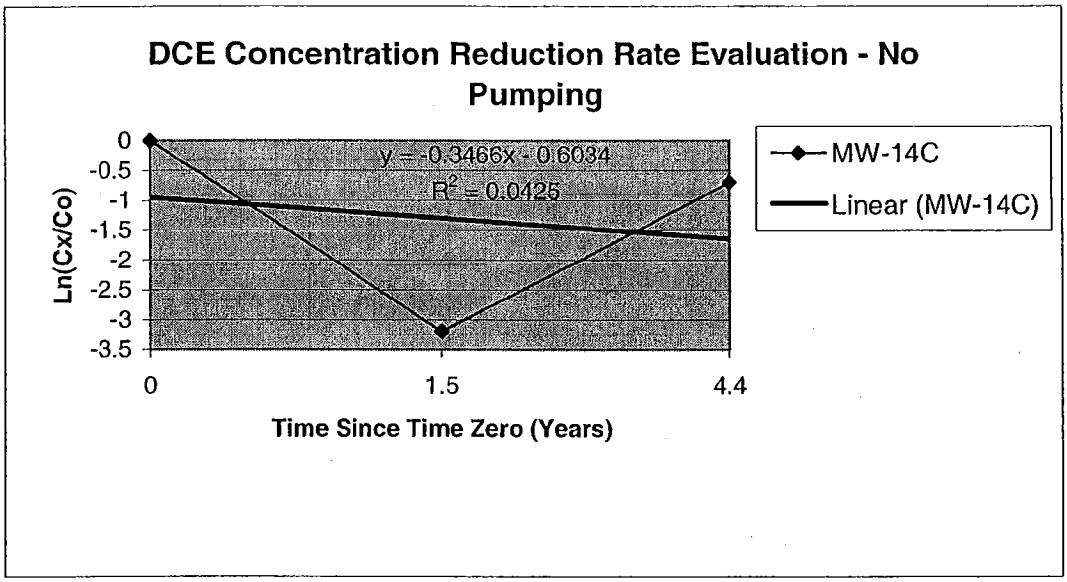

DCE Concentration Reduction Rate Evaluation - Active Pumping
y = 0.2275x - 0.2844
R² = 0.7155
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
0 1.3 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

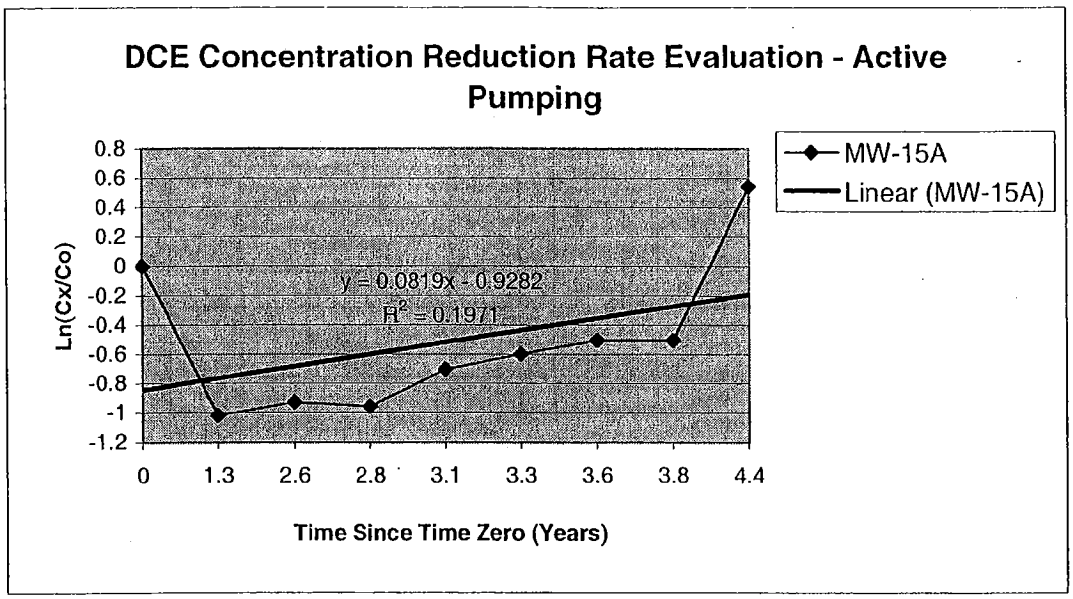

DCE Concentration Reduction Rate Evaluation - No Pumping
y = 0.571x - 0.6218
R² = 0.9768
Ln(Cx/Co)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
1.5
4.4
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

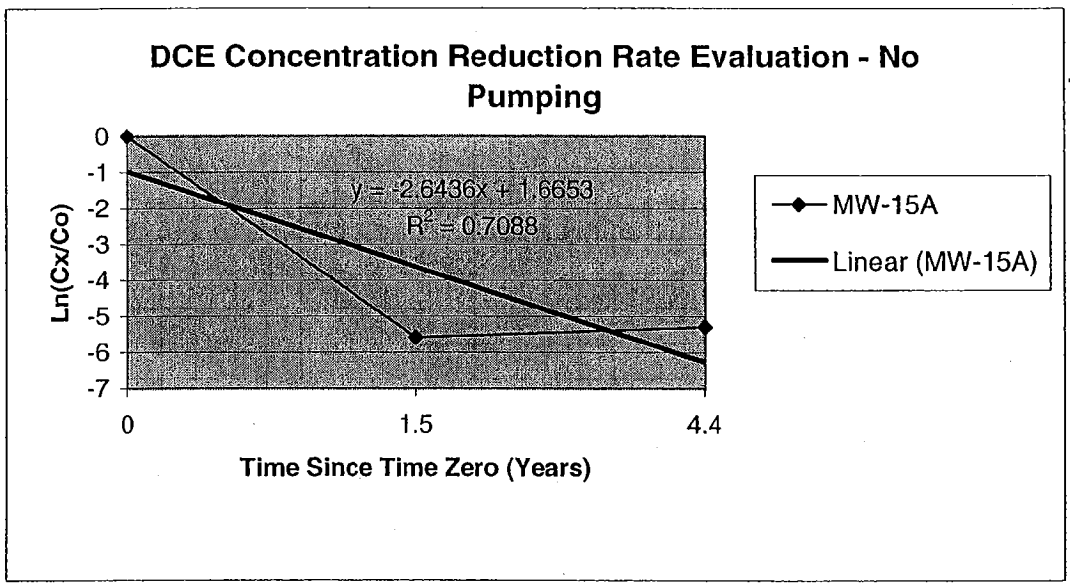

DCE Concentration Reduction Rate Evaluation - Active Pumping
0
-1
-2
-3
-4
-5
-6
Ln(Cx/Co)
y = -0.332x - 0.5671
R² = 0.6892
0 1.3 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 5.8 6.4
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

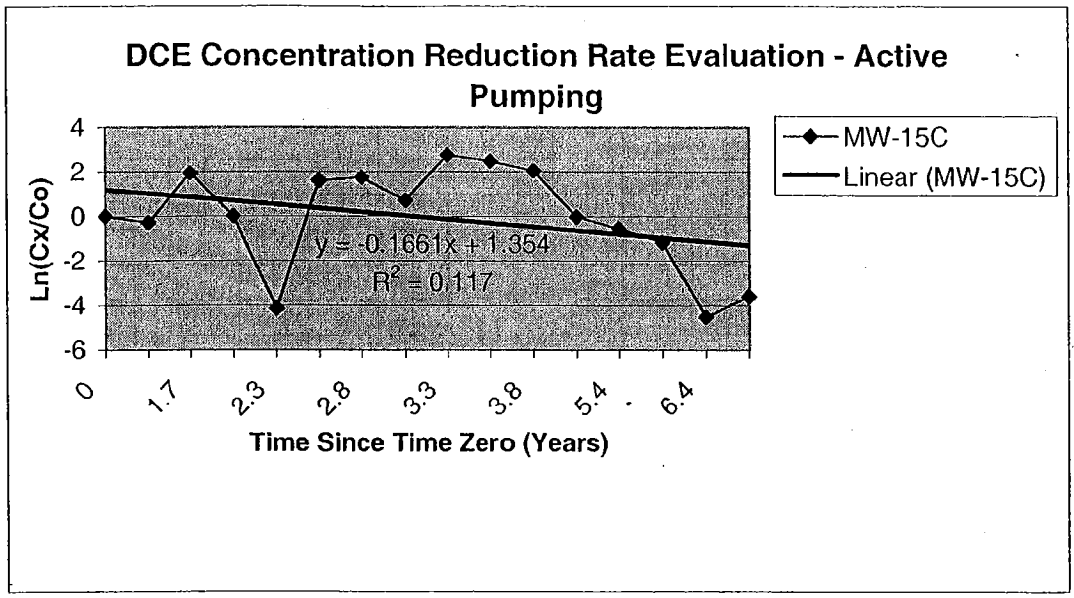

DCE Concentration Reduction Rate Evaluation - No Pumping
1
0.5
0
-0.5
-1
-1.5
Ln(Cx/Co)
y = 0.2756x - 0.8032
R² = 0.0834
0
1.5
4.4
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

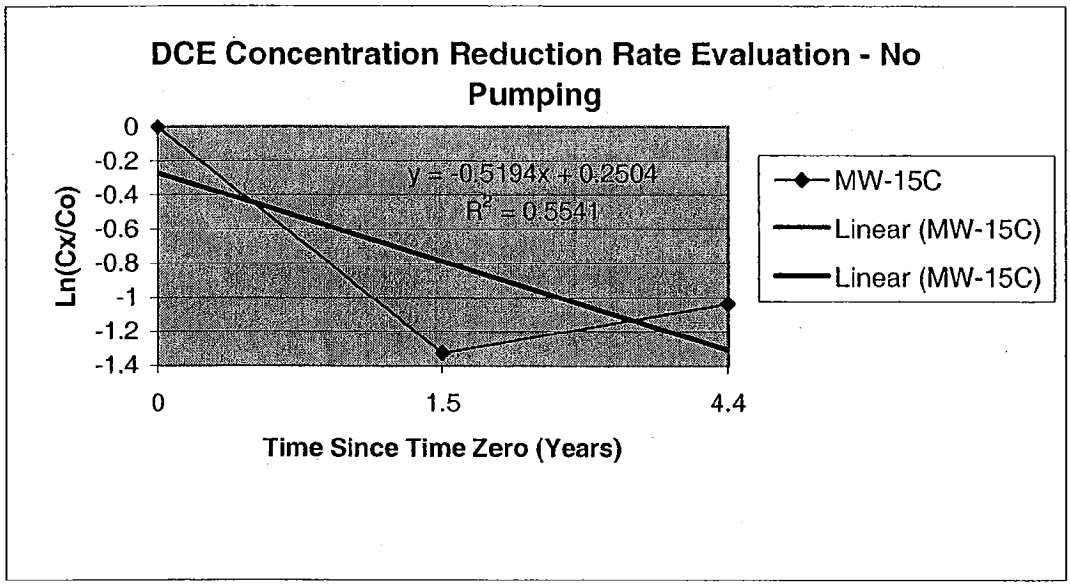

DCE Concentration Reduction Rate Evaluation - Active Pumping
MW-14C
Linear (MW-14C)
y = -0.3141x + 2.1691
R² = 0.664
Ln(Cx/Co)
3
2
1
0
-1
-2
-3
-4
-5
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 6.4 6.9
Time Since Time Zero (Years)

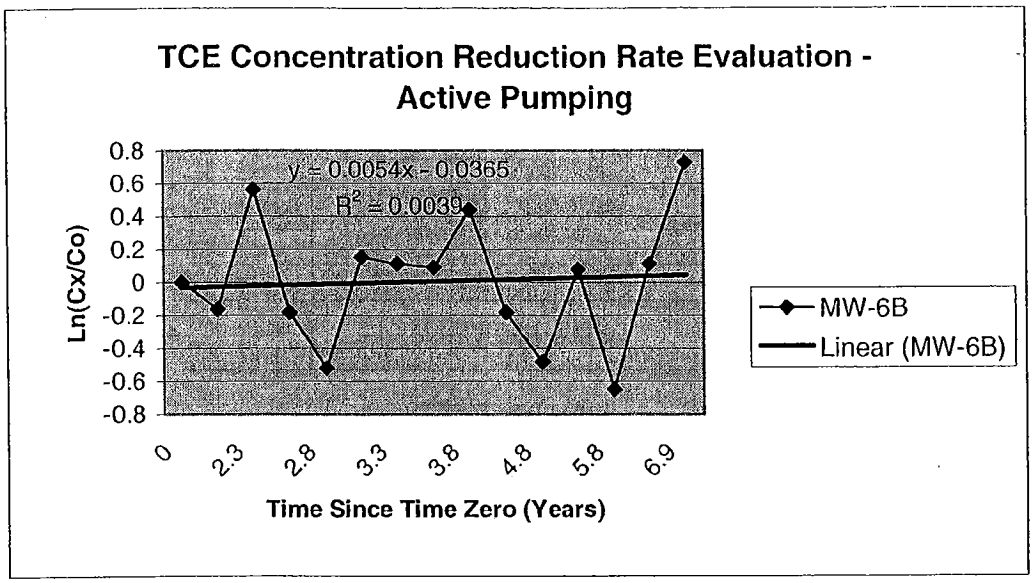

DCE Concentration Reduction Rate Evaluation - No Pumping
MW-14C
Linear (MW-14C)
y = -0.3466x - 0.6034
R² = 0.0425
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
1.5
4.4
Time Since Time Zero (Years)

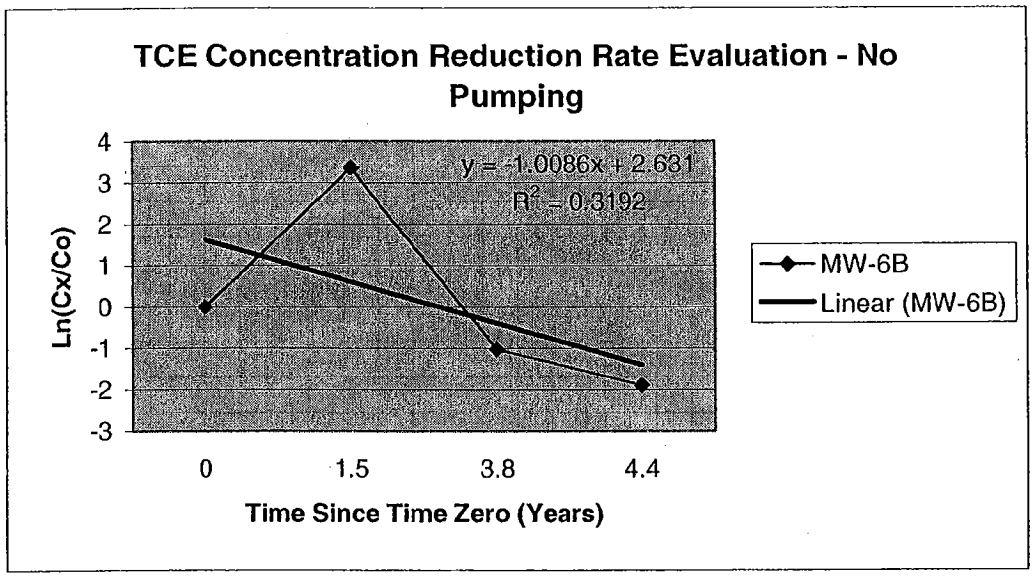

DCE Concentration Reduction Rate Evaluation - Active Pumping
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
Ln(Cx/Co)
y = 0.0819x - 0.9282
R² = 0.1971
0
1.3
2.6
2.8
3.1
3.3
3.6
3.8
4.4
Time Since Time Zero (Years)
MW-15A
Linear (MW-15A)

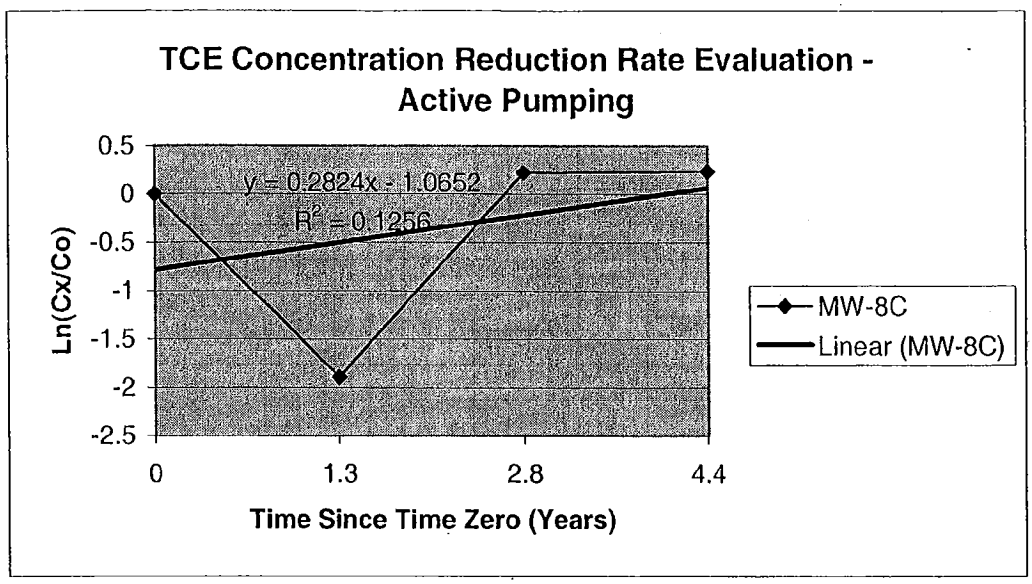

DCE Concentration Reduction Rate Evaluation - No Pumping
0
-1
-2
-3
-4
-5
-6
-7
Ln(Cx/Co)
y = -2.6436x + 1.6653
R² = 0.7088
0
1.5
4.4
Time Since Time Zero (Years)
MW-15A
Linear (MW-15A)

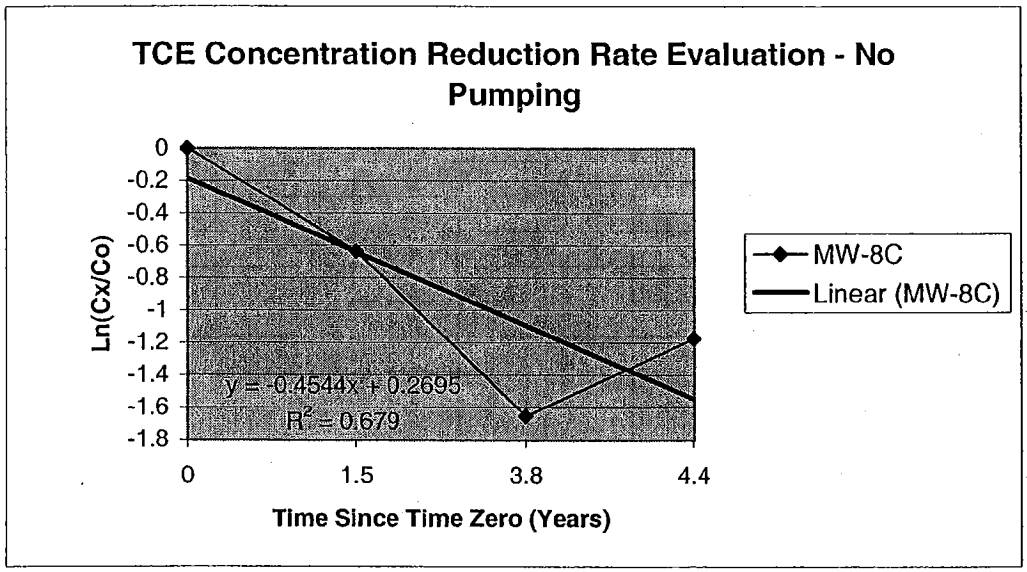

DCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
4
2
0
-2
-4
-6
y = -0.1661x + 1.354
R² = 0.117
0
1.7
2.3
2.8
3.3
3.8
5.4
6.4
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)

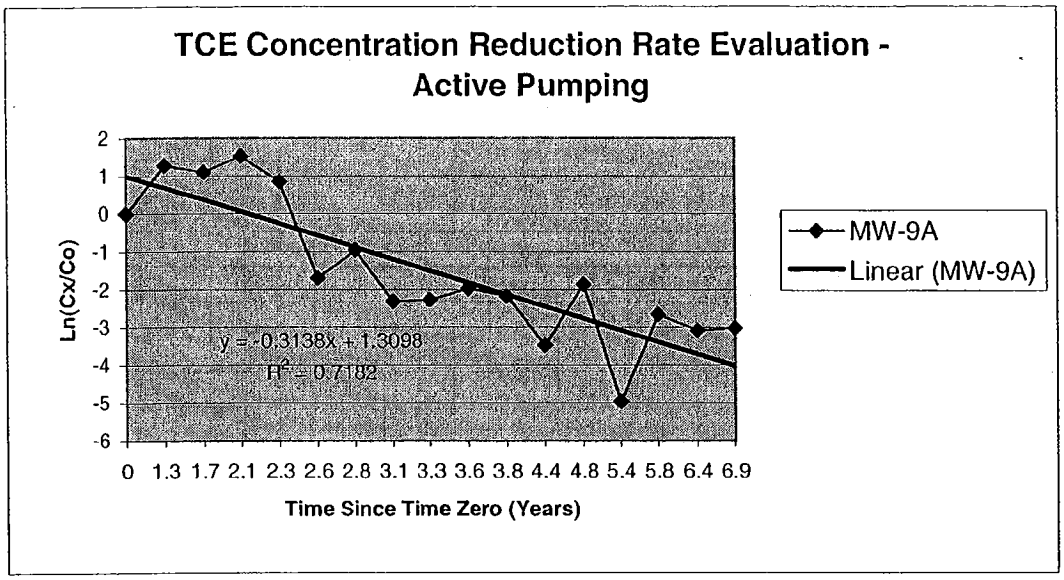

DCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
y = -0.5194x + 0.2504
R² = 0.5541
0
1.5
4.4
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)
Linear (MW-15C)

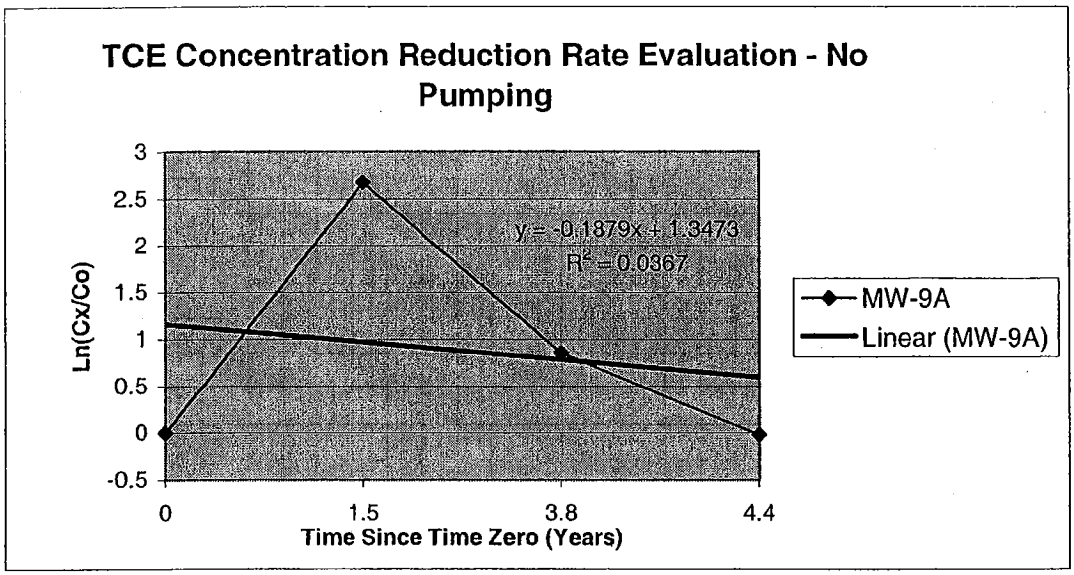

TCE Concentration Reduction Rate Evaluation - Active Pumping
y = 0.0054x - 0.0365
R² = 0.0039
Ln(Cx/Co)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

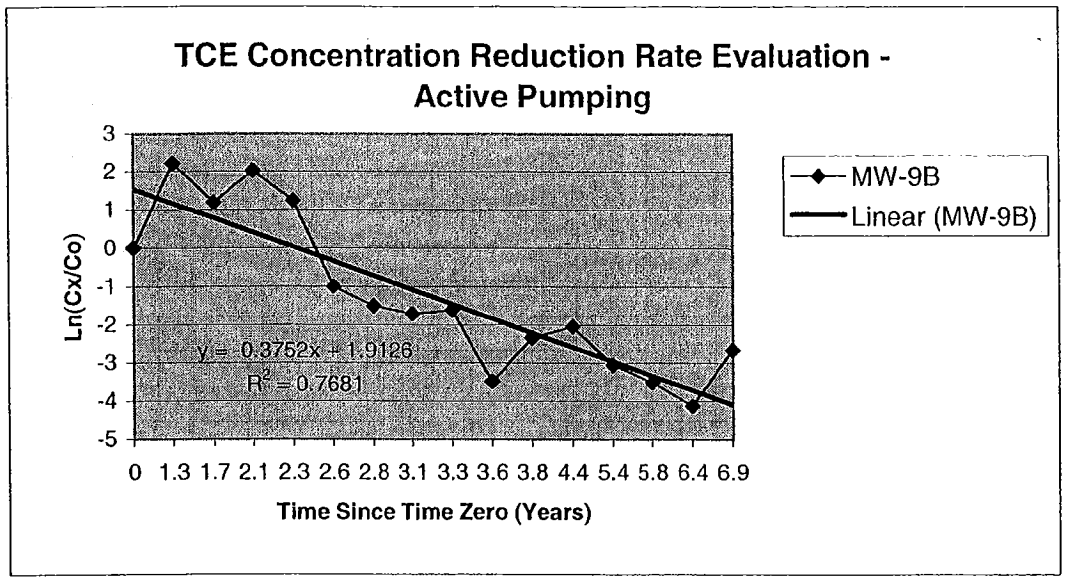

TCE Concentration Reduction Rate Evaluation - No Pumping
y = -1.0086x + 2.631
R² = 0.3192
Ln(Cx/Co)
4
3
2
1
0
-1
-2
-3
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

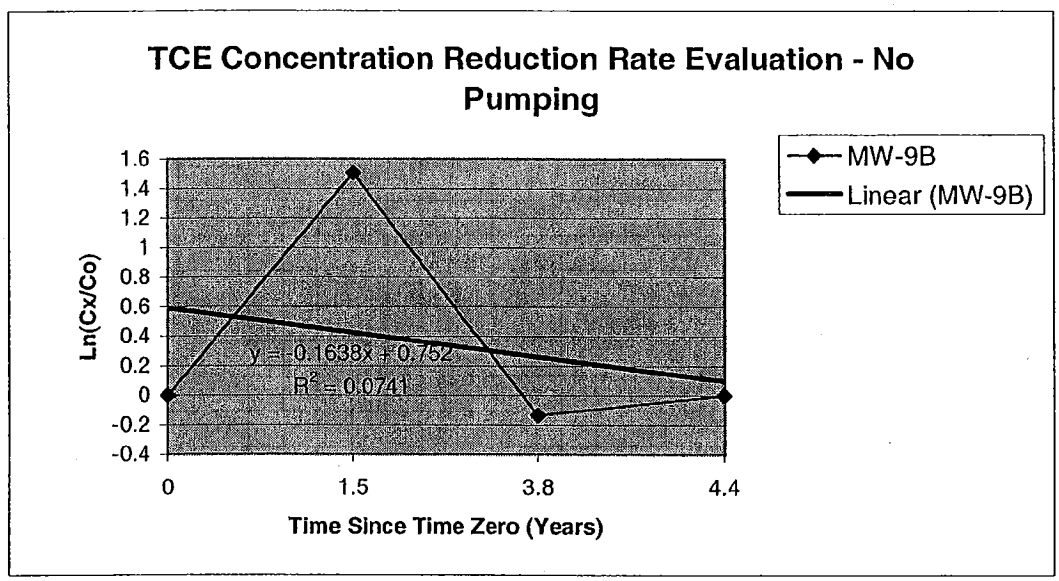

TCE Concentration Reduction Rate Evaluation - Active Pumping
0.5
0
-0.5
-1
-1.5
-2
-2.5
Ln(Cx/Co)
y = 0.2824x - 1.0652
R² = 0.1256
0
1.3
2.8
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

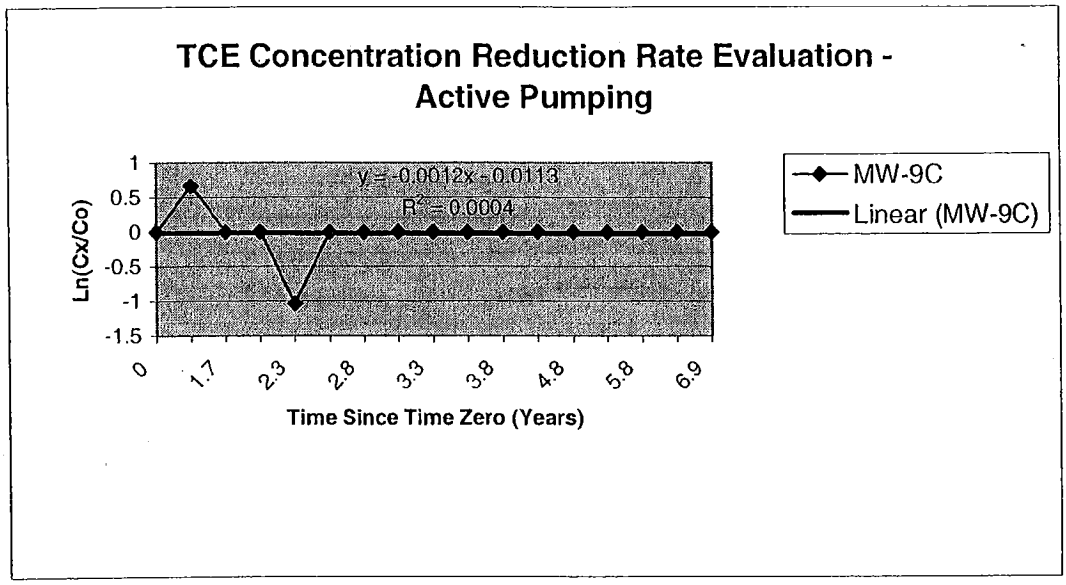

TCE Concentration Reduction Rate Evaluation - No Pumping
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
Ln(Cx/Co)
y = -0.4544x + 0.2695
R² = 0.679
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

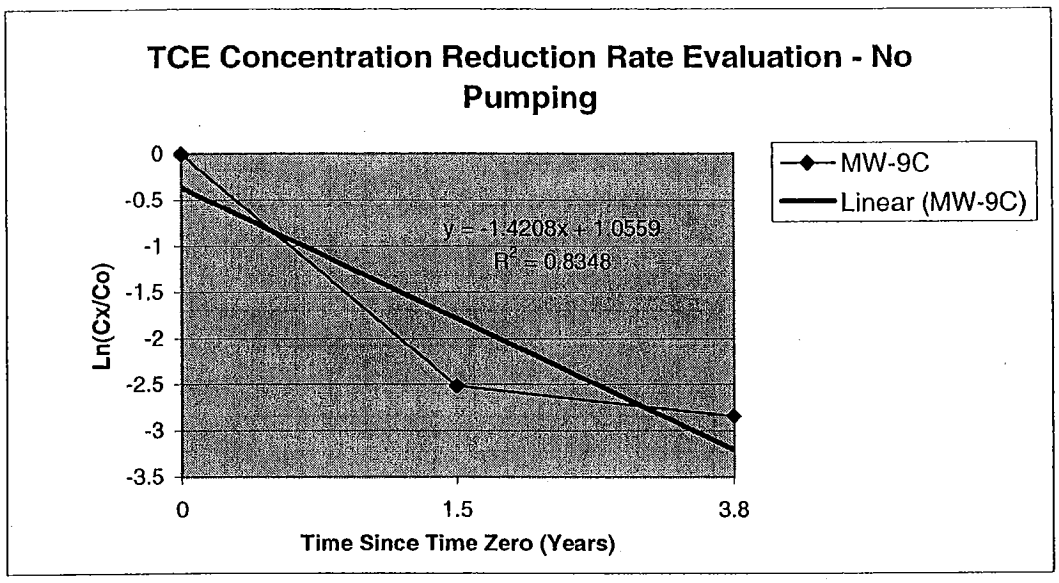

TCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
-4
-5
-6
y = -0.3138x + 1.3098
R² = 0.7182
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

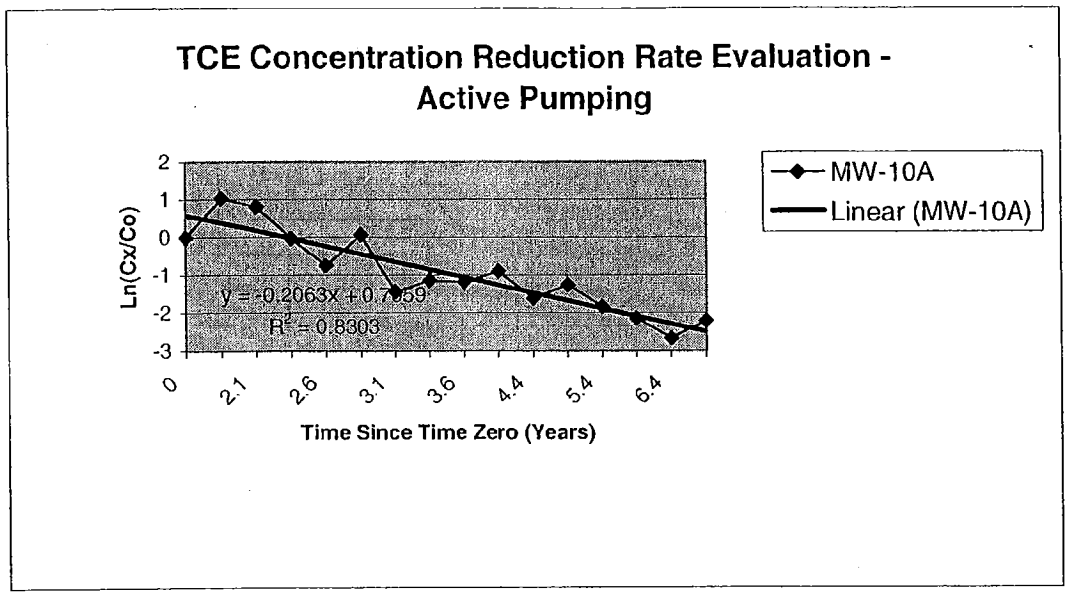

TCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
3
2.5
2
1.5
1
0.5
0
-0.5
y = -0.1879x + 1.3473
R² = 0.0367
0 1.5 3.8 4.4
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

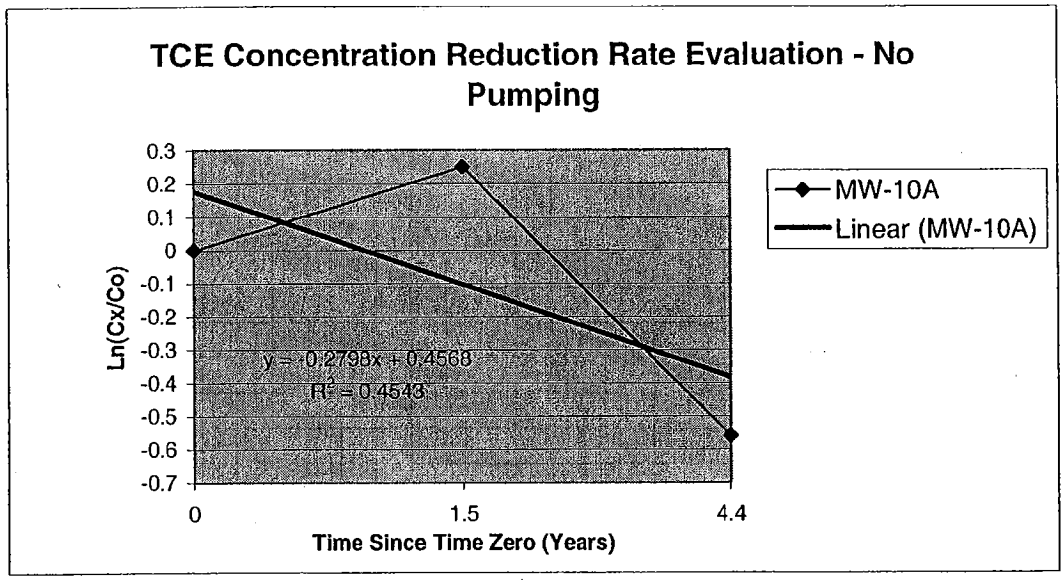

TCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
3
2
1
0
-1
-2
-3
-4
-5
y = -0.3752x + 1.9126
R² = 0.7681
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

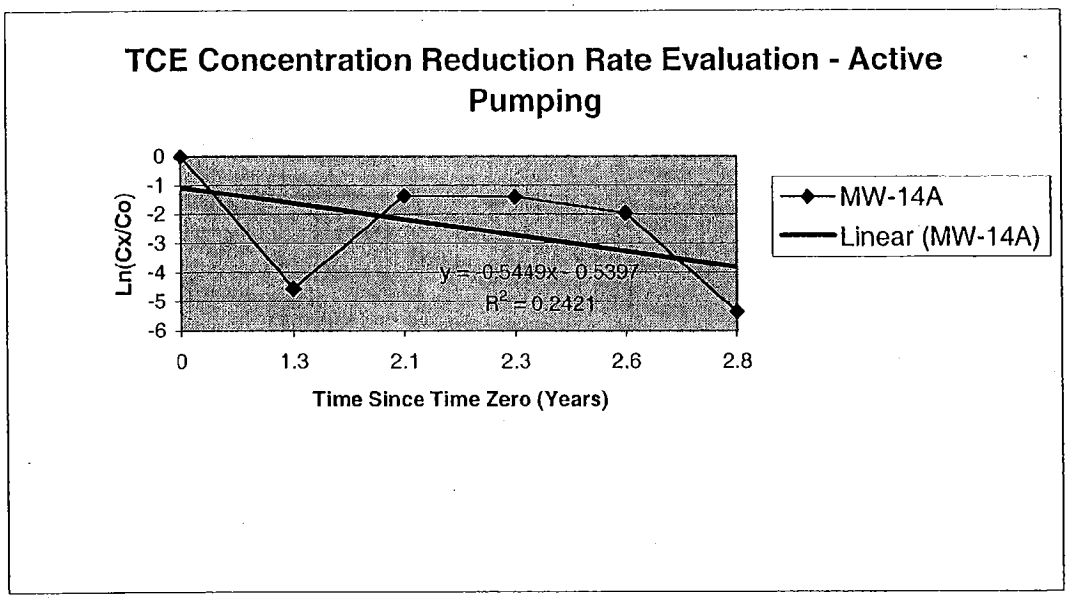

TCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
y = -0.1638x + 0.752
R² = 0.0741
0 1.5 3.8 4.4
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

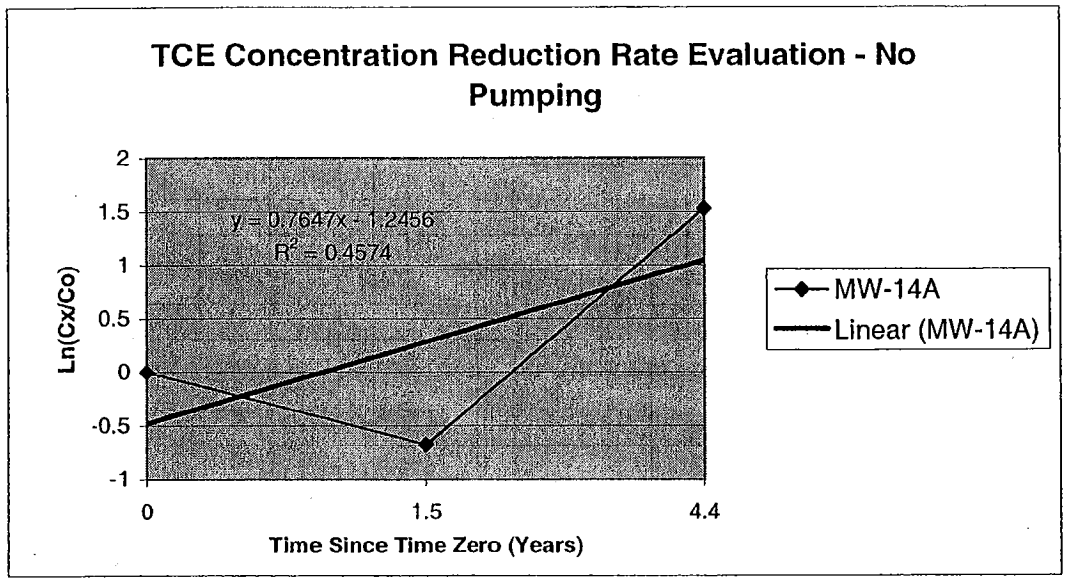

TCE Concentration Reduction Rate Evaluation - Active Pumping
y = -0.0012x - 0.0113
R² = 0.0004
Ln(Cx/Co)
1
0.5
0
-0.5
-1
-1.5
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

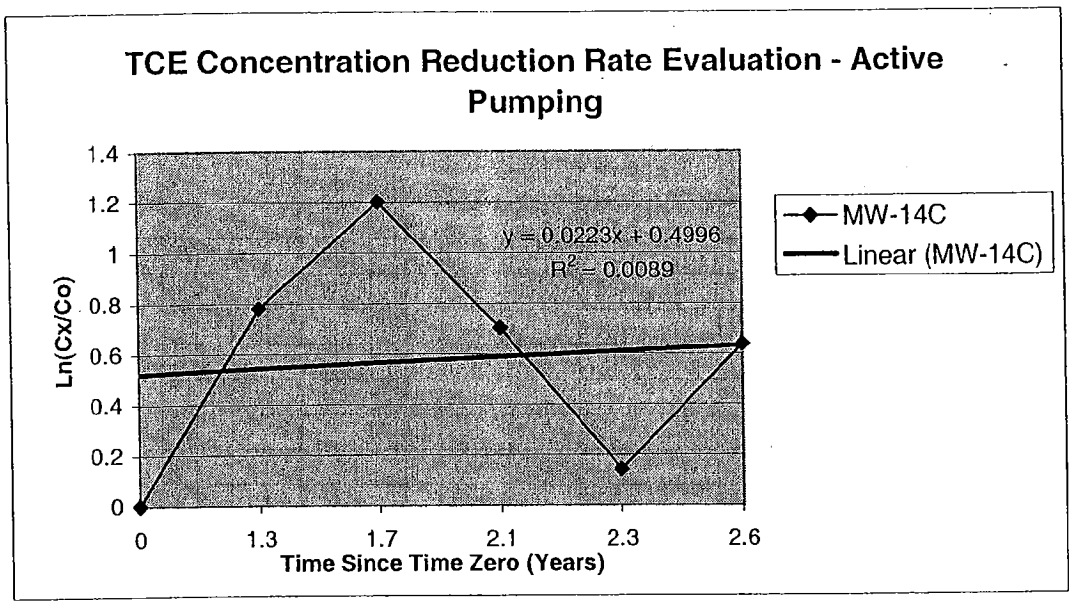

TCE Concentration Reduction Rate Evaluation - No Pumping
y = -1.4208x + 1.0559
R² = 0.8348
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
1.5
3.8
Time Since Time Zero (Years)
MW-9C
Linear (MW-9C)

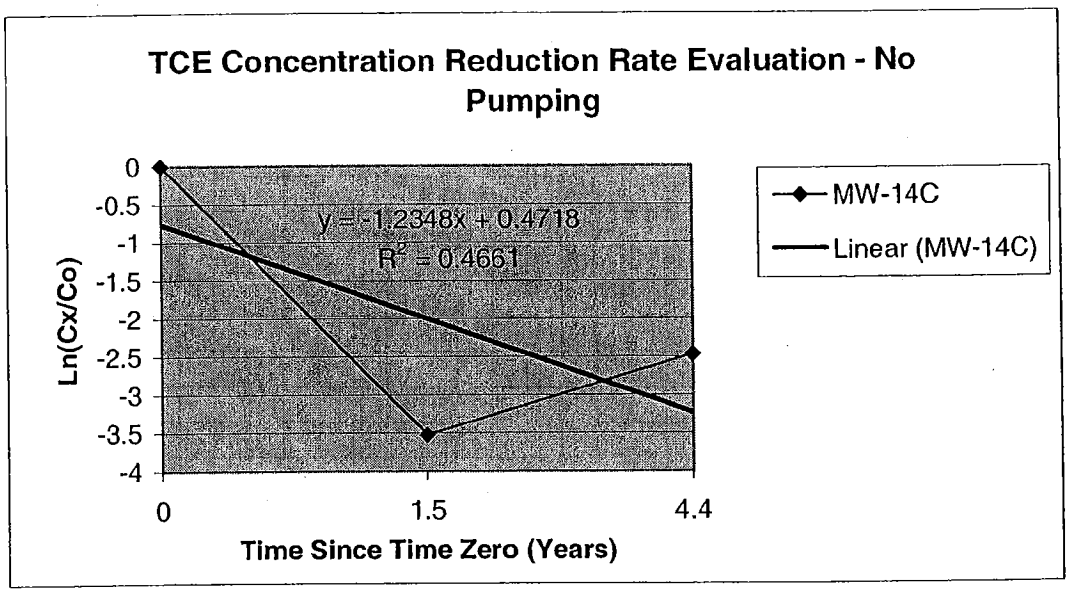

TCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
1
0
-1
-2
-3
y = -0.2063x + 0.7059
R² = 0.8303
0
2.1
2.6
3.1
3.6
4.4
5.4
6.4
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)


TCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
y = -0.2798x + 0.4568
R² = 0.4543
0
1.5
4.4
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

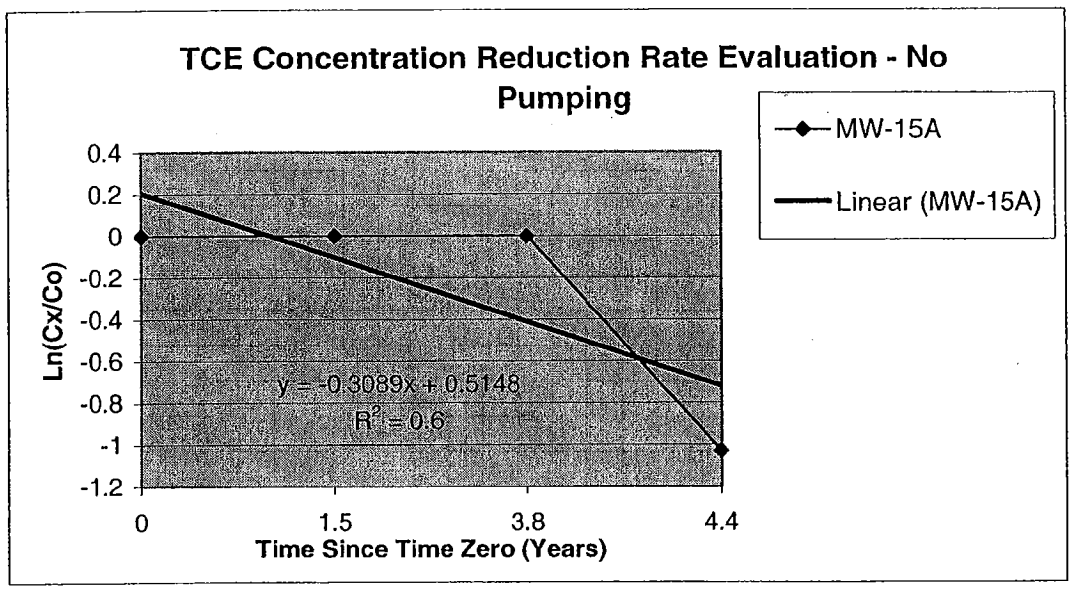

TCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
0
-1
-2
-3
-4
-5
-6
y = -0.5449x - 0.5397
R² = 0.2421
0
1.3
2.1
2.3
2.6
2.8
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

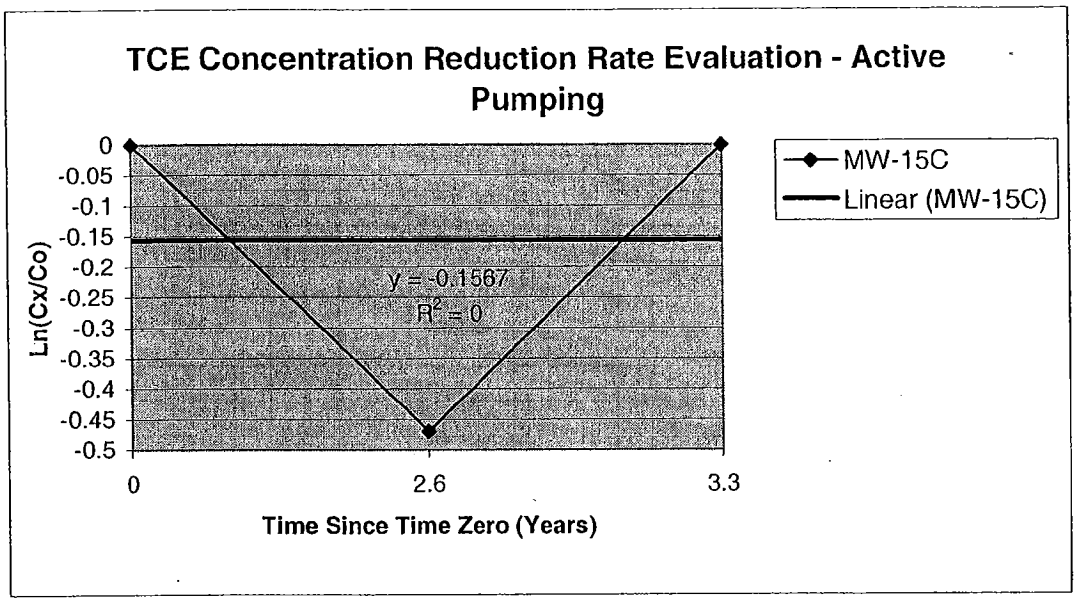

TCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
2
1.5
1
0.5
0
-0.5
-1
y = 0.7647x - 1.2456
R² = 0.4574
0
1.5
4.4
Time Since Time Zero (Years)
MW-14A
Linear (MW-14A)

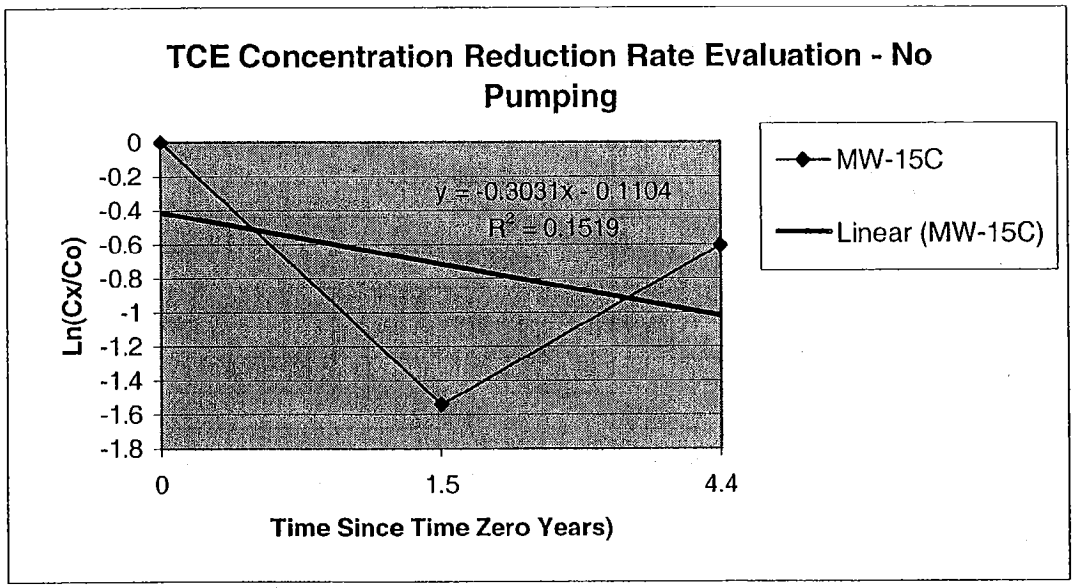

TCE Concentration Reduction Rate Evaluation - Active Pumping
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Ln(Cx/Co)
y = 0.0223x + 0.4996
R² = 0.0089
0
1.3
1.7
2.1
2.3
2.6
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)


TCE Concentration Reduction Rate Evaluation - No Pumping
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
Ln(Cx/Co)
y = -1.2348x + 0.4718
R² = 0.4661
0
1.5
4.4
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)

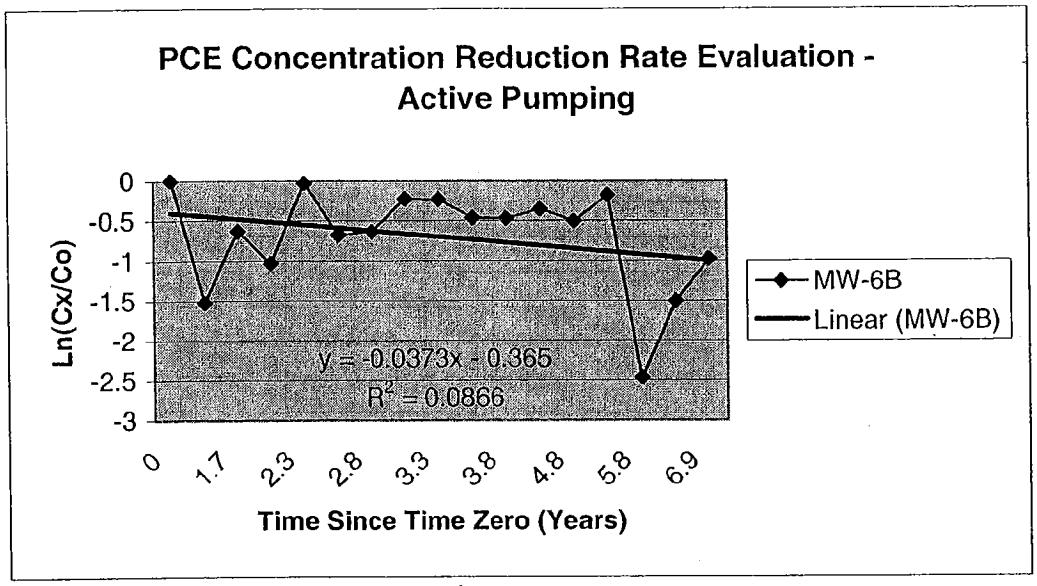
Concentration Reduction Rate for 15A Under a Pumping Scenario was not Determined Because Reported Concentrations Have Been Less Than Detection Limits Since the Inception of Pumping.

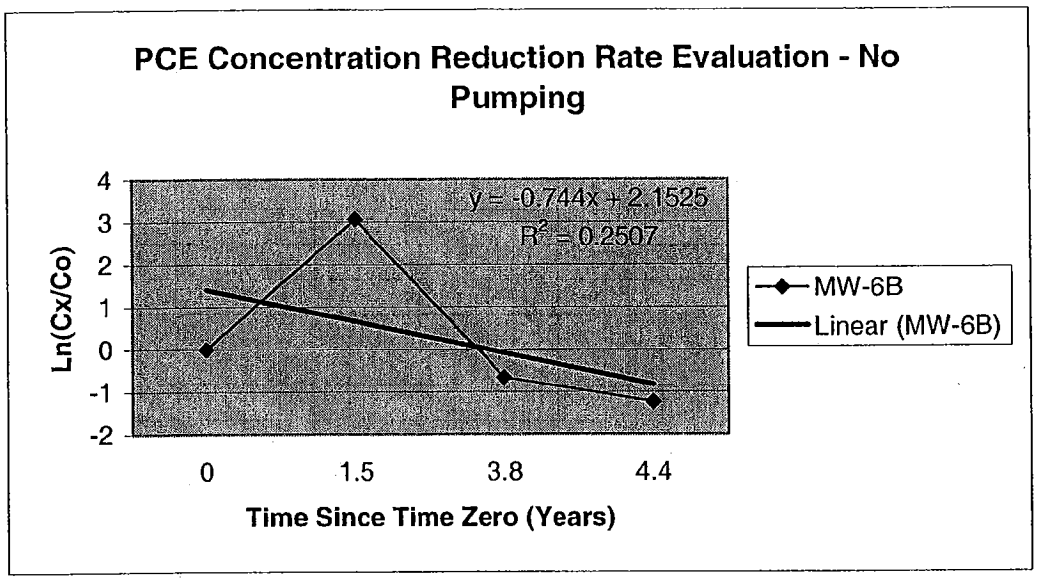



TCE Concentration Reduction Rate Evaluation - Active Pumping
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5
Ln(Cx/Co)
y = -0.1567
R² = 0
0
2.6
3.3
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)

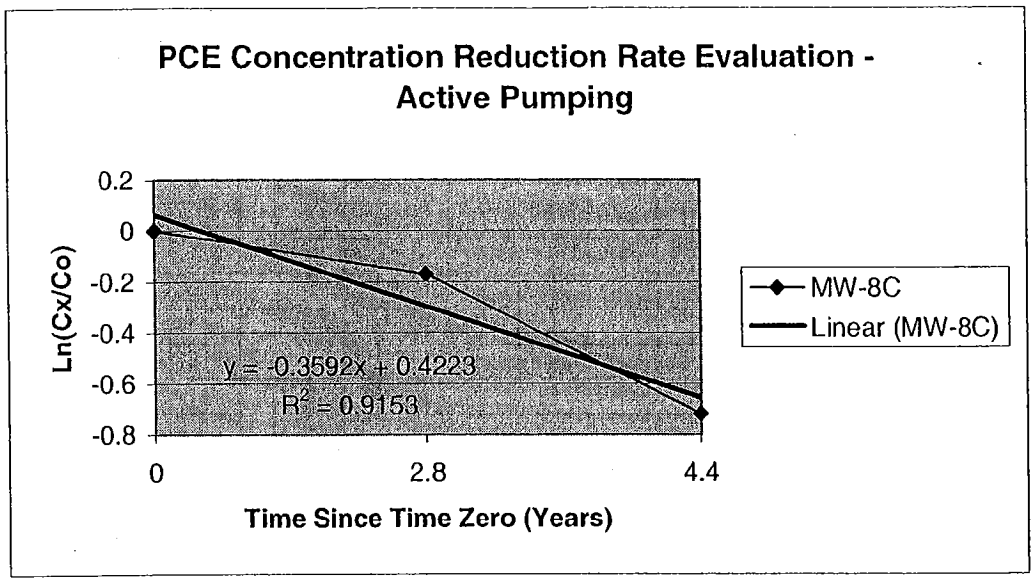

TCE Concentration Reduction Rate Evaluation - No Pumping
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
Ln(Cx/Co)
y = -0.3031x - 0.1104
R² = 0.1519
0
1.5
4.4
Time Since Time Zero Years)
MW-15C
Linear (MW-15C)

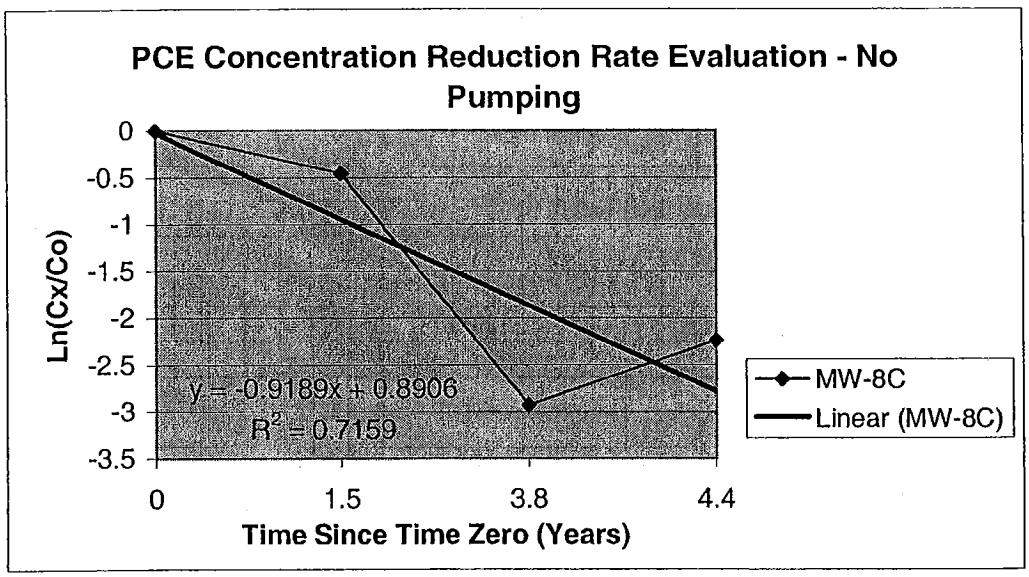
# PCE


PCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
y = -0.0373x - 0.365
R² = 0.0866
0
1.7
2.3
2.8
3.3
3.8
4.8
5.8
6.9
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

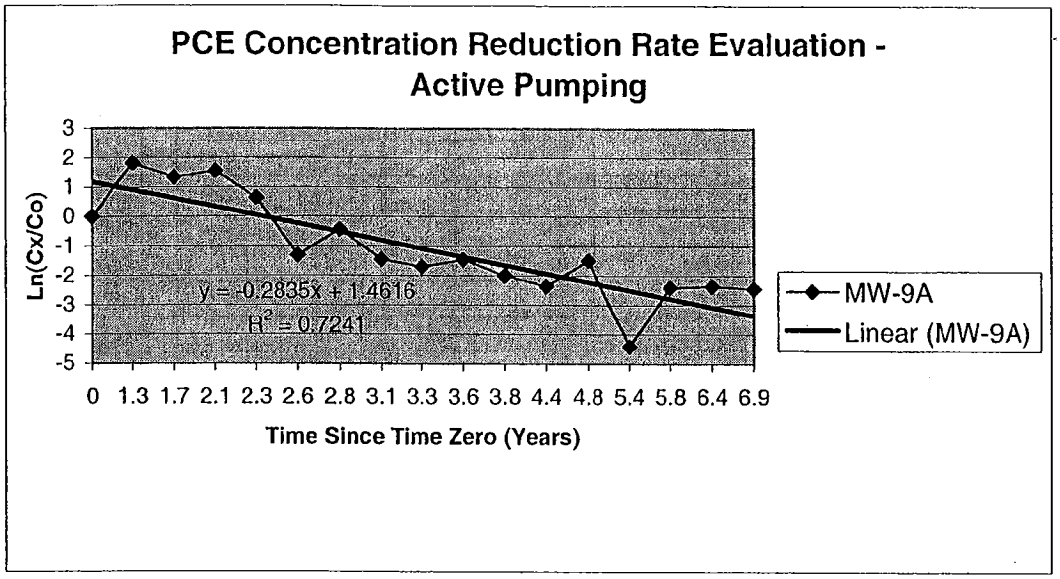

PCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
4
3
2
1
0
-1
-2
y = -0.744x + 2.1525
R² = 0.2507
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-6B
Linear (MW-6B)

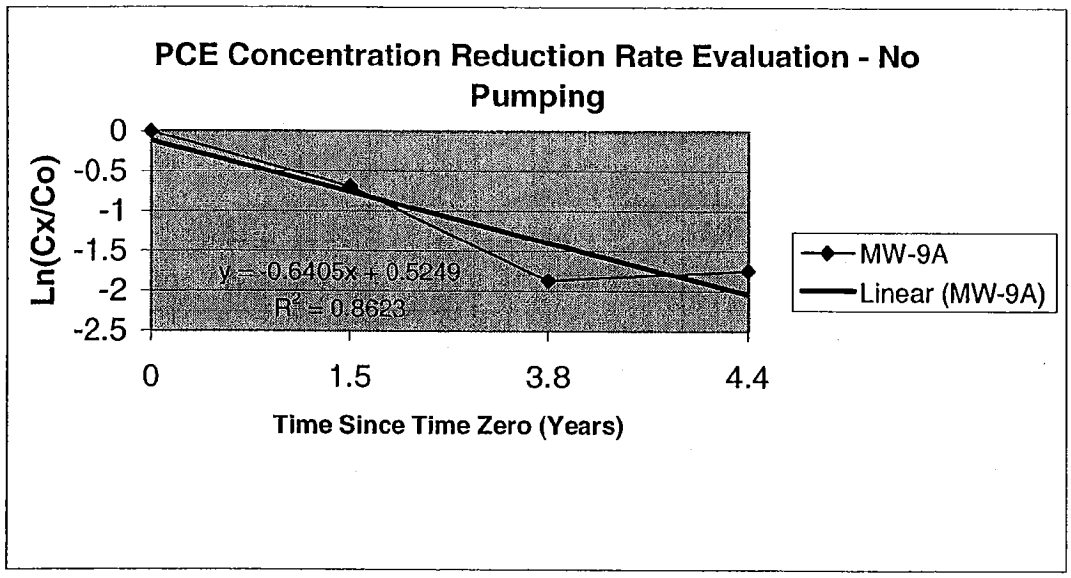
# PCE


PCE Concentration Reduction Rate Evaluation - Active Pumping
0.2
0
-0.2
-0.4
-0.6
-0.8
Ln(Cx/Co)
y = -0.3592x + 0.4223
R² = 0.9153
0
2.8
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

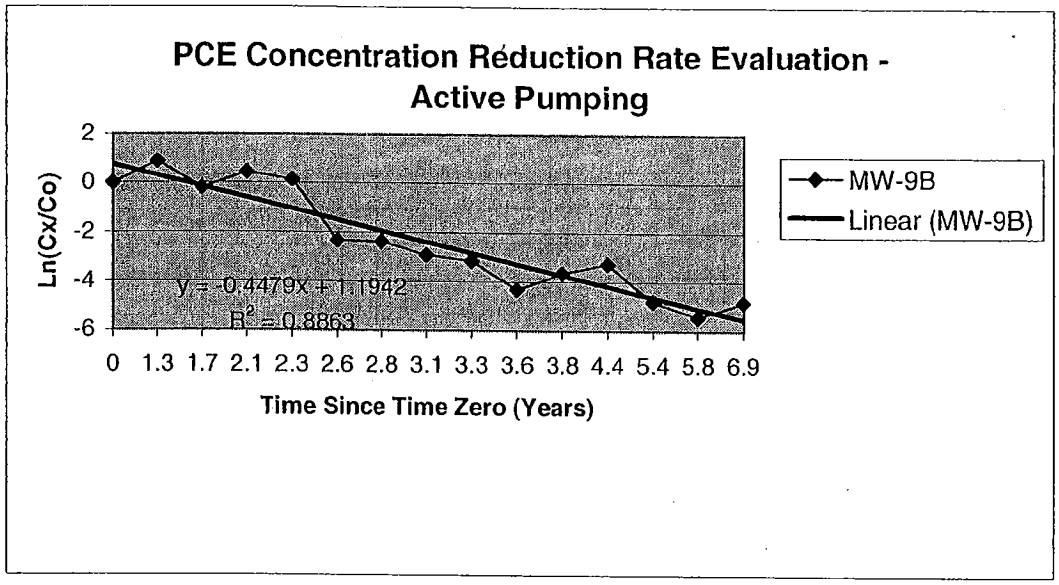

PCE Concentration Reduction Rate Evaluation - No Pumping
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Ln(Cx/Co)
y = -0.9189x + 0.8906
R² = 0.7159
0
1.5
3.8
4.4
Time Since Time Zero (Years)
MW-8C
Linear (MW-8C)

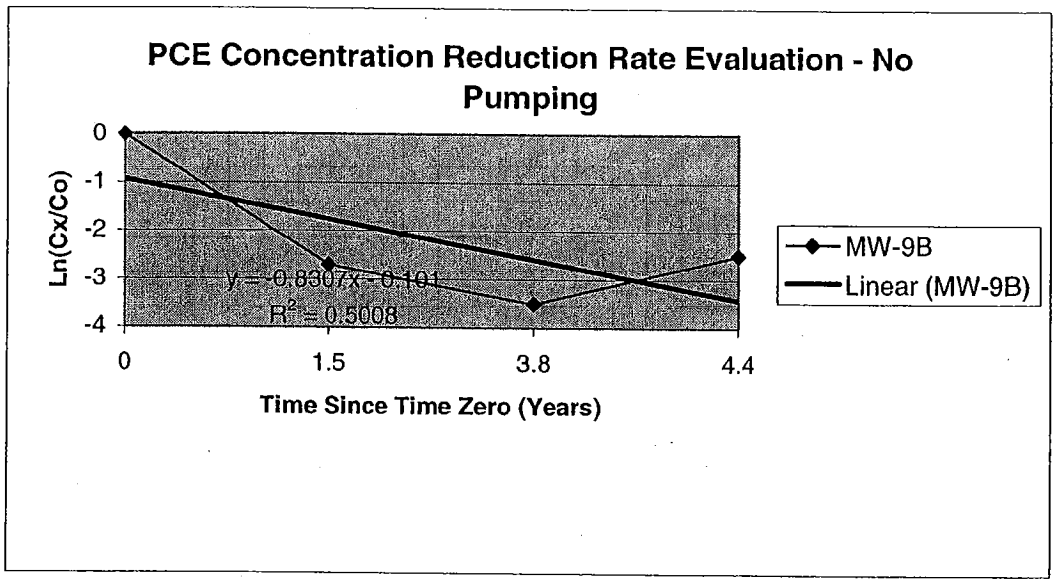
# PCE


PCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
3
2
1
0
-1
-2
-3
-4
-5
y = -0.2835x + 1.4616
R² = 0.7241
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

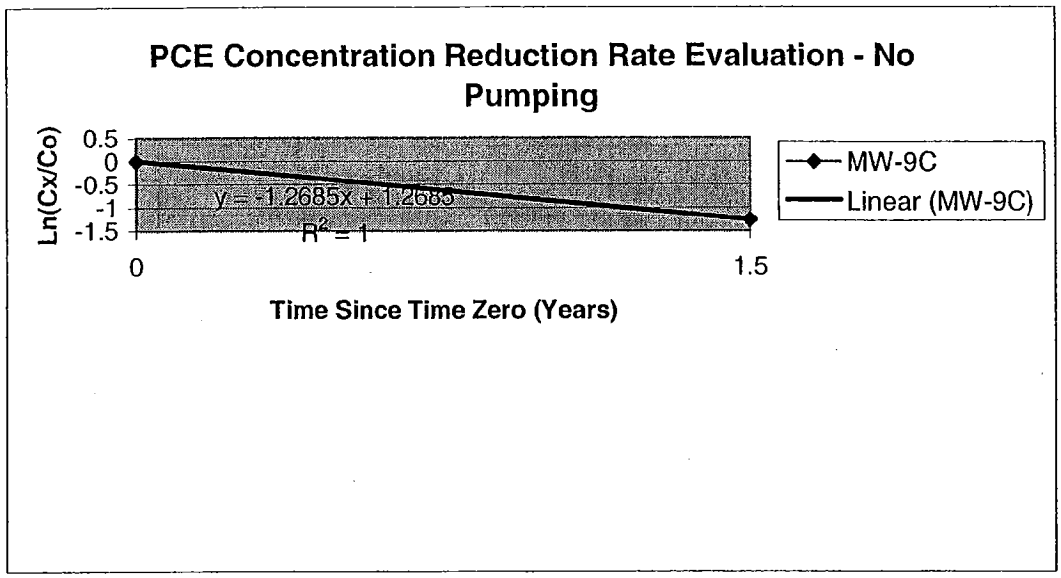

PCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
y = -0.6405x + 0.5249
R² = 0.8623
0 1.5 3.8 4.4
Time Since Time Zero (Years)
MW-9A
Linear (MW-9A)

# PCE

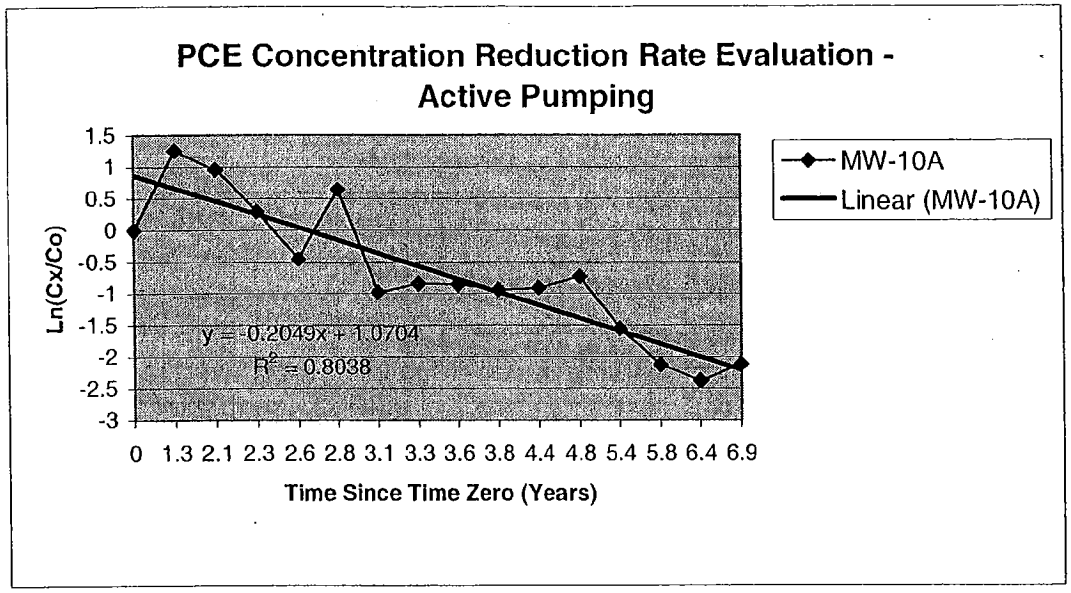

PCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
2
0
-2
-4
-6
y = -0.4479x + 1.1942
R² = 0.8863
0 1.3 1.7 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 5.4 5.8 6.9
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

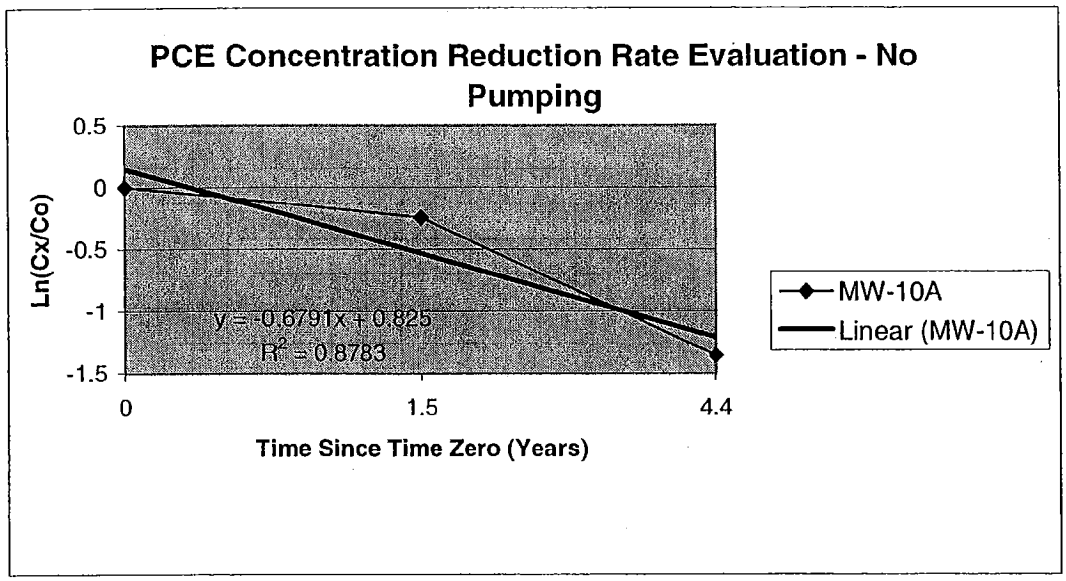

PCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-1
-2
-3
-4
y = -0.8307x - 0.101
R² = 0.5008
0 1.5 3.8 4.4
Time Since Time Zero (Years)
MW-9B
Linear (MW-9B)

**Regression Analysis Not Completed for Active Pumping at MW-9C Because Baseline Sample was Non-Detect for PCE**

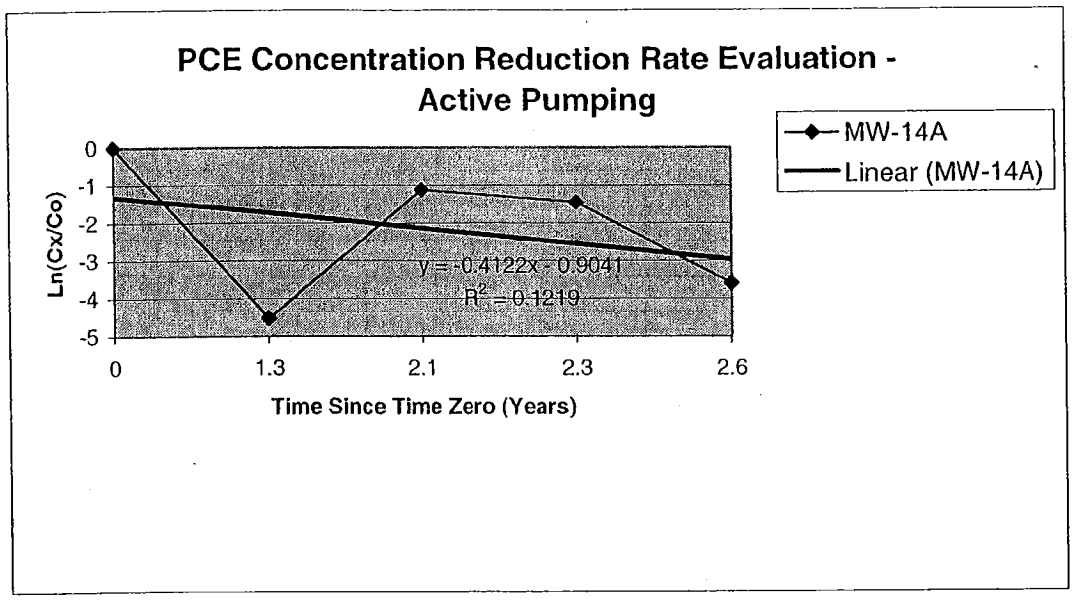


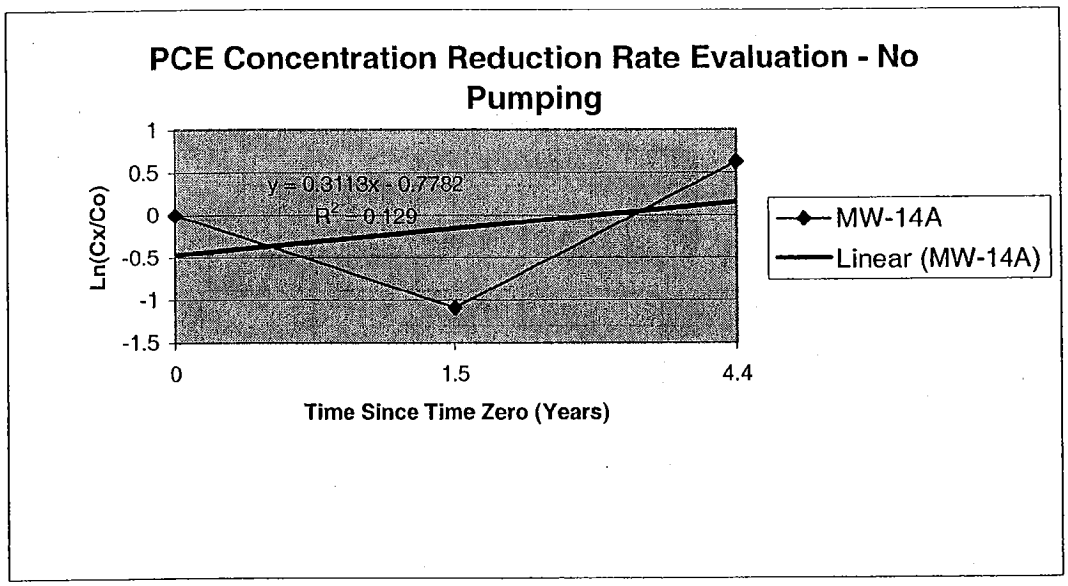
# PCE

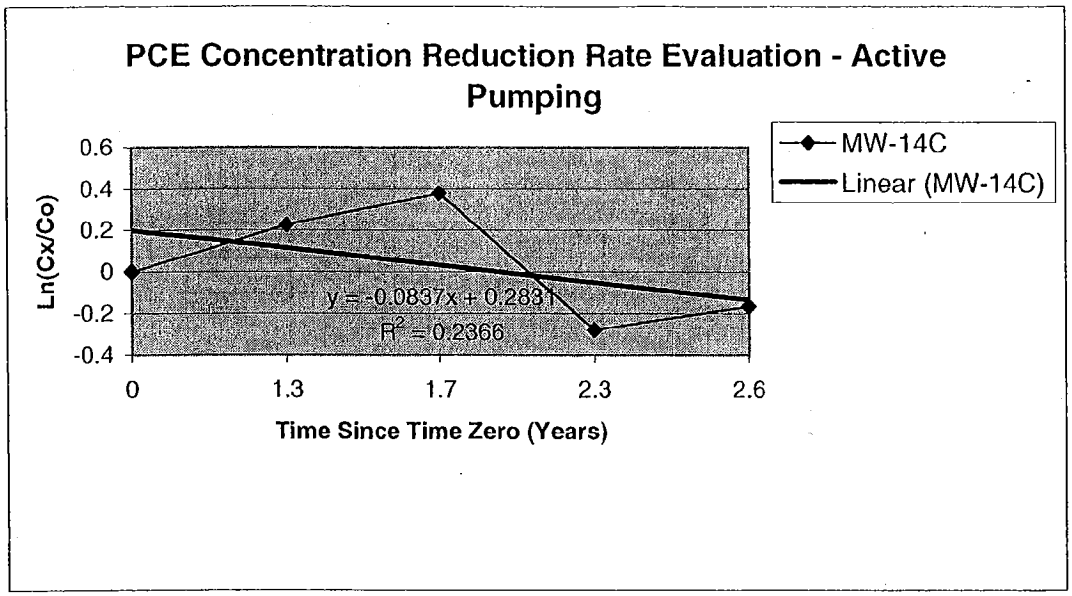

PCE Concentration Reduction Rate Evaluation - Active Pumping
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Ln(Cx/Co)
y = -0.2049x + 1.0704
R² = 0.8038
0 1.3 2.1 2.3 2.6 2.8 3.1 3.3 3.6 3.8 4.4 4.8 5.4 5.8 6.4 6.9
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

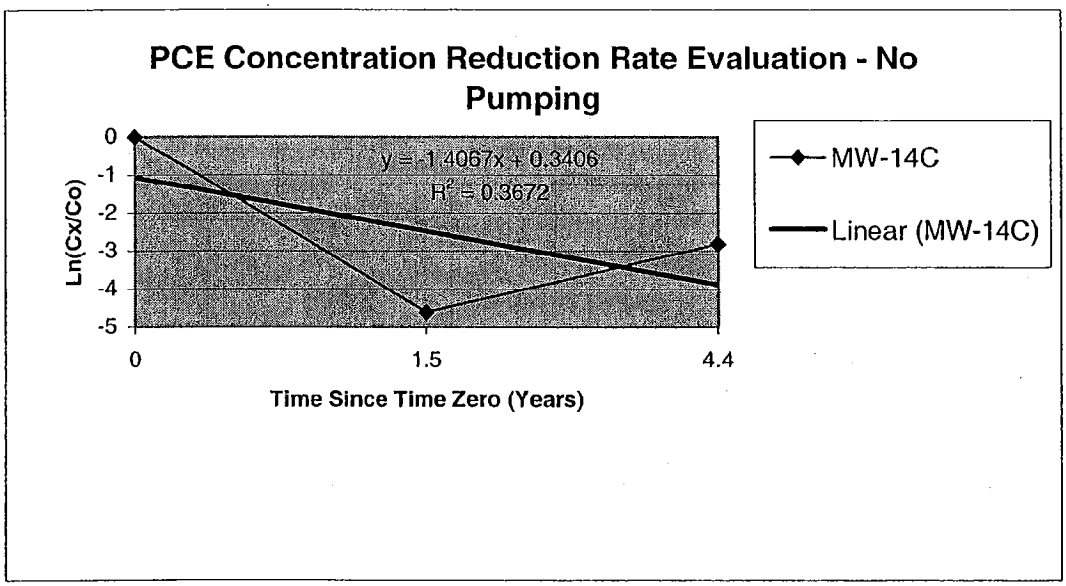

PCE Concentration Reduction Rate Evaluation - No Pumping
0.5
0
-0.5
-1
-1.5
Ln(Cx/Co)
y = -0.6791x + 0.825
R² = 0.8783
0
1.5
4.4
Time Since Time Zero (Years)
MW-10A
Linear (MW-10A)

# PCE


PCE Concentration Reduction Rate Evaluation - Active Pumping
MW-14A
Linear (MW-14A)
Ln(Cx/Co)
0
-1
-2
-3
-4
-5
y = -0.4122x - 0.9041
R² = 0.1219
0
1.3
2.1
2.3
2.6
Time Since Time Zero (Years)

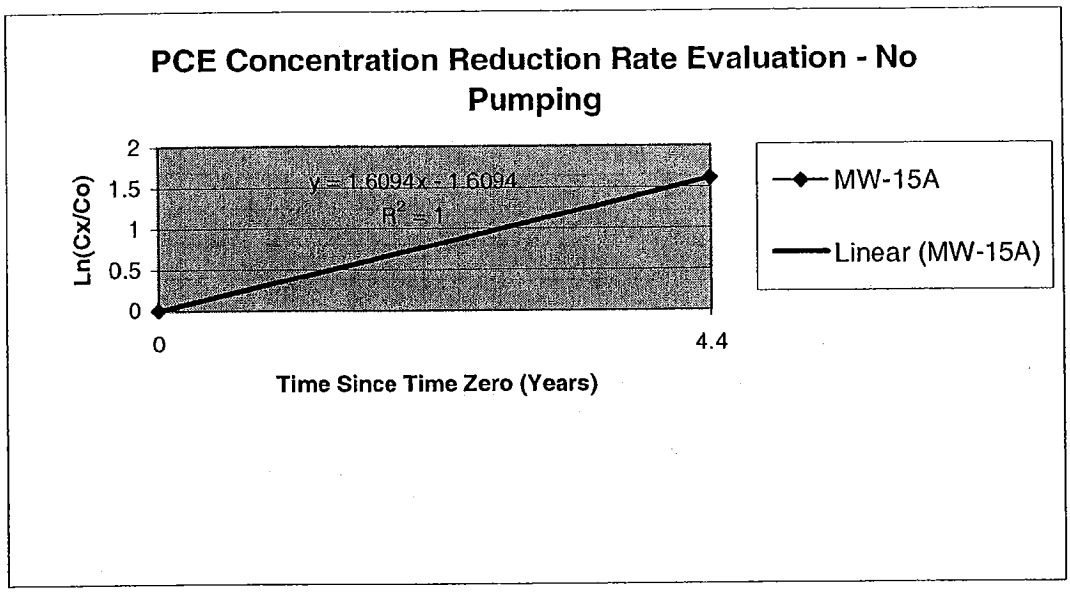

PCE Concentration Reduction Rate Evaluation - No Pumping
MW-14A
Linear (MW-14A)
Ln(Cx/Co)
1
0.5
0
-0.5
-1
-1.5
y = 0.3113x - 0.7782
R² = 0.129
0
1.5
4.4
Time Since Time Zero (Years)

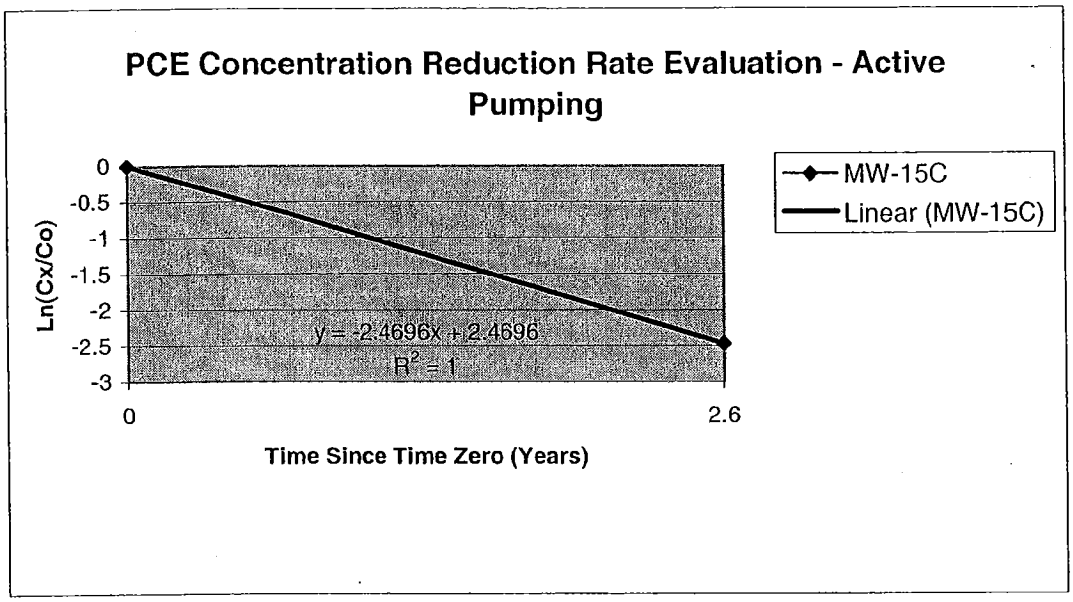

PCE Concentration Reduction Rate Evaluation - Active Pumping
0.6
0.4
0.2
0
-0.2
-0.4
Ln(Cx/Co)
y = -0.0837x + 0.2831
R² = 0.2366
0
1.3
1.7
2.3
2.6
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)

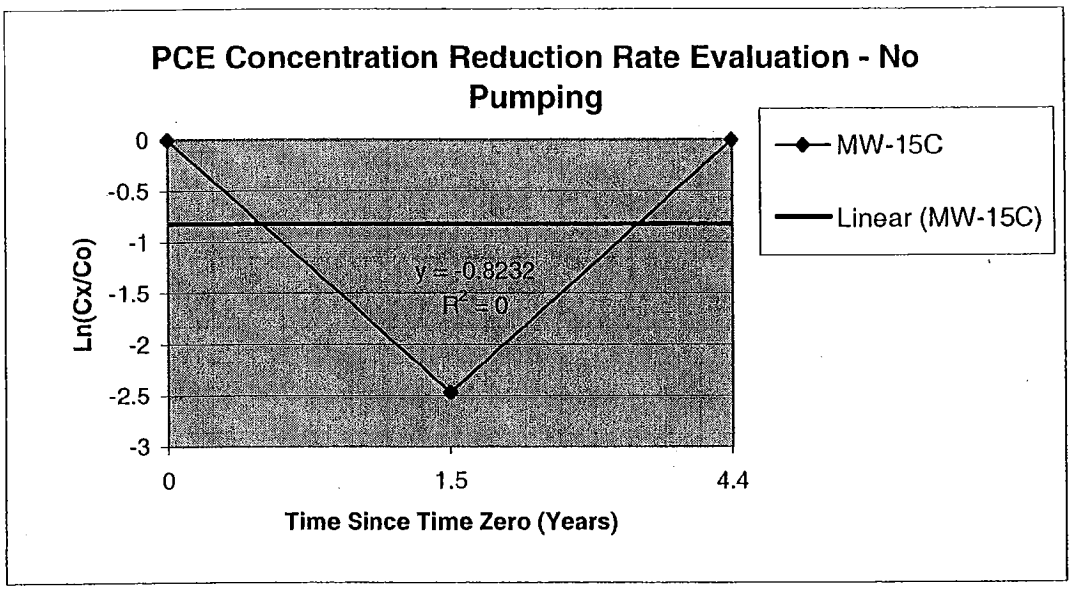

PCE Concentration Reduction Rate Evaluation - No Pumping
0
-1
-2
-3
-4
-5
Ln(Cx/Co)
y = -1.4067x + 0.3406
R² = 0.3672
0
1.5
4.4
Time Since Time Zero (Years)
MW-14C
Linear (MW-14C)

# PCE

**Well 15A attenuation rate cannot be evaluated due to insufficient detected values**




PCE Concentration Reduction Rate Evaluation - Active Pumping
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
y = -2.4696x + 2.4696
R² = 1
0
2.6
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)


PCE Concentration Reduction Rate Evaluation - No Pumping
Ln(Cx/Co)
0
-0.5
-1
-1.5
-2
-2.5
-3
y = -0.8232
R² = 0
0
1.5
4.4
Time Since Time Zero (Years)
MW-15C
Linear (MW-15C)

APPENDIX C

# Acceptance of Closure Certification Letter from Washington State Department of Ecology

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
*Northwest Regional Office, 3190 - 160th Ave S.E. • Bellevue, Washington 98008-5452 • (206) 649-7000*

September 3, 1997

**CERTIFIED MAIL**
P 115 514 037

Mr. Andro B. Wipplinger
Supervisor, Environmental Management
Boeing Defense and Space Group
P.O. Box 3707
Seattle, WA 98124-2207

Dear Mr. Wipplinger:

Re: Ecology's Acceptance of Certification for Final Facility Clean Closure of the Boeing Developmental Center (WAD 093639946).

The Department of Ecology, Hazardous Waste and Toxics Reduction Program, (Ecology) has received and reviewed the clean closure certification and the supporting documentation for final facility closure of the Boeing Developmental Center Building 9-50, 9-60, and 9-69/70 Dangerous Waste Container Storage Areas [*Closure Certification Report, Building 9-50, 9-60, and 9-69/70, Container Storage Area*, dated April 1997]. In addition, Ecology has previously received and reviewed the clean closure certification and supporting documentation for the Building 9-101 above ground dangerous waste storage tanks [*Above Ground Tank Closure Investigation Report, Building 9-101, Boeing Developmental Center*, dated June 17, 1993]. These reports were submitted as required by WAC 173-303-400(3), and by reference 40 CFR 265.

The report is documentation that final facility closure of the dangerous waste container storage areas and above ground storage tanks have been completed in accordance with the specifications of the approved closure plans: *Closure Plan, Container Storage Area, Buildings 9-50, 9-60, 9-69/9-70, Boeing Developmental Center, April 1993,* the Ecology closure plan approval letter dated December 7, 1993, and the *Closure Plan, Aboveground Tank Closure Investigation, Building 9-101, Boeing Developmental Center, October 13, 1992.*

Based on the data and information obtained in the above mentioned reports, Ecology accepts the final facility closure certification for the Boeing Developmental Center dangerous waste container storage units located at Buildings 9-50, 9-60, and 9-69/70 in addition to the Building 9-101 dangerous waste above ground storage tanks. The Boeing Developmental Center has now satisfied the interim status requirements for closure of the dangerous waste container storage areas and above ground tanks described above in accordance with WAC 173-303-400(3), by reference 40 CFR 265. As of the date of this letter, The Boeing Developmental Center may no longer store (>90 days), treat, or dispose of dangerous wastes on site. However, the facility will maintain interim status as a dangerous waste storage facility, until all requirements of RCRA corrective action are completed to the satisfaction of Ecology.

The Boeing Developmental Center is released from the financial assurance requirements for closure in accordance with WAC 173-303-400(3), by reference 40 CFR 265.143(h).

Please do not hesitate to call Dean Yasuda at (425) 649-7264 if you have any questions.

Sincerely,

Julie Sellick, Supervisor
Hazardous Waste and Toxics Reduction Section

JAS:jbs

cc: Dean Yasuda, NWRO
Rob Kirkwood, HWTR Financial Assurance Officer

Mellon Bank, NA
Cost Analysis Division

# Review Of Environmental Status

**Original Project #:** 2040112
**Current Task #:** 2040124

**Privileged And Confidential**
**Attorney-Client Communication**
**Legal/Cost Analysis Group**

| | | | |
|---|---|---|---|
| **Project Name:** | Desimone/ Oxbow Boeing | **Relationship Mgr.:** | Bill Kaull |
| **Borrower:** | Desimone Family Trust | **AIM #:** | 024-0074 |
| **Location:** | Tukwilla, WA | **Company Number:** | 1 |
| **Date:** | August 26, 2004 | **Cost Code:** | 9510 |
| **Revision Date:** | | **Action:** | REP REV |

**The Following Document Has Been Reviewed For Completeness And Acceptability**

**ENVIRONMENTAL ASSESSMENT REPORT**

| | |
|---|---|
| **Type of Report:** | Summary Report Corrective Action |
| **Consultants Qualifications:** | Acceptable |
| **Quality of Assessment Report:** | Acceptable |
| **Consultant:** | Landau Associates |
| **Final Report Date:** | 2/27/2002 |

**Status Review History**

| Control | Consultant | Report Type | Report Date | Action | Issue Date |
|---|---|---|---|---|---|
| 2040112 | Landau Associates | Evaluation Report | 3/10/2004 | Report Review | 8/26/2004 |

**Closing recommendation based on the documents listed above:**

__ **The site does not represent a significant environmental risk.**

___ **The site does not represent a significant environmental risk, if the recommendations listed in remarks are completed.**

_X_ **The site evaluation requires a Phase II, further investigation or remediation of the items listed in remarks.**

Remarks: 1/ The Summary Report Corrective Action prepared by Landau Associates outlines 157 SWMUs and 5 AOCs. Nearly all of the issues have been resolved by Boeing between 2002 and 2004.
2/ The Evaluation Report prepared by Landau Associates provides the status of several remaining Solid Waste Management units (SWMU) and Area of Concern (AOC) located on the property. This report was prepared for The Boeing Company and Boeing is completing the work under the Washington State Department of Ecology Voluntary Cleanup Program. Continued remediation (SWMU 20) and monitoring (AOC-5) is recommended for several locations. Based on the efforts of Boeing, these issues do not represent a significant environmental risk.

Cost Analyst: Dolores H. Selby

cc: Jeffrey M. Parker, Esq..

No Further Action Required
by Cost Analysis Group
Date:
Initials: _____

# Evaluation Report
# SWMU-17, SWMU-20, and AOC-05
# Boeing Developmental Center
# Tukwila, Washington

March 10, 2004

Prepared for

**The Boeing Company**
**Seattle, WA**

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

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# 1.0 INTRODUCTION

This report evaluates current conditions at solid waste management units (SWMUs) SWMU-17 and SWMU-20, and at area of concern (AOC) AOC-05 located at The Boeing Company (Boeing) Developmental Center (BDC) in Tukwila, Washington (Figure 1). The BDC is a Resource Conservation and Recovery Act (RCRA) corrective action site with remedial activities conducted under the Washington State Department of Ecology (Ecology) Voluntary Cleanup Program (VCP). Preparation of this report was authorized under Work Order No. ENV-G-04DC-019.

## 1.1 BACKGROUND

Under its RCRA corrective action authority, the U.S. Environmental Protection Agency (EPA) conducted a RCRA Facility Assessment (RFA) in 1994 and identified 157 SWMUs and 5 AOCs at the BDC (SAIC 1994). Ecology approved exclusion of most SWMUs and AOCs from further investigation based on the determination that they do not pose a threat to human health or the environment. The status of each SWMU and AOC was documented in a previous summary report (Summary Report) prepared by Landau Associates (Landau Associates 2002a).

Following submittal of the Summary Report (Landau Associates 2002a) to Ecology, only two SWMUs (SWMU-17 and SWMU-20) and three AOCs (AOC-01/02, AOC-03/04, and AOC-5) remained subject to continued monitoring and evaluation. Monitoring was subsequently discontinued at AOC-01/02 and AOC-03/04, in accordance with the Developmental Center Groundwater Monitoring Plan (Boeing 2001), following two consecutive quarters and four consecutive quarters, respectively, during which contaminants of concern were not detected (Boeing 2002, 2003). Based on these monitoring results, no further remedial action is required at AOC-01/02 and AOC-03/04.

At SWMU-20, the pump and treat system was shut down December 14, 2001 and semiannual monitoring was performed through November 2003 to evaluate natural attenuation of volatile organic compounds (VOCs) as a remedial alternative to reach site clean-up concentrations. At AOC-05, Oxygen Release Compound (ORC®) was injected during May 2002 to address gasoline-range petroleum hydrocarbons (TPH-G) and benzene, toluene, ethylbenzene, and xylenes (BTEX) present in groundwater. Subsequent to injection, groundwater monitoring at AOC-05 was conducted monthly, then quarterly, then seminannually through November 2003. At SWMU-17, remedial action has consisted of groundwater monitoring only. Figure 2 shows the locations of SWMU-20, AOC-05, and SWMU-17.

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## 1.2 REPORT ORGANIZATION

Following this introductory section, this report is divided into four main sections. Section 2.0 presents evaluation of groundwater monitoring results for SWMU-17. AOC-05 injection of ORC® is described and monitoring results are evaluated in Section 3.0. Section 4.0 presents evaluation of monitoring results for SWMU-20 following shutdown of the pump and treat system in December 2001. A preliminary indoor air evaluation for Buildings 9-101 and 9-90, located in partially in or near SWMU-20, is presented in Section 5.0. Conclusions are summarized in Section 6.0, appropriate use of the report is described in Section 7.0, and references are listed in Section 8.0. A work plan for additional remedial action at SWMU-20 is presented in Appendix A.

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# 2.0 SWMU-17

SWMU-17 is a former 67-gal sump and associated 4,000-gal steel underground storage tank (UST; designated DC-05), located east of the Building 9-75 water tank (Figure 3). Waste oil generated by hydraulic testing shops, automotive maintenance shops, and various other operations at the BDC was poured into the sump and flowed into the UST. Periodically, the waste oil was pumped from the UST for offsite treatment and disposal (SAIC 1994). The sump and UST were installed in 1957 and removed in late March or early April 1986 (Landau Associates 1987).

## 2.1 REMEDIAL ACTION

Minor amounts of hydrocarbons present in soil samples collected prior to and following UST removal led to the installation of three monitoring wells (BDC-05-1, BDC-05-2, and BDC-05-3) during 1986 (Norton Corrosion Limited, Inc. 1985; Landau Associates 1987). Four additional monitoring wells (BDC-05-2A, BDC-05-4, BDC-05-5, and BDC-05-6) were installed in January 1987 and an additional well, BDC-05-7, was installed in March 1987. In December 1987, Ecology requested that additional groundwater sampling be conducted. Following one to two sampling events at each well for analysis of volatile organic compounds (VOCs) and priority pollutant metals, Ecology stated in August 1988 that no further work was required at this SWMU and that monitoring wells could be abandoned (Ecology 1988). Monitoring wells BDC-05-01 and BDC-05-06 were subsequently abandoned.

From 1996 through 2003, groundwater samples from the five remaining wells (BDC-05-2A, BDC-05-3, BDC-05-4, BDC-05-5, and BDC-05-7) were analyzed on an annual or semiannual basis for VOCs, total petroleum hydrocarbon (TPH), and metals. Split samples collected in December 2001 were sent to Analytical Resources, Inc. (ARI) of Seattle, Washington, as well as to the Boeing laboratory used for analysis of previous samples. Metals concentrations in the ARI samples were significantly lower than the concentrations reported by the Boeing laboratory, indicating that the elevated concentrations of metals in previous samples may have been inaccurate. It was determined that samples submitted to the Boeing laboratory in December 2001 and during previous sampling events had been collected in reused METRO sample bottles that had not been acid washed by the laboratory and were, therefore, a possible source of metals contamination. Groundwater samples have been submitted to ARI since December 2001.

Detected concentrations of arsenic, copper, and tetrachloroethene (PCE) have exceeded the preliminary screening levels. In December 2001, Ecology asked for continued groundwater monitoring at SWMU-17 to evaluate the possible need to pursue more active cleanup (Ecology 2001).

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## 2.2 SAMPLING AND ANALYSIS

Following Ecology's request, groundwater was sampled during four semiannual events during 2002 and 2003 for analysis of VOCs and total and dissolved metals. During these four events, arsenic was analyzed by Method 200.8 (ICP MS) to obtain a lower reporting limit for comparison to the preliminary screening level. Monitoring results through December 2001 were presented in the Summary Report (Landau Associates 2002a) and subsequent monitoring results have been reported in four semiannual groundwater reports (Landau Associates 2002b, 2002c, 2003a, 2003b).

## 2.3 MONITORING RESULTS

This section discusses the semiannual results for total and dissolved arsenic, total and dissolved copper, and PCE for 2002 and 2003 and compares results to preliminary screening levels established for the BDC in the Summary Report (Landau Associates 2002a). The results for dissolved analysis of arsenic and copper are most applicable for comparison to preliminary screening levels because dissolved results are more representative of concentrations in groundwater given the potential for metals absorbed to particulates in unfiltered samples to affect total metals results. Data for this period are compared to preliminary screening levels in Table 1 and presented below:

- **Dissolved Arsenic:** The only detection of dissolved arsenic during 2002 and 2003 occurred at the reporting limit (0.001 mg/L) at well BDC-05-4 in November 2003. Well BDC-05-4 is located crossgradient of the former UST (Figure 3). Prior to 2002, previous analysis of dissolved arsenic, performed in December 2001 at each of the SWMU-17 wells, resulted in no detections.

- **Dissolved Copper:** Dissolved copper was detected at upgradient well BDC-05-5 and well BDC-05-7 near the former UST during 2002 and 2003. One or more detections during this period exceeded the 0.0034 mg/L preliminary screening level (Method B marine surface water) at wells BDC-05-5 (0.007 mg/L) and BDC-05-7 (0.004-0.005 mg/L), but did not exceed the preliminary screening level for fresh surface water. These concentrations are significantly lower than the maximum historical concentration of dissolved copper of 0.067 mg/L detected at well BDC-05-3 in December 2001. Dissolved copper concentrations for the period of February 1988 to November 2003 are plotted on Figure 4.

- **PCE:** PCE was detected at wells BDC-05-2 (upgradient), BDC-05-3 (downgradient), and BDC-05-7 (near former UST) during 2002 and 2003. Detected concentrations exceeded the 9 µg/L (Method B fresh and marine surface water criteria) preliminary screening level two or more times at wells BDC-05-2 (17 to 23 µg/L) and BDC-05-7 (12 to 20 µg/L). These concentrations are significantly lower than the maximum historical concentration of 79 µg/L measured at well BDC-05-2 in February 1987. Since February 1988, PCE concentrations above the preliminary screening level (9 µg/L) have been measured only at wells BDC-05-2 and BDC-05-7. Since May 1987, PCE concentrations at wells BDC-05-2 and BDC-05-7 have varied above and below the preliminary screening level but have remained consistently within the concentration range of about 5 µg/L to about 20 ug/L; PCE concentrations detected

in 2002 and 2003 at these two wells remain consistent with this trend. Breakdown products TCE and cis-1,2-DCE are present in SWMU-17 wells, indicating the occurrence of reductive dechlorination. TCE and cis-1,2-DCE concentrations are below preliminary screening levels. Vinyl chloride has not been historically detected. PCE concentrations for the period of July 1986 to November 2003 are plotted on Figure 5.

## 2.4 CONCLUSIONS

Based on the recent SWMU-17 monitoring results, we recommend discontinuing metals analysis and continued semiannual monitoring for PCE. Monitoring results for 2002 and 2003 are summarized below:

- Dissolved arsenic was detected at only one well and this detection was at a concentration well below the preliminary screening level.

- Although dissolved copper was detected at low concentrations in wells BDC-05-5 and BDC-05-7, located nearest the former UST, it was not detected in the other three SWMU-17 wells, located upgradient, crossgradient, and downgradient of the former UST. Some of the dissolved copper concentrations at wells BDC-05-5 and BDC-05-7 are above the preliminary screening level for marine surface water, but below the preliminary screening level for fresh surface water; other detections at these two wells have been below both preliminary screening levels.

- PCE was detected at only two wells (BDC-05-2 and BDC-05-7) at concentrations greater than the preliminary screening levels; detected concentrations at these two wells were consistent with previous results since May 1987. Since May 1987, PCE concentrations at wells BDC-05-2 and BDC-05-7 have varied above and below the preliminary screening level but have remained consistently within the concentration range of about 5 µg/L to about 20 µg/L. The presence of TCE and cis-1,2-DCE (Landau Associates 2002a, 2002b, 2002c, 2003a, 2003b) indicates the occurrence of reductive dechlorination. PCE concentrations below the preliminary screening level or below detection limits at the other three SWMU-17 wells, located upgradient, crossgradient, and downgradient of the former UST, indicate PCE contamination is localized. The periodic low-level detections above the screening level at wells BDC-05-2 and BDC-05-7 do not warrant more active cleanup, but do indicate the need for continued monitoring.

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# 3.0 AOC-05

AOC-05 was a 1,000-gal unleaded gasoline steel UST identified as DC-01 and an associated pump island that were located approximately 25 to 30 ft south of the southwest corner of Building 9-61 (Figure 6). The UST was removed in 1985 after it was punctured by a measuring rod and approximately 830 gal of unleaded gasoline was released.

## 3.1 REMEDIAL ACTION

During UST removal, approximately 500 to 600 gallons of floating product were recovered and additional gasoline was removed with excavated soil (Boeing 2001). Between January and June 2001, groundwater was sampled from twelve soil borings and three remaining monitoring wells (BDC-101, BDC-102, and BDC-103) in the vicinity of the former UST. This groundwater analytical data (IT 2001) indicated that residual gasoline-range petroleum hydrocarbons (TPH-G) and benzene were present at concentrations in excess of preliminary screening levels established for the BDC in the Summary Report (Landau Associates 2002a). Subsequently, groundwater monitoring was performed at the three AOC-05 monitoring wells on a quarterly then semiannual basis.

In November 2001, Ecology and Boeing agreed that ORC® injection and subsequent groundwater monitoring would be performed in AOC-05. Baseline groundwater monitoring and ORC® injection were performed in April and May 2002 in general accordance with the *ORC® Injection Plan: AOC-05* (work plan; Landau Associates 2002d). Subsequent to injection, groundwater sampling was conducted monthly, then quarterly, then seminannually through November 2003. Groundwater data is used to monitor concentrations of TPH-G and benzene in groundwater and to evaluate the effectiveness of the ORC® injection.

## 3.2 ORC® INJECTION ACTIVITIES

ORC® material was injected into the aquifer in the vicinity of the former UST to promote aerobic biodegradation of petroleum hydrocarbons. ORC® is a powdered magnesium peroxide distributed by Regenesis, Inc. of San Clemente California that slowly releases oxygen to the aquifer when hydrated. On May 6 and 7, 2002, approximately 80 lbs of ORC® were mixed with tap water and injected as a slurry at each injection location (ORC-1 through ORC-13). Direct-push drilling and ORC® injection was performed by Cascade Drilling of Woodinville, Washington. The ORC® slurry was injected through direct-push probe rods over an interval from 10 to 20 ft below ground surface (BGS); depth to water measurements at the three AOC-05 monitoring wells indicated groundwater was at approximately 12 ft

BGS at the time of injection. Following ORC® injection and groundwater sampling, borings were abandoned by backfilling with bentonite chips to the bottom of the pavement and constructing a concrete pavement patch.

A total of 1,060 lbs of ORC® were injected at 13 injection locations in the vicinity of the former UST (Figure 7). Eight of the injection borings are located hydraulically downgradient of the former UST, one is immediately adjacent to the former UST, and four are located hydraulically upgradient. Groundwater flow is westward in the vicinity of AOC-05.

## 3.3 GROUNDWATER SAMPLING AND ANALYSIS

Groundwater samples were collected for measurement of field parameters and laboratory analysis. Samples were collected prior to ORC® injection to establish baseline conditions and following injection to monitor the effects of the ORC®. Field parameters consisting of dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, and pH were measured at each location using a flow through cell and field meters. Groundwater samples were submitted for laboratory analysis of TPH-G by NWTPH-Gx and benzene, toluene, ethylbenzene, and xylene (BTEX) by EPA Method 8021B. Samples collected in November 2003 were also analyzed for redox parameters nitrate, sulfate, and methane by EPA Methods 353.2, 300, and 8015 modified, respectively.

Baseline groundwater monitoring was conducted at three existing wells (BDC-101, BDC-102, and BDC-103); three temporary well points (GS-1, GS-2, and GS-3); and the 13 ORC® injection borings (ORC-1 through ORC-13). Baseline groundwater samples were collected from monitoring wells on April 29, 2002. Baseline groundwater monitoring was performed at the temporary well points and injection borings on May 6 and 7, 2002; at each injection boring, the groundwater sample was collected immediately prior to ORC® injection. Sample locations are shown on Figure 7. Table 2 presents baseline field measurements and laboratory data for the temporary well points and injection borings. Baseline data for the three monitoring wells is presented in Table 3 along with subsequent monitoring data.

Post-injection groundwater monitoring was conducted monthly at the three monitoring wells in June, July, and August 2002, then quarterly in December 2002 through June 2003, with the final sampling conducted in November 2003. Table 3 compares baseline field measurements and analytical results to post-injection results. Table 4 presents the four quarters of data collected prior to baseline sampling for additional comparison. Laboratory reports for data presented in Tables 2, 3, and 4 have been previously submitted to Ecology and quarterly and semiannual groundwater monitoring at AOC-05 has been reported in the Summary Report (Landau Associates 2002a) and in subsequent semiannual groundwater reports (Landau Associates 2002b, 2002c, 2003a, 2003b).

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## 3.4 MONITORING RESULTS

This section discusses the results of baseline and post-injection monitoring and compares these results to four quarters of monitoring data collected prior to baseline sampling.

### 3.4.1 BASELINE MONITORING

Baseline concentrations of TPH-G exceeded the preliminary screening level at eight of the nineteen groundwater sample locations and benzene concentrations exceeded the preliminary screening level at three of these locations. Groundwater sampled from seven of the thirteen injection borings (ORC-4, ORC-6, ORC-7, ORC-9, ORC-10, ORC-11, and ORC-12) and from monitoring well BDC-103 exceeded the 0.8 mg/L preliminary screening level for TPH-G. Four of these sample locations where TPH-G concentrations exceeded the preliminary screening level are located hydraulically upgradient or crossgradient of the former UST and pump island (ORC-6, ORC-9, ORC-11, and ORC-12). The concentrations of detected TPH-G ranged from 0.27 to 230 mg/L with the maximum concentration occurring at boring ORC-10, located adjacent to the former UST. The 71 $\mu$g/L preliminary screening level for benzene was exceeded at injection borings (ORC-7 and ORC-10) and at monitoring well BDC-103. Detected concentrations of benzene ranged from 2.6 to 28,000 $\mu$g/L with the maximum detected concentration occurring at ORC-7, located slightly downgradient of the former UST and pump island. Baseline concentrations of TPH-G and benzene are presented on Figure 8. The approximate baseline extent of groundwater with TPH-G and benzene concentrations greater than preliminary screening levels are also shown on Figure 8.

A number of the baseline samples also contained detectable concentrations of toluene, ethylbenzene, and xylenes. The detected concentrations of toluene (1.1 to 47,000 $\mu$g/L) and ethylbenzene (1.3 to 5,400 $\mu$g/L) were well below the respective preliminary screening levels of 200,000 $\mu$g/L and 29,000 $\mu$g/L. There is no preliminary screening level established for xylenes; total xylene concentrations ranged from 2.1 to 28,900 $\mu$g/L.

Baseline DO concentrations were generally less than 1 mg/L and ORP was generally positive, indicating transitional aquifer redox conditions (i.e., aquifer conditions somewhere between aerobic and anaerobic). Three degrees of aquifer redox conditions are defined as follows (Beil et. al. 2002):

| | |
|---|---|
| Aerobic | DO > 1 mg/L, ORP > 0 mV |
| Transitional | DO < 1 mg/L, ORP > 0 mV |
| Anaerobic and Reducing | DO < 1 mg/L, ORP < 0 mV |

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Baseline DO concentrations were less than 1 mg/L except at borings ORC-4 (2.64 mg/L) and ORC-8 (3.37 mg/L), and at monitoring well BDC-101 (1.70 mg/L). Baseline ORP was consistently positive and varied from 0.8 to 215 mV.

### 3.4.2 POST-INJECTION MONITORING

No significant changes were observed in groundwater analytical concentrations or aquifer redox conditions during the seven monitoring events that were conducted following ORC® injection. Post-injection monitoring was conducted at the three monitoring wells for a year and a half between June 2002 and November 2003. Well BDC-103 is located in the release area near the former UST, and wells BDC-101 and BDC-102 are located downgradient (Figure 6). Table 3 compares the results of post-injection monitoring to baseline monitoring data collected from monitoring wells in April 2002. For additional comparison, Table 4 presents the four quarters of monitoring well data collected prior to baseline monitoring (June 2001 and March 2002).

#### 3.4.2.1 Release Area Well BDC-103

At well BDC-103, located near the former UST, post-injection monitoring results were as follows:

- Following injection, TPH-G concentrations varied from 180 to 270 mg/L. These concentrations show no significant change compared to the baseline concentration of 200 mg/L and concentrations that varied from 120 to 200 mg/L during the year prior to baseline sampling and ORC® injection. TPH-G concentrations in groundwater consistently exceeded the 0.8 mg/L preliminary screening level.

- Following injection, benzene concentrations varied from 780 to 4,600 μg/L with a concentration of 850 μg/L measured during the last sampling event in November 2003. These concentrations show no significant change compared to the baseline concentration of 980 μg/L and concentrations that varied from 494 to 5,100 μg/L during the year prior to baseline sampling and ORC® injection. Benzene groundwater concentrations consistently exceeded the 71 μg/L preliminary screening level.

- Concentrations of toluene, ethylbenzene, and xylenes were similar before and after ORC® injection. Concentrations of toluene and ethylbenzene in groundwater were consistently below preliminary screening levels; a preliminary screening level is not established for xylenes.

- DO concentrations stayed below 1 mg/L and ORP was generally positive during post-injection monitoring. DO concentrations ranged from 0.17 to 0.69 mg/L, compared to the 0.21 mg/L baseline concentration. ORP concentrations varied from 4.9 to 143.1 mV, except for negative readings in June 2002 (-110.3 mV) and November 2003 (-74.6 mV). The baseline ORP reading was 44.2 mV.

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Figure 9 presents a plot of TPH-G and benzene concentrations at well BDC-103 before and after ORC® injection. Plots of DO concentrations and ORP readings for the three AOC-05 monitoring wells are presented on Figures 10 and 11, respectively.

#### 3.4.2.2 Downgradient Wells BDC-101 and BDC-102

Post-injection monitoring results at downgradient wells BDC-101 and BDC-102 are as described below. November 2003 TPH-G and BTEX results for well BDC-102 are inconsistent with previous results; November 2003 results for BDC-101 are also somewhat inconsistent. These anomalous results may be the result of laboratory error, as reanalysis was required on all three SWMU-17 samples due to laboratory quality control and the results of reanalysis were significantly different for the BDC-102 sample (i.e., TPH-G and BTEX not detected by reanalysis) compared to the original results. The results of the original analyses that resulted in the highest concentrations for the BDC-101 and BDC-102 samples are reported as estimated, but the results are suspect and should be evaluated in light of future sampling results:

- During the six post-injection sampling events prior to November 2003, TPH-G was only detected once at well BDC-101 (0.61 mg/L) and twice at well BDC-102 (0.25 and 0.26 mg/L). Concentrations of 0.42 mg/L (estimated) and 0.99 mg/L (estimated) were reported in November 2003 for wells BDC-101 and BDC-102, respectively. During baseline sampling, TPH-G was not detected at well BDC-101 and was detected at a concentration 0.33 mg/L at well BDC-102. At both wells, baseline and post-injection concentrations were lower than concentrations from the previous year, which ranged from below detection limits to 6.5 mg/L at well BDC-101, and from 0.38 to 1.6 mg/L at well BDC-102.

- During baseline and subsequent sampling, benzene concentrations at BDC-101 and BDC-102 ranged from below detection limits to 4.4 µg/L, with the exception of November 2003 results. In November 2003, concentrations of 13 mg/L (estimated) and 120 mg/L (estimated) were reported for BDC-101 and BDC-102, respectively. With the exception of November 2003 results, baseline and subsequent concentrations are well below the preliminary screening level of 71 µg/L and are lower than benzene concentrations measured during the prior year, which ranged from 1.4 to 95 µg/L at BDC-101 and from 1.3 to 5.33 µg/L at BDC-102.

- With the exception of the ethylbenzene concentration reported for BDC-102 in November 2003, the concentrations of toluene, ethylbenzene, and xylenes corresponding to baseline and post-injection sampling were as low or lower than concentrations detected during the previous year. Groundwater concentrations of toluene and ethylbenzene have consistently been below preliminary screening levels; there is no preliminary screening level established for xylenes.

- DO concentrations occasionally exceeded 1 mg/L at well BDC-101, but not at well BDC-102 and ORP was generally positive at both wells. DO concentrations ranged from 0.35 to 1.89 mg/L at BDC-101, compared to the 1.70 mg/L baseline concentration. DO concentrations at BDC-102 ranged from 0.24 to 1.0 mg/L compared to a baseline concentration of 0.33 mg/L. ORP measurements at the two wells varied from 19.6 to

234.1 mV, except for two negative readings at BDC-102 in June 2002 (-127.2 mV) and November 2003 (-122.2). Baseline ORP readings were 215.3 and 113.5 mV at BDC-101 and BDC-102, respectively.

With the exception of November 2003 results, data shows general decreasing trends in TPH-G and BTEX concentrations at wells BDC-101 and BDC-102. Decreasing trends do not appear attributable to the ORC® injection, as decreasing concentrations were observed prior to baseline sampling and injection. Additionally, consistently low DO and ORP levels indicate that aquifer conditions were not enhanced for aerobic degradation. Figures 12 and 13 present plots of TPH-G and benzene concentrations for wells BDC-101 and BDC-102, respectively. DO concentration and ORP plots for all three monitoring wells are presented on Figures 10 and 11, respectively.

## 3.5 CONCLUSIONS

Monitoring results indicate that ORC® was ineffective in changing aquifer redox conditions or in significantly decreasing concentrations of TPH-G or benzene. However, generally decreasing downgradient concentrations indicate the plume is not spreading and may be shrinking.

Even at well BDC-103, located just 2.5 ft from boring ORC-10 where 20 pounds of ORC® were injected, no effects of the injection were observed. It appears that released oxygen was quickly consumed by background aquifer demand consisting of organic carbon and/or reduced metals and that little to no oxygen remained to facilitate aerobic degradation of petroleum hydrocarbons. Although total organic carbon (TOC) data has not been collected for AOC-05 soil or groundwater, TOC results for five soil samples collected previously at SWMU-20 indicate elevated concentrations of naturally occurring organic carbon are present in site soil. The SWMU-20 soil samples were collected from depths ranging from 20 to 37.5 ft at wells 14E, 17D, 18D, 18C, and 20D and contained 247 mg/kg to 1,456 mg/kg of TOC (Landau Associates 1992). With the exception of well 14E, these wells are located crossgradient of the former SWMU-20 degreaser and TOC concentrations are unlikely to be the result of an organic carbon release (e.g., TPH) from the degreaser.

In spite of no observable effects of the ORC® injection, baseline and post-injection monitoring results at downgradient wells BDC-101 and BDC-102 show a general decrease in TPH-G and benzene concentrations compared to monitoring results from the previous year (with the exception of November 2003 data). Although injected ORC® was ineffective at reducing concentrations at the release area (BDC-103) and decreasing concentrations at the downgradient wells do not appear to be attributable to ORC® injection, decreasing downgradient concentrations indicate the plume is not spreading and may be shrinking.

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Based on downgradient results that indicate the plume is stable or shrinking, we recommend continued semiannual monitoring at wells BDC-101, BDC-102, and BDC-103 to monitor the effectiveness of natural attenuation processes in containing and potentially shrinking the plume. Following four consecutive semiannual monitoring events with results below preliminary screening levels at downgradient wells BDC-101 and BDC-102, we recommend that monitoring be discontinued and that institutional controls be applied to address worker safety and management of AOC-05 groundwater during any excavation activities within the plume.

# 4.0 SWMU-20

SWMU-20 was a vapor degreaser located in the northwest corner of Building 9-101 (Figure 2). PCE and TCE were reportedly used during operation of the degreaser from about 1956 to 1984. In 1984, the vapor degreaser, associated piping, and other equipment were removed and all openings through the walls and floor were plugged. The concrete-lined degreaser pit and sumps were then backfilled with compacted sand backfill material and capped with a 10-inch thick concrete slab. (Landau Associates 1990). During subsequent soil excavation near the backfilled degreaser pit, groundwater was observed at a depth of 2 to 29 inches above the concrete floor of the degreaser pit.

## 4.1 REMEDIAL ACTION

Remedial action beginning in 1989 has included removal of contaminated soil, soil and groundwater sampling, monitoring well installation and subsequent monitoring, and operation of a groundwater pump and treat system. Investigations confirmed the presence of PCE, TCE, and breakdown products in groundwater and the solvent release was interpreted to be from the former degreaser pit (SAIC 1994). Benzene and napthalene were also frequently detected in SWMU-20 groundwater samples. The location of SWMU-20, including the former vapor degreaser pit, monitoring wells, and extraction wells, are shown on Figure 14. Remedial action at SWMU-20 is summarized below; a more detailed discussion is contained in Landau Associates (2002a):

- In 1989, approximately 1,400 tons of soil contaminated with PCE and TCE were removed from the area of the former degreaser pit and sumps during a structural upgrade of Building 9-101. Soil and/or water samples were collected before and during excavation for analysis of VOCs, SVOCs, metals, and cyanide.

- During a Phase II investigation performed in August 1989, 65 soil samples were collected from borings and 24 monitoring wells were installed in the vicinity of the former degreaser pit/sump area. Investigation soil samples were analyzed for VOCs, SVOCs, TPH, and polychlorinated biphenyls (PCBs); groundwater samples were analyzed for VOCs and TPH.

- A Phase III investigation was completed in February 1991, which included additional soil sampling and installation of 13 monitoring wells. Soil samples were analyzed for VOCs. Groundwater samples from the 24 existing monitoring wells and 13 new monitoring wells were analyzed for VOCs.

- During the fall of 1993, a groundwater treatment system was installed to remove chlorinated VOCs from groundwater and prevent migration of contaminants. The treatment system consists of two extraction wells (E-1 and E-2), and a sieve tray aerating treatment system. Well E-1 was installed first and operated as the sole extraction well from March 4, 1994 to December 13, 1995. Following installation of a second groundwater extraction well (E-2) in July 1996, groundwater was extracted alternately from the two wells, with E-2 operated most

of the time. The groundwater treatment system processed approximately 25,000 gal per day of treated water, which was discharged to a National Pollution Discharge Elimination System (NPDES) permitted stormwater outfall. The treatment system was shutdown December 14, 2001 to allow the groundwater to equilibrate and to evaluate natural attenuation as a remedial alternative to reach site clean-up concentrations.

## 4.2 MONITORING WELL CONSTRUCTION

Groundwater monitoring wells installed at SWMU-20 and throughout the site have been constructed to allow evaluation of discrete intervals, or horizons, within the aquifer system beneath the site (horizons A, B, C, D, and E). Monitoring wells have been screened as follows:

A Horizon Wells – screen depths ranging from 6.5 to 21.5 ft BGS

B Horizon Wells – screen depths ranging from 22.0 to 27.5 ft BGS

C Horizon Wells – screen depths ranging from 23.5 to 40.5 ft BGS

D Horizon Wells – screen depths ranging from 40.0 to 56.0 ft BGS

E Horizon Wells – screen depths ranging from 77.0 to 82.0 ft BGS.

The A, B, and C Horizon wells are intended to monitor three distinct layers of groundwater located in the shallow, unconfined aquifer. The D Horizon wells are intended to evaluate the semi-confined layer of groundwater present beneath a discontinuous silt aquitard present beneath the unconfined aquifer. The E Horizon well (MW-14E) is intended to monitor the water quality in the fully confined aquifer located below a massive marine silt deposit. The distinction of these horizons has been useful in developing the conceptual groundwater model for the site and important for both the investigation and remediation of SWMU-20.

## 4.3 SAMPLING AND ANALYSIS

Most of the 35 monitoring wells located a SWMU-20 have been sampled at least semiannually since January 1994 for VOC analysis, with most wells sampled quarterly in 1996 and 1997. Monitoring results through December 2001 were presented in the Summary Report (Landau Associates 2002a) and subsequent monitoring results have been reported in four semiannual groundwater reports (Landau Associates 2002b, 2002c, 2003a, 2003b).

## 4.4 MONITORING RESULTS

PCE, TCE, dichloroethene (DCE), VC, benzene, and naphthalene have been frequently detected in SWMU-20 since the startup of the groundwater treatment system during the Fall of 1993. A summary of monitoring results from January 1994 through November 2003 is outlined below:

- **Naphthalene:** All detected naphthalene concentrations have been below the preliminary screening level of 4,940 µg/L.

- **Benzene**: Benzene concentrations were initially below the 71 µg/L preliminary screening level at all wells at SWMU-20, and then increased at several wells to a maximum concentration of 230 µg/L measured at well MW-06C in October 1995. Benzene concentrations then dropped below the screening level at all wells by February 1997. Concentrations remained below the preliminary screening levels between February 1997 and December 2001, when the groundwater treatment system was shutdown. Since the system shutdown, concentrations have not rebounded and remain below the preliminary screening levels. Initial increases in concentrations of benzene and the other contaminants discussed below are likely the result of desorption and contaminant mobilization caused by aquifer disturbance at the start of pumping. Benzene concentrations are presented in Table 5 and plotted for select wells on Figure 15.

- **PCE:** PCE was initially detected at 14 wells at concentrations greater than the 9 µg/L preliminary screening level, with the highest concentrations of 420 µg/L and 820 µg/L detected at MW-9A and MW-9B, respectively. During pumping, PCE concentrations increased at four wells to a maximum concentration of 2,568 µg/L at well MW-9A in May 1995. At the time of the system shutdown in December 2001, PCE was detected in only five wells and exceeded the preliminary screening level only at wells MW-9A (16 µg/L) and 10A (11 µg/L). Since the system shutdown, PCE concentrations have rebounded above the preliminary screening level at wells MW-9A (1000 µg/L), MW-9B (250 µg/L), and MW-10A (58 µg/L). These three wells are located in the immediate vicinity of the former degreaser. PCE concentrations are presented in Table 6 and plotted for select wells on Figure 16.

- **TCE:** TCE was initially detected at four wells at concentrations greater than the 81 µg/L preliminary screening level, with the highest concentrations detected at wells MW-9A (500 µg/L) and MW-14A (600 µg/L). During pumping, TCE concentrations increased at six wells to a maximum concentration of 2,318 µg/L at well MW-9A in February 1996. At the time of system shutdown in December 2001, TCE was detected in only five wells and all concentrations were below the preliminary screening level. Since the system shutdown, TCE concentrations have rebounded above the preliminary screening at wells MW-9A (1,500 µg/L) and MW-9B (370 µg/L). These wells are located in the immediate vicinity of the former degreaser. TCE concentrations are presented in Table 7 and plotted for select wells on Figure 17.

- **Cis-1,2-DCE:** Cis-1,2-DCE was initially detected at four wells at concentrations greater than 500 µg/L. No preliminary screening level is established for cis-1,2-DCE and the practical quantitation limit (PQL) is 5 µg/L. The highest initial concentration was 2,500 µg/L at well MW-9A. During pumping, cis-1,2-DCE concentrations increased at four wells to a maximum concentration of 7,484 µg/L detected at well MW-9A in February 1996. At the time of system shutdown in December 2001, the maximum detected concentration of cis-1,2-DCE was 100 µg/L measured at wells MW-9A and MW-9B and detectable concentrations at

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ten other wells ranged from 1.1 to 36 µg/L. Since the system shutdown, cis-1,2-DCE concentrations have rebounded above 500 µg/L at wells MW-9A (2,300 µg/L) and MW-9B (850 µg/L). These wells are located in the immediate vicinity of the former degreaser. Cis-1,2-DCE concentrations are presented in Table 8 and plotted for select wells on Figure 18.

- **Vinyl chloride:** Vinyl Chloride was initially detected at concentrations greater than the 525 µg/L preliminary screening level at well MW-13C only (760 µg/L). During pumping, vinyl chloride concentrations increased at five wells to a maximum concentration of 1,587 µg/L measured at well MW-14C (October 1995); MW-14 is located downgradient of the former degreaser. At the time of system shutdown in December 2001, vinyl chloride was detected in only seven wells and all concentrations were below the preliminary screening level. Since the system shutdown, vinyl chloride concentrations remain below the preliminary screening level at all at wells, with the highest concentration detected at well MW-14A located approximately 50 ft downgradient of the former degreaser. Vinyl chloride concentrations are presented in Table 9 and plotted for select wells on Figure 19.

Evaluation of groundwater data collected prior to and during operation of the groundwater treatment system, indicated that the rate of concentration reduction was at least as great for most of the constituents of concern under non-pumping conditions as it was under pumping conditions. In fact, the rates of concentration reduction for PCE and TCE were significantly greater under non-pumping conditions. The rates of concentration reduction for cis-1,2-DCE were the same under pumping and non-pumping conditions. Only vinyl chloride exhibited a greater rate of concentration reduction under pumping conditions (Landau Associates 2002a-Appendix B)

Over time, the highest concentrations of PCE, TCE, DCE, have been observed in the A Horizon near the former degreaser pit (MW-9A) with the second highest concentrations observed in the same location in the B Horizon (MW-9B). Concentrations of these compounds decrease in the downgradient direction from monitoring well MW-9A and generally show a decreasing trend with depth. Although some of the highest concentrations of vinyl chloride have been observed at wells MW-9A and MW-9B near the former degreaser, concentrations have also been occasionally high at downgradient wells MW-14A and MW-14C. Near the former degreaser, vinyl chloride concentrations have typically been higher in the A Horizon (MW-9A) than in the B Horizon (MW-9B). Farther downgradient, vinyl chloride concentrations were initially higher in C horizon well MW-14C than in A Horizon well MW-14A (no B Horizon wells were constructed at this location). Beginning in October 1998, higher vinyl chloride concentrations were typically observed at well MW-14A than in MW-14B and this trend continued following the shut down of the groundwater treatment system. Chlorinated hydrocarbons have not been detected in E Horizon well MW-14E since August 1997; earlier detections of cis-1,2-DCE and vinyl chloride at MW-14E were all less than 10 µg/L, well below the preliminary screening levels.

## 4.5 CONCLUSIONS

We recommend enhanced reductive dechlorination through electron donor amendment to address the rebound in VOC concentrations observed following pump and treat system shutdown. This *in situ* approach is based on previous evaluation indicating that the rate of concentration reduction was at least as great for most constituents of concern under non-pumping conditions as it was under pumping conditions (Landau Associates 2002a-Appendix B). Additionally, the limited number of monitoring wells showing significant rebound in concentrations 2 years after pumping was discontinued does not indicate pumping is needed to hydraulically contain the plume. As indicated in WAC 173-340-360, remedial methods that destroy or reduce the toxicity of hazardous substances, such as enhanced reductive dechlorination, are preferred over methods that transfer contaminants from one medium to another (i.e., groundwater treatment system transfer from groundwater to air). The details of proposed donor injection and monitoring are contained in a work plan presented in Appendix A.

# 5.0 INDOOR AIR EVALUATIONS

This section describes the indoor air evaluations performed to estimate potential human health risks associated with exposure to indoor air in Buildings 9-90 and 9-101 due to impacts by VOCs in the underlying shallow groundwater. This evaluation is performed because Buildings 9-90 and 9-101 are located in areas that are expected to have a reasonable likelihood of being impacted by contaminated groundwater associated with SWMU-20.

## 5.1 APPROACH

SWMU-20 is located near the northwest corner of Building 9-101; the building area underlain by SWMU-20 constitutes approximately 0.5 percent of the total building area (Figure 14). Two evaluations were performed for Building 9-101. For an initial conservative evaluation, SWMU-20 groundwater data for shallow A Horizon wells was assumed to be representative of groundwater quality conditions beneath the entire footprint of Building 9-101. This assumption is expected to be very conservative, as SWMU-20 is located on the hydraulic downgradient (west) end of the building structure. Although no groundwater sampling data is available for the Building 9-101 footprint outside of SWMU-20, there are no known or suspected sources of VOCs beneath the building. Except for the 0.5 percent of the Building 9-101 footprint occupied by SWMU-20, groundwater beneath building 9-101 is not expected to be impacted by VOCs. A more realistic evaluation of potential impacts to Building 9-101 indoor air was also performed, assuming that VOCs are not detected in groundwater beneath 99.5 percent of the building footprint.

Building 9-90 is located hydraulically downgradient of SWMU-20 and vinyl chloride is the only VOC detected in groundwater monitoring wells located immediately upgradient. Based on this data, vinyl chloride is considered the only VOC with the potential to impact indoor air in Building 9-90. It is conservatively assumed that vinyl chloride concentrations beneath Building 9-90 are the same as those observed in the A Horizon SWMU-20 monitoring wells. The data set used for evaluation of indoor air at Buildings 9-101 and 9-90 is described in more detail in Section 5.2.

The indoor air evaluation performed for Buildings 9-90 and 9-101 follows EPA guidance for human health risk assessment and indoor air evaluation (EPA 1989, 2000, 2003). A conceptual site model, data evaluation methodology, and the Johnson-Ettinger vapor intrusion modeling process are described below.

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## 5.2 CONCEPTUAL SITE MODEL

The conceptual site model described in this section applies only to the process by which contaminants in SWMU-20 groundwater could impact indoor air. Shallow A Horizon groundwater, encountered between approximately 10 and 21.5 ft BGS, contains VOCs that could potentially volatilize and migrate through void spaces in the unsaturated zone toward the ground surface by diffusion processes. The unsaturated zone at SWMU-20 generally consists of silt, sand, and mixtures thereof (Landau Associates 2002a). Once within the building's zone of influence, migration of volatilized contaminants into the building's indoor air through cracks in the floor slab is controlled by convection processes.

Buildings 9-90 and 9-101 are used for confidential purposes. Building 9-90, used primarily for office space, has a length of 390 ft, width of 175 ft, and an average height of 28 ft. Building 9-101, used primarily for test or development manufacturing, has a length of 950 ft, width of 750 ft, and an average height of 51 ft. If present, contaminants in indoor air could be inhaled by employees working in Buildings 9-90 and 9-101. For the purpose of this evaluation, it was assumed that an adult occupational receptor could be exposed to indoor air for an employment duration of 30 years with a work schedule of 250 days per year.

## 5.3 DATA EVALUATION

Groundwater samples have been collected from a number of monitoring wells since 1989 to characterize groundwater quality in and around SWMU-20. For the purposes of the indoor air evaluation, data from the two most recent sampling events for A Horizon shallow groundwater monitoring wells were considered to be representative of average groundwater conditions likely to impact indoor air in Buildings 9-90 and 9-101. This data set of two groundwater samples at each of 13 wells is presented in Table 10. VOCs included in the evaluation for Building 9-101 include tetrachloroethylene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), vinyl chloride, and naphthalene. These are the five VOCs that were detected in at least 5 percent of the samples; VOCs detected in less than 5 percent of the samples were considered to have a *de minimus* effect on potential human health impacts. As described in Section 5.1, vinyl chloride was the only VOC evaluated for Building 9-90.

The 95 percent upper confidence limit (UCL95) of the arithmetic mean of the SWMU-20 Zone A groundwater samples was calculated as an estimate of the upper bounds average groundwater concentration that could contribute to indoor air impacts (Table 10). The calculations presented in Table 10 represent the very conservative assumption that VOC concentrations within the data set of 13 A Horizon wells represent concentrations beneath the entire footprints of Buildings 9-101 and 9-90.

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The simulated UCL95 representing the more realistic assumption that groundwater beneath Building 9-101 but outside the footprint of SWMU-20 has not been impacted by VOCs is calculated in Table 11. This simulated UCL95 was calculated by incorporating an additional 5,174 theoretical data points (equivalent to 99.5 percent of the total building data set if the original 26 samples characterize the 0.5 percent area of SWMU-20 beneath Building 9-101) at the most frequently achieved laboratory reporting limit for each VOC (1 μg/L for PCE, TCE, cis-1,2-DCE, and vinyl chloride; 5 μg/L for naphthalene).

## 5.4 JOHNSON-ETTINGER MODELING

EPA recommends the use of the Johnson-Ettinger model for the prediction of indoor air concentrations based on measured groundwater concentrations (EPA 2003). Version 3.0 of the Johnson-Ettinger advanced model, released in February 2003 and available for free download on EPA's risk assessment web site (http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm), was used to model potential migration of VOCs from shallow groundwater to indoor air and human health impacts associated with the inhalation of impacted indoor air.

Site-specific information regarding the type of soil present between shallow groundwater and ground surface, building dimensions, and average chemical concentrations in groundwater (Sections 5.2 and 5.3) were used in the advanced Johnson-Ettinger model to predict carcinogenic and noncarcinogenic health risks to human receptors exposed to indoor air on a regular occupational basis. Version 3.0 of the Johnson-Ettinger model incorporates toxicity data for each of the chemicals evaluated in this modeling exercise, current as of February 2003. This model does include the provisional toxicity values for TCE that were identified by EPA in 2002. Input parameters and output files from the Johnson-Ettinger are presented in Appendix B.

As defined by MTCA, the acceptable level of excess cancer risk (for carcinogenic effects) is $1x10^{-6}$ for exposure to individual contaminants (individual excess cancer risk) and $1x10^{-5}$ for exposure to multiple contaminants (total excess cancer risk). MTCA also defines the acceptable hazard quotient (for noncarcinogenic effects) and hazard index (sum of the individual hazard quotients) as 1.

## 5.5 EVALUATION RESULTS

This section describes results for two evaluations performed for Building 9-101 and for a single evaluation performed at Building 9-90. Results of the conservative evaluation and the more realistic evaluation performed for Building 9-101 are described in Section 5.5.1. Results of the conservative evaluation performed for Building 9-90 are described in Section 5.5.2.

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### 5.5.1 BUILDING 9-101

The excess cancer risk and hazard quotient for the conservative assumption that all of the groundwater beneath Building 9-101 has been impacted to the same extent as the groundwater at the SWMU-20 A Horizon wells are presented in Table 10. As shown in Table 10, the total excess cancer risk value ($5x10^{-6}$), the maximum hazard quotient ($7x10^{-3}$ for cis-1,2-DCE), and the hazard index ($1x10^{-2}$) associated with inhalation of VOCs in Building 9-101's indoor air are all less than the regulatory criteria. However, the maximum estimated individual excess cancer risk value ($4x10^{-6}$ for TCE) exceeds the regulatory criterion by a factor of 4 for this conservative evaluation.

Evaluation of the more realistic scenario (i.e., groundwater beneath Building 9-101, but outside the footprint of SWMU-20 has not been impacted by VOCs) results in a maximum estimated individual excess cancer risk value of $3x10^{-8}$ (for TCE), which is less than the regulatory criterion. The total excess cancer risk value ($4x10^{-8}$), the maximum hazard quotient ($3x10^{-5}$ for vinyl chloride), and the hazard index ($1x10^{-4}$) are also less than regulatory criteria for this evaluation. The excess cancer risks, hazard quotient, and hazard index for this more realistic evaluation are presented in Table 11.

Although the conservative evaluation shows a potential for a human health risk concern, the more realistic simulation demonstrates that the risk associated with inhalation of indoor air at Building 9-101 is below acceptable levels.

### 5.5.2 BUILDING 9-90

The estimated excess cancer risk value ($1x10^{-6}$) and the hazard quotient ($4x10^{-3}$) for the conservative evaluation of vinyl chloride in Building 9-90's indoor air are less than or equal to the regulatory criteria. In other words, the evaluation indicates that the risk associated with inhalation of indoor air at Building 9-90 is below acceptable levels.

## 5.6 CONCLUSIONS

Based on these evaluations, potential impacts to indoor air in Buildings 9-90 and 9-101 associated with contaminated groundwater at SWMU-20 are not expected to result in unacceptable health risks. As described in Section 5.2, these results are specific to the building configurations of Buildings 9-101 and 9-90. Therefore, if future development plans involve the construction of additional buildings in the vicinity of SWMU-20, a supplemental indoor air evaluation to consider potential impacts for the specific building configuration should be performed to confirm protection of human health.

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# 6.0 SUMMARY OF CONCLUSIONS

This section summarizes the conclusions presented in the previous four sections:

- **SWMU-17 Continued Monitoring for PCE:** Based on the monitoring results for 2002 and 2003, we recommend no further action for dissolved arsenic and copper (i.e., discontinuing total and dissolved metals analysis) and continued semiannual monitoring for PCE.

- **AOC-5 Continued Monitoring:** We recommend a monitored natural attenuation approach with continued semiannual monitoring at wells BDC-101, BDC-102, and BDC-103. Following four consecutive monitoring events with results below preliminary screening levels at downgradient wells BDC-101 and BDC-102, we recommend that monitoring be discontinued and institutional controls applied to address worker safety and management of AOC-05 groundwater during any excavation activities within the plume.

- **SWMU-20 Active Remediation:** We recommend injection of electron donor to enhance naturally occurring reductive dechlorination that has been documented at SWMU-20. Previous evaluation of groundwater data from before and during pumping indicated that the rate of concentration reduction was at least as great for most of the constituents of concern under non-pumping conditions as it was under pumping conditions. In fact, the rates of concentration reduction for PCE and TCE were significantly greater under non-pumping conditions. The rates of concentration reduction for cis-1,2-DCE were the same under pumping and non-pumping conditions. Only vinyl chloride exhibited a greater rate of concentration reduction under pumping conditions. Additionally, the limited number of monitoring wells showing rebound in concentrations 2 years after pumping was discontinued does not indicate a need for pumping to hydraulically contain the plume. As indicated in WAC 173-340-360, remedial methods that destroy or reduce the toxicity of hazardous substances, such as enhanced reductive dechlorination, are preferred over methods that transfer contaminants from one medium to another (i.e., pump and treat system transfer from groundwater to air). The details of proposed donor injection and monitoring are contained in a work plan presented in Appendix A.

- **SWMU-20 Indoor Air Evaluation:** Potential impacts to indoor air in Buildings 9-90 and 9-101 associated with contaminated groundwater at SWMU-20 are not expected to result in unacceptable health risks. These results are specific to the building configurations of Buildings 9-101 and 9-90. Therefore, if future development plans involve the construction of additional buildings in the vicinity of SWMU-20, a supplemental indoor air evaluation to consider potential impacts for the specific building configuration should be performed to confirm protection of human health.

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# 7.0 USE OF REPORT

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

LANDAU ASSOCIATES, INC.

Clinton L. Jacob, P.E.
Senior Project Engineer

CLJ/tam

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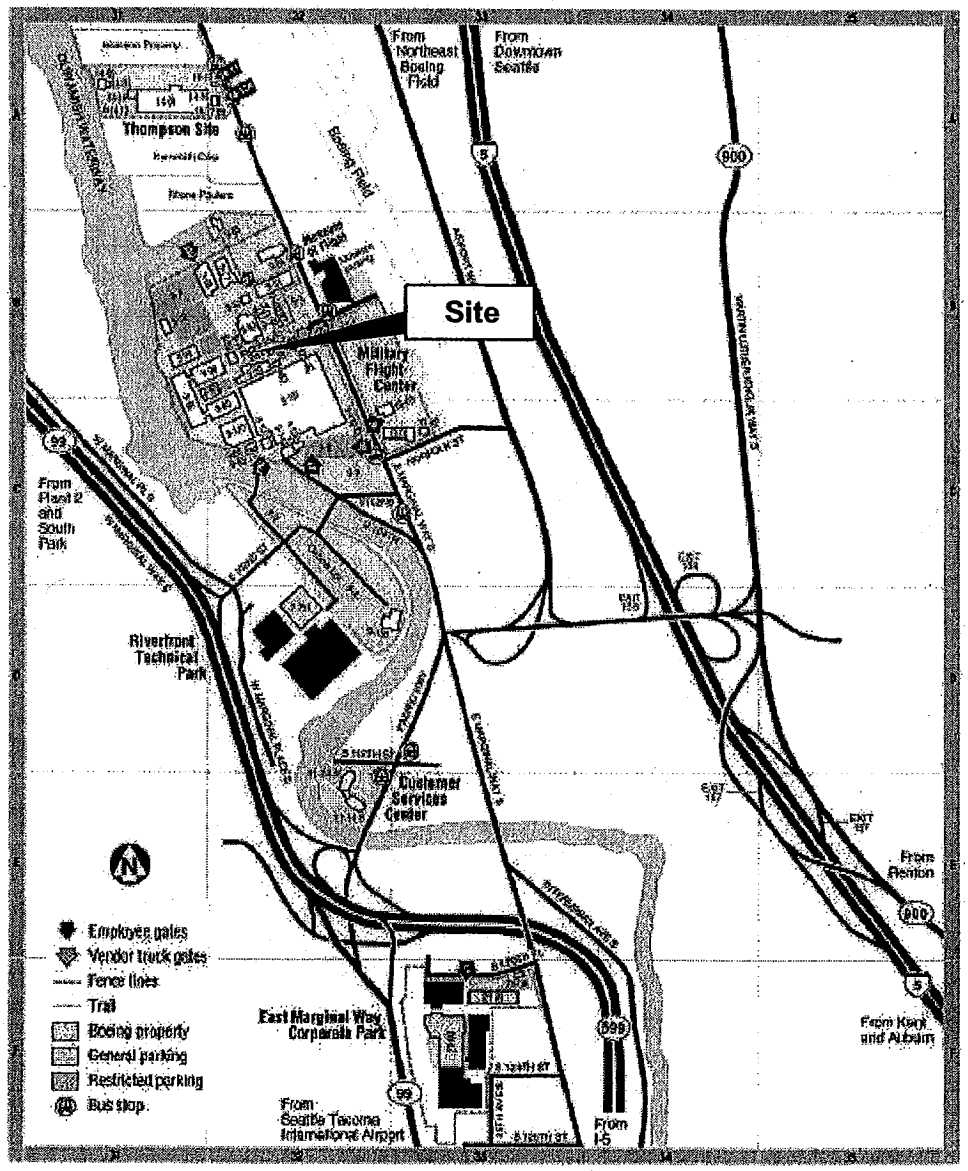


Revised 3-00

Map provided by Boeing, March 2000

**Not To Scale**

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| Boeing Developmental Center<br>Tukwila, Washington | **Site Location Map** | Figure<br>1 |
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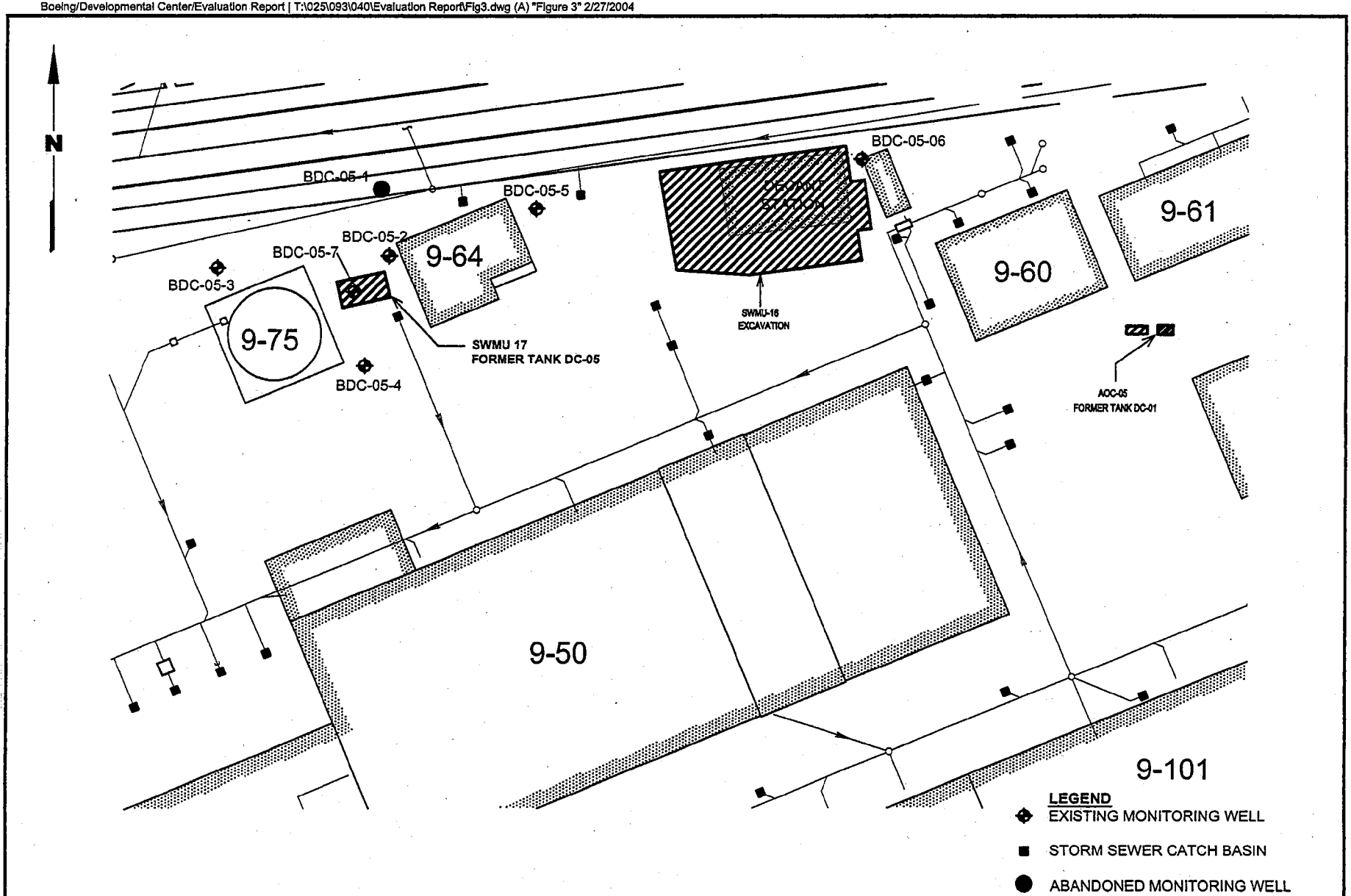


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| Boeing Developmental Center<br>Tukwila, Washington | **SWMU-17 Details** | Figure<br>3 |
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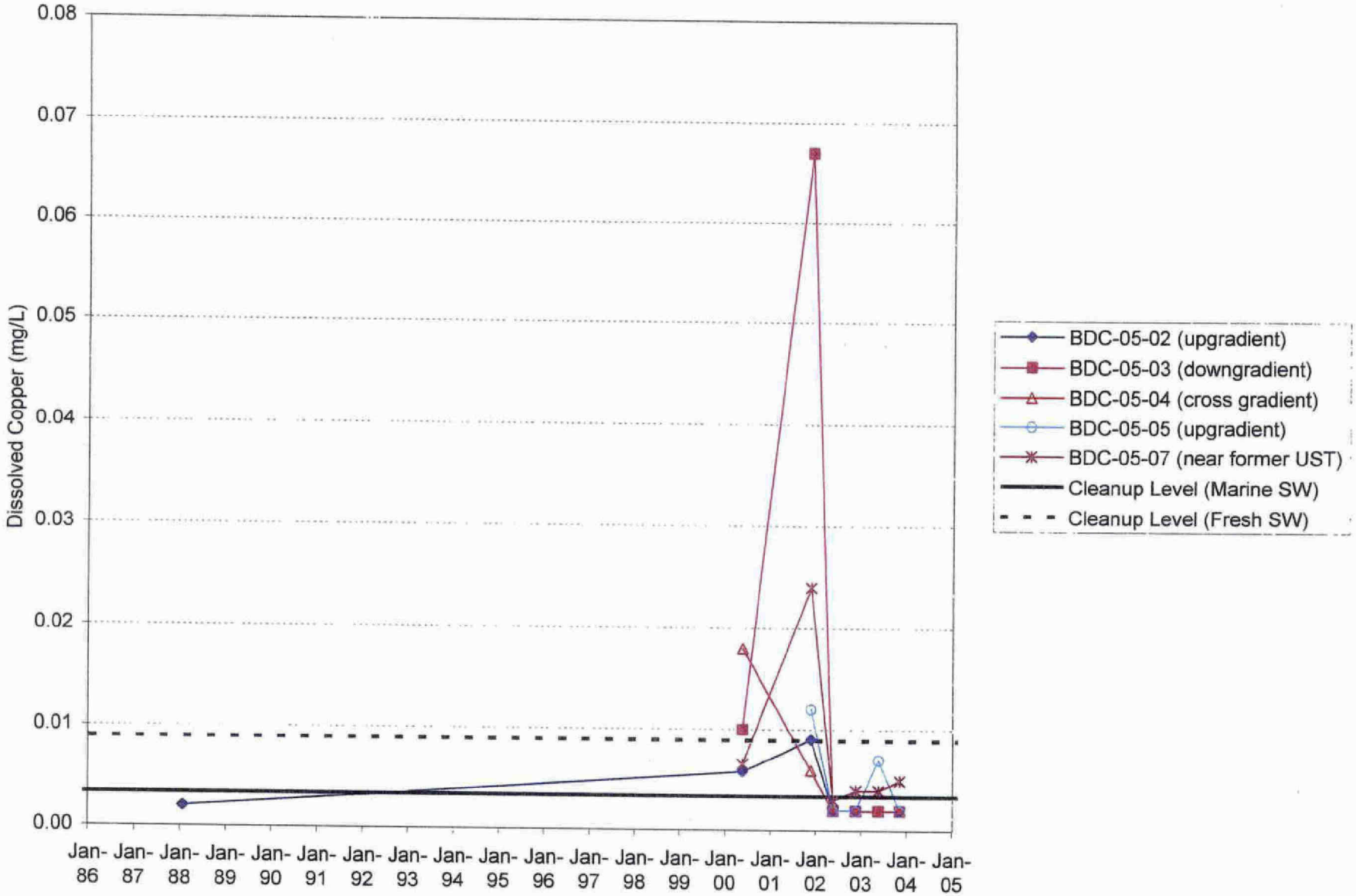


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**SWMU-17 Dissolved Copper Concentrations**

Figure
4

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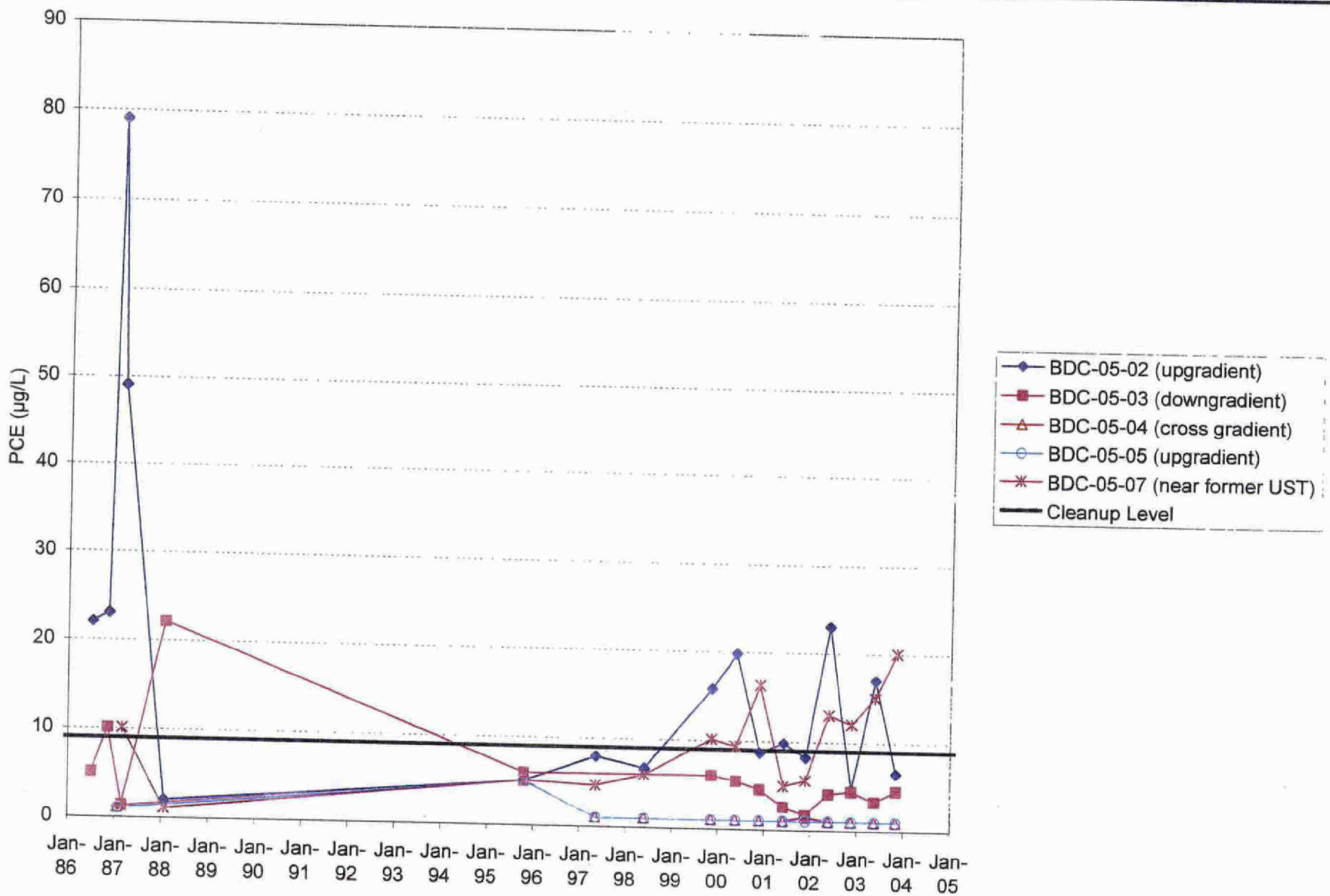


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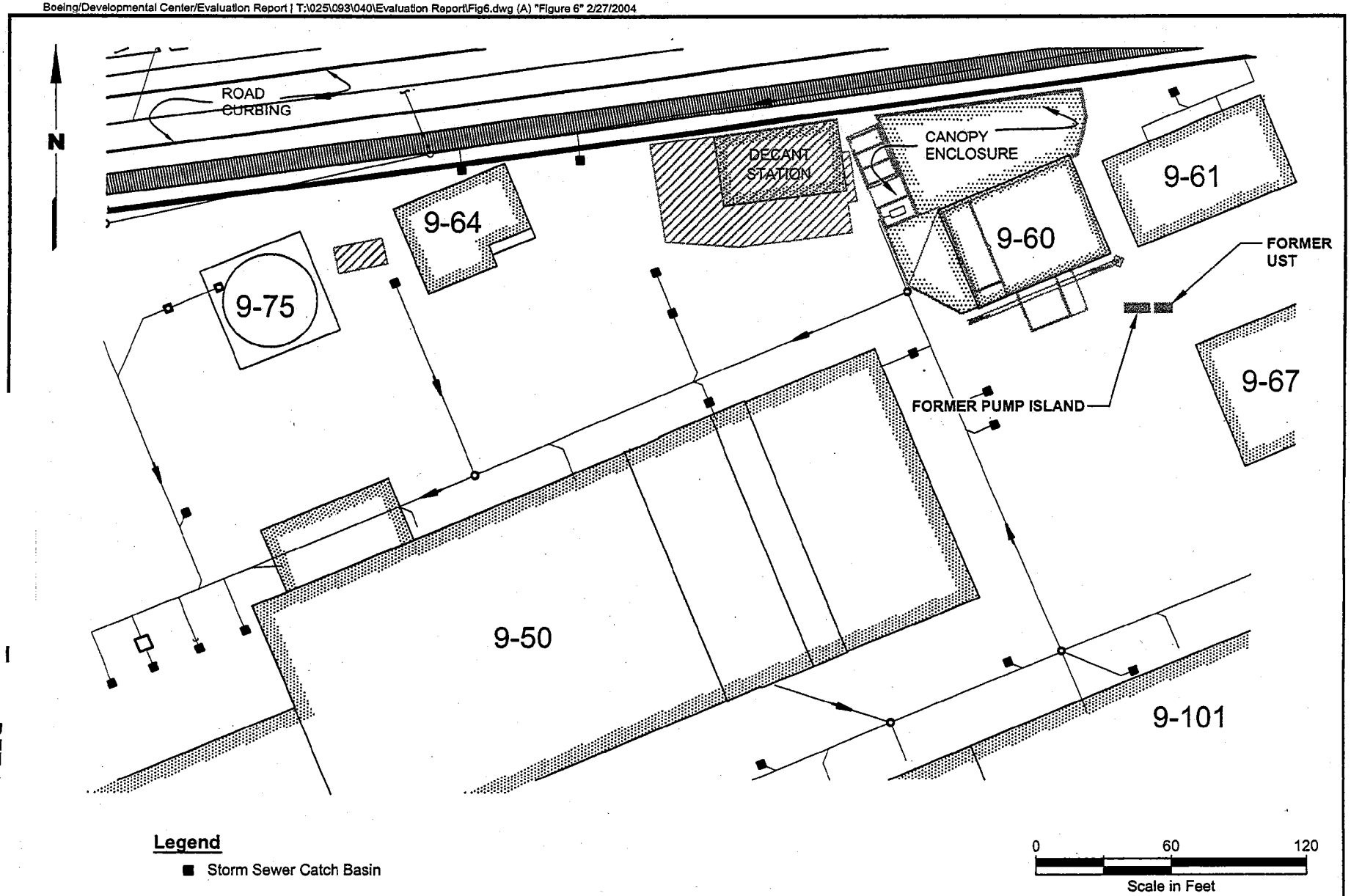
**SWMU-17 PCE Concentrations**

Figure
5

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| Boeing Developmental Center<br>Tukwila, Washington | **AOC-05 Details** | Figure<br>6 |
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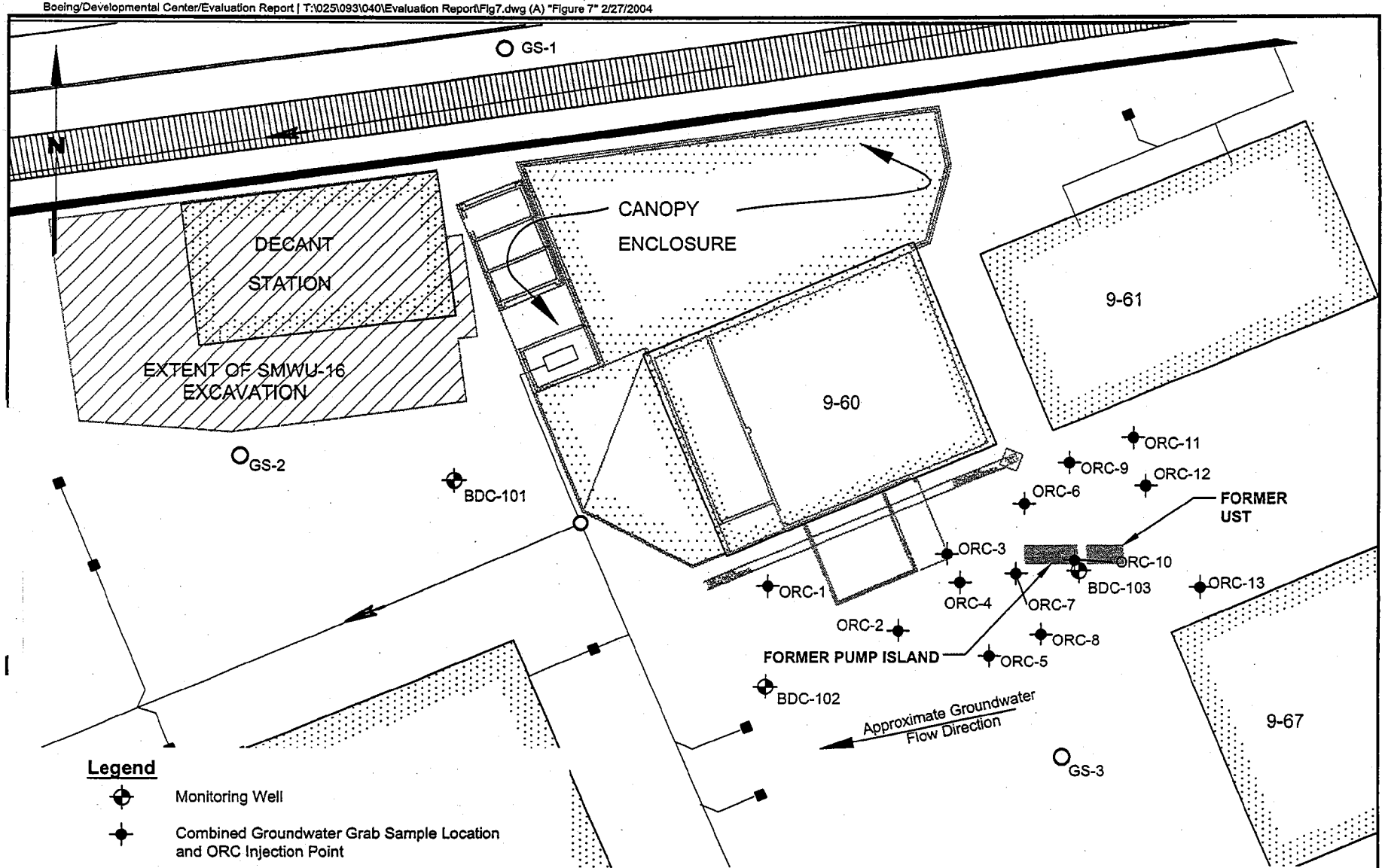


**Legend**

- Monitoring Well
- Combined Groundwater Grab Sample Location and ORC Injection Point
- Groundwater Grab Sample Location
- Storm Sewer Catch Basin

**Note**

The locations of ORC injection points are approximate.

0 30 60
Scale in Feet

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| Boeing Developmental Center<br>Tukwila, Washington | **AOC-05 ORC Injection and Groundwater Sample Locations** | Figure<br>7 |
|---|---|---|

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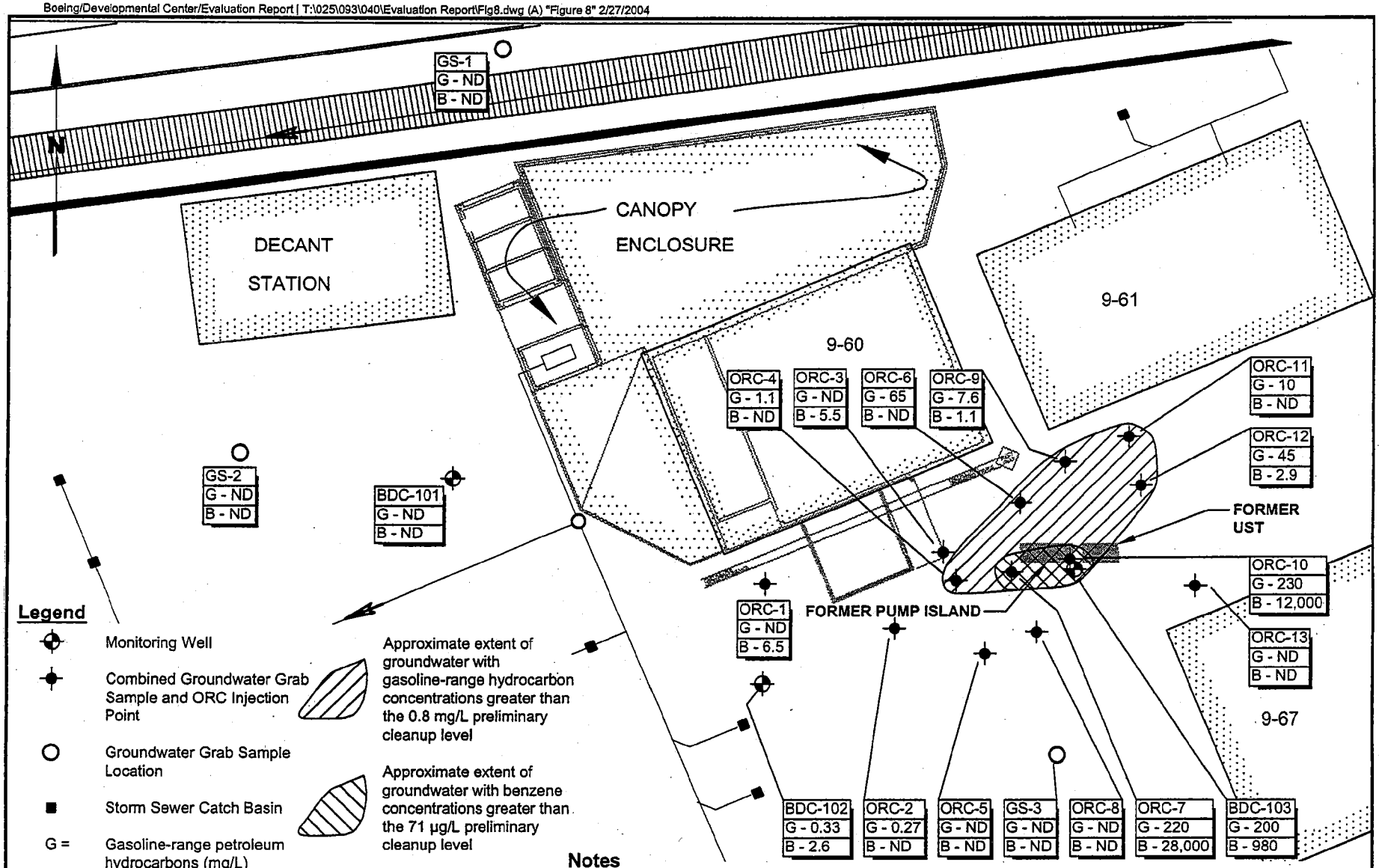


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| Boeing Developmental Center<br>Tukwila, Washington | **AOC-05 Baseline Groundwater Concentrations** | Figure<br>8 |
|---|---|---|

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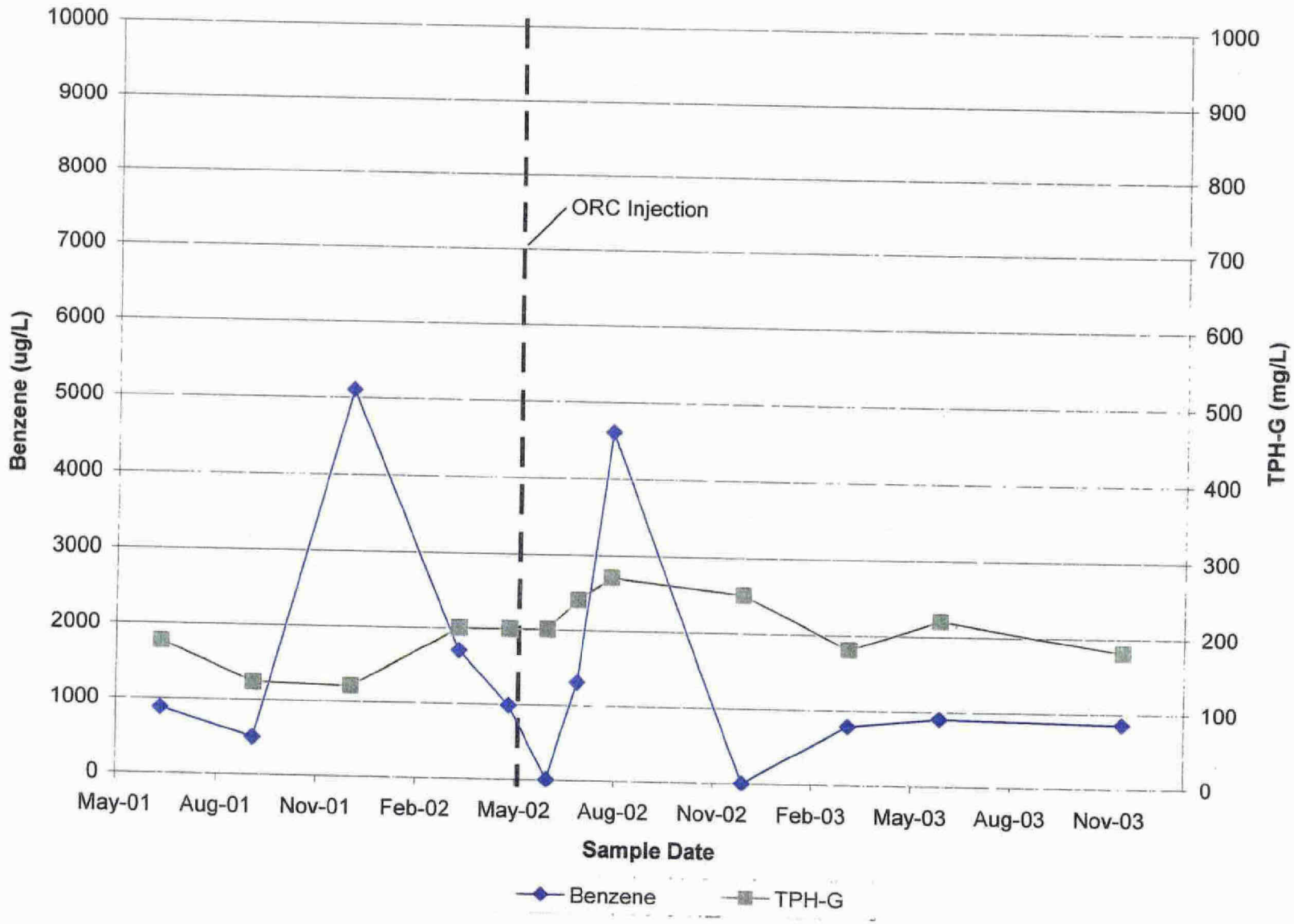


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**Well BDC-103**
**TPH-G and Benzene Concentrations**

Figure
9

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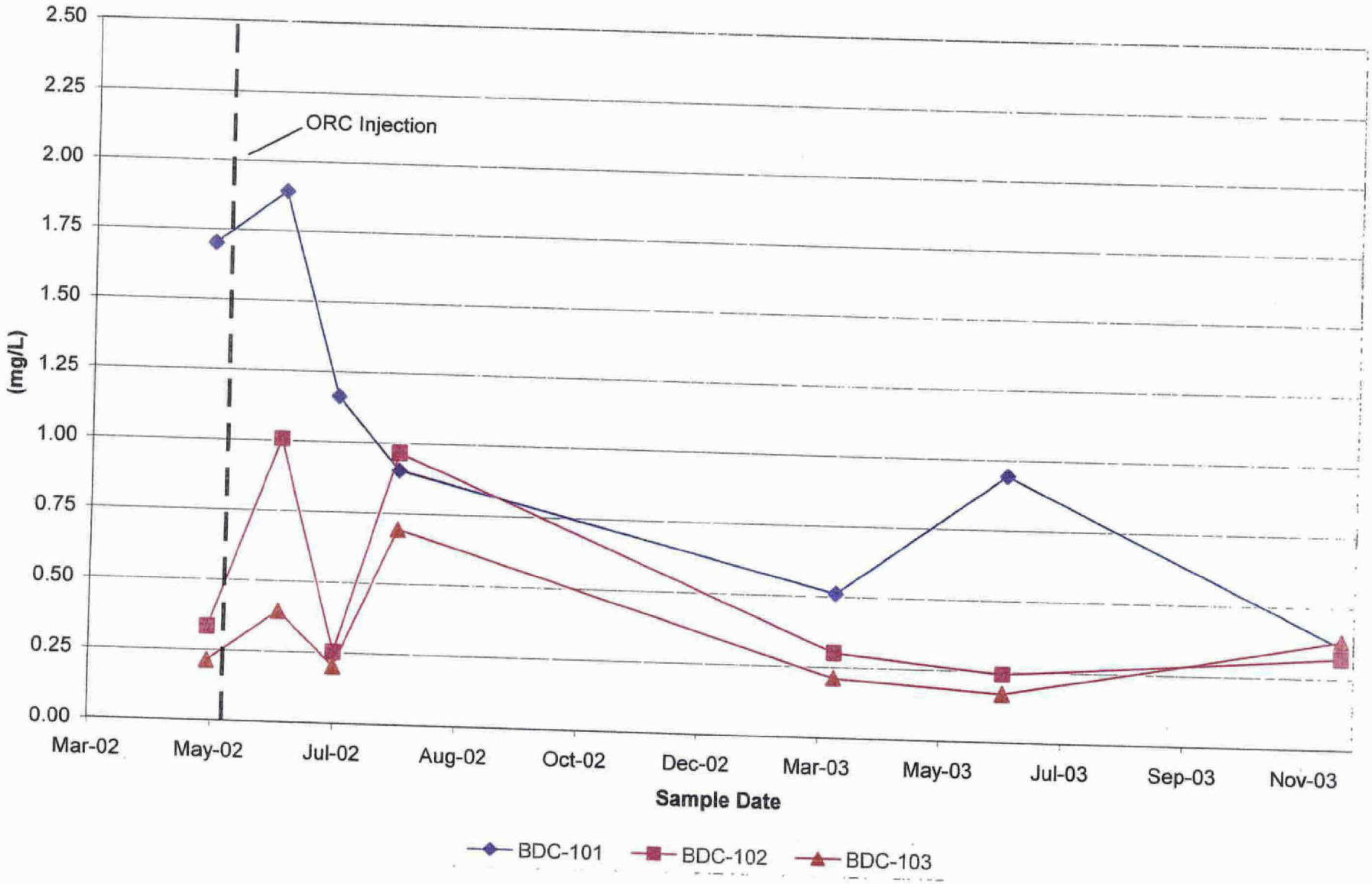


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**AOC-05**
**Dissolved Oxygen Concentrations**

Figure
10

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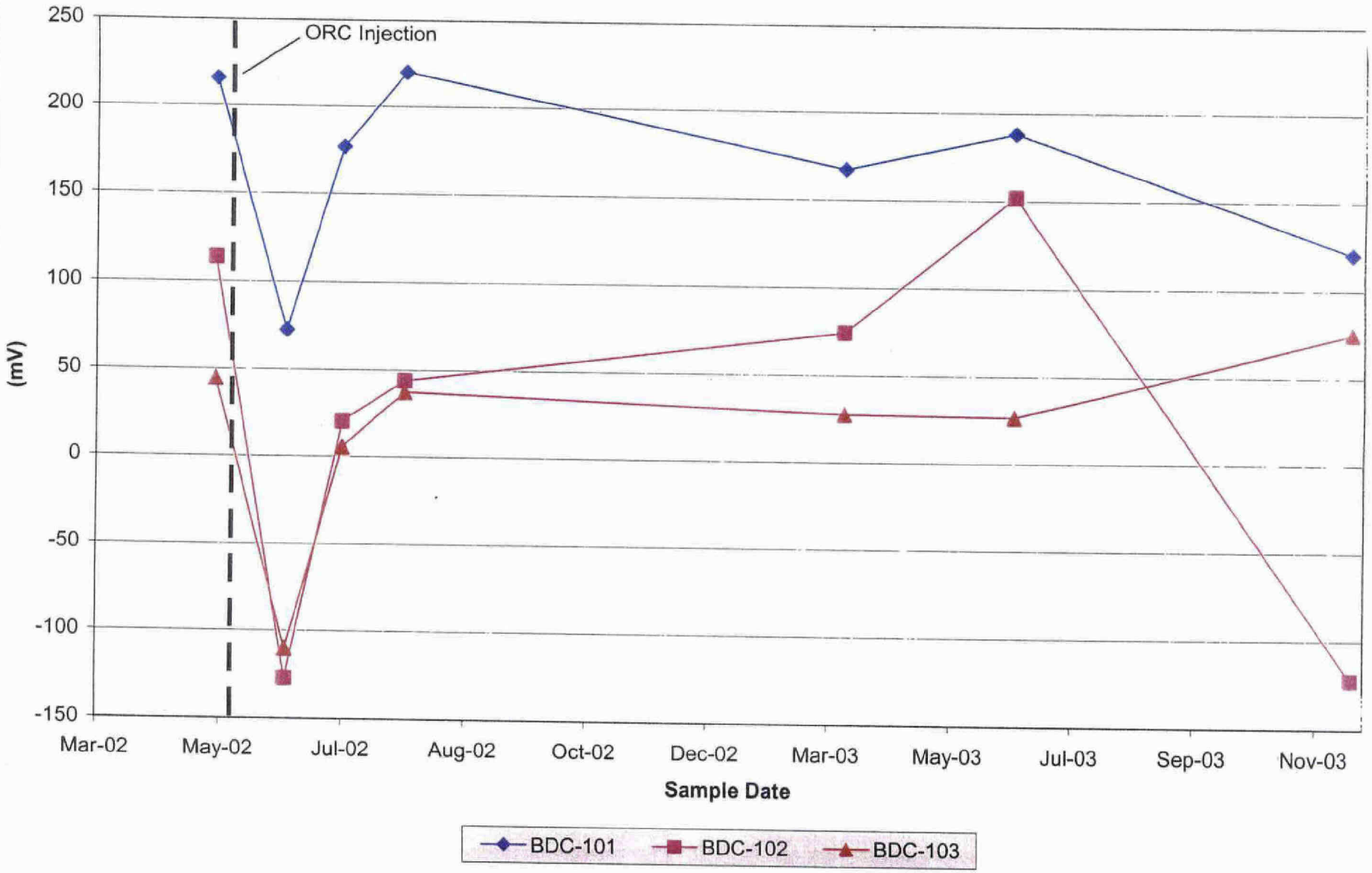


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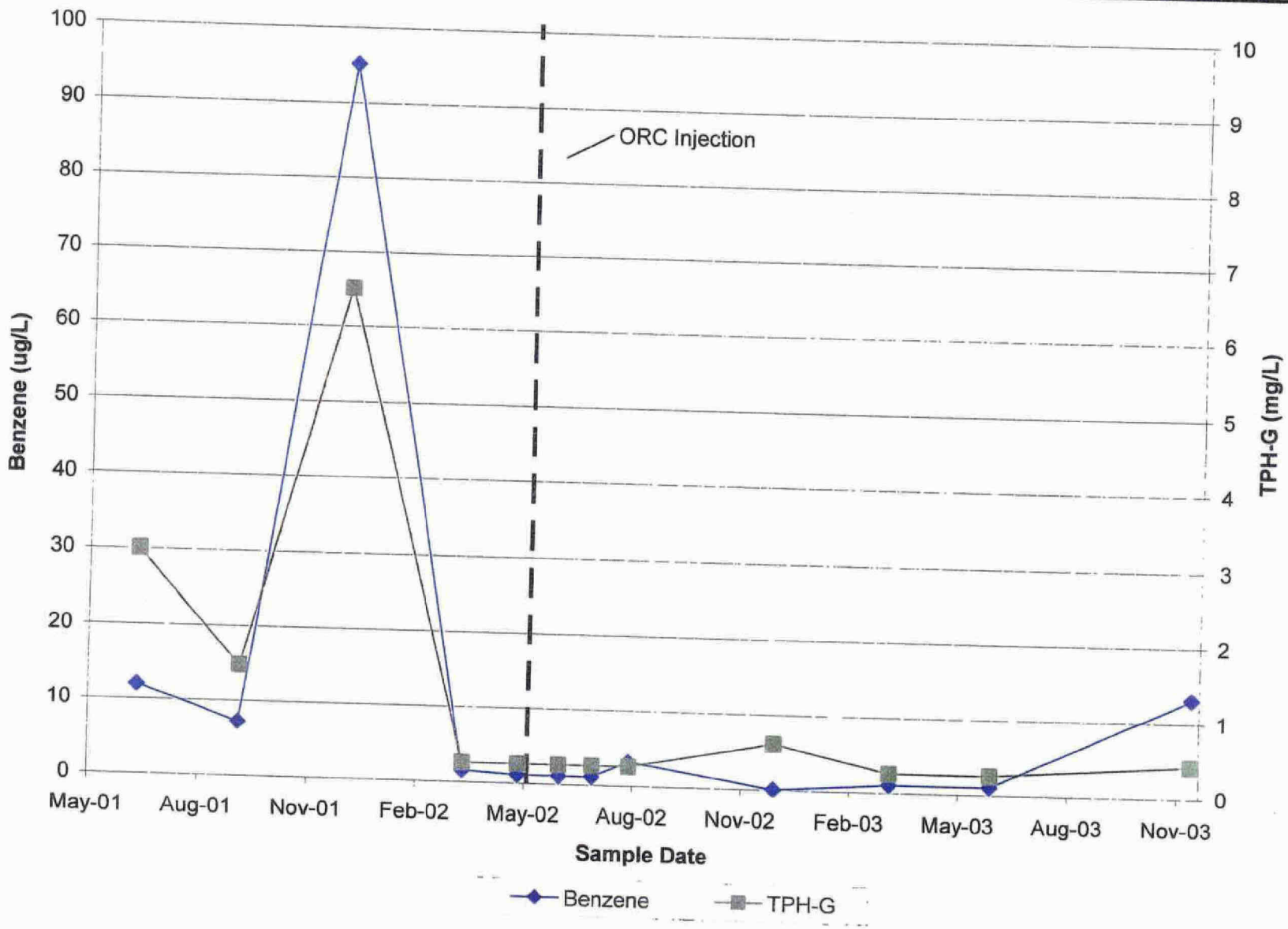
**AOC-05**
**ORP Readings**

Figure
11

Source: S:\Wproc\025\093\040\ORC Inj Eval Rpt GW Tbs.xls BDC-101




DFT 001194

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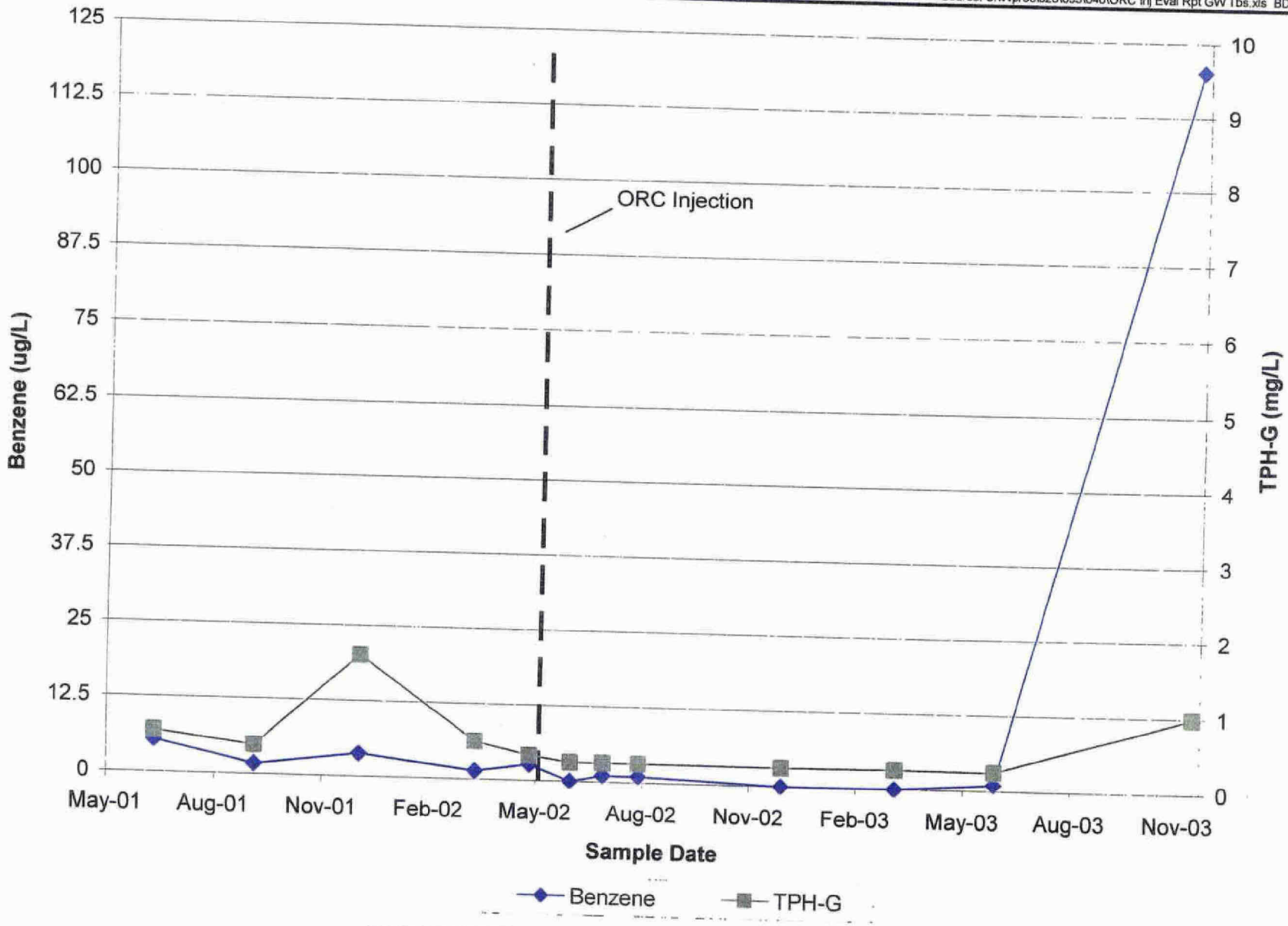
**Well BDC-101**
**TPH-G and Benzene Concentrations**

Figure
12

Source: S:\Wproc\025\093\040\ORC Inj Eval Rpt GW Tbs.xls BDC-102

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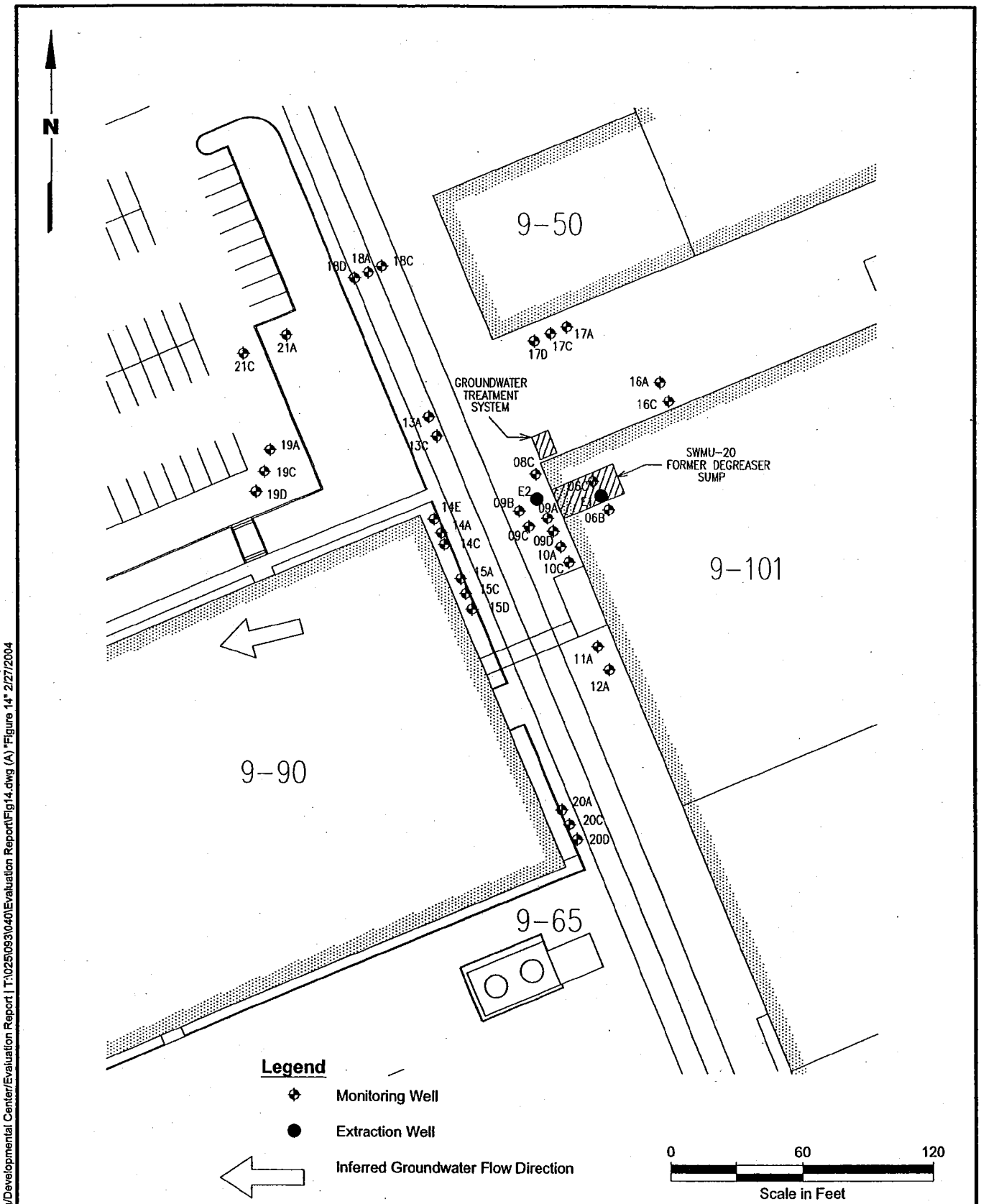
**Well BDC-102**
**TPH-G and Benzene Concentrations**

Figure
13




Boeing/Developmental Center/Evaluation Report | T:\025\093\040\Evaluation Report\Fig14.dwg (A) "Figure 14" 2/27/2004

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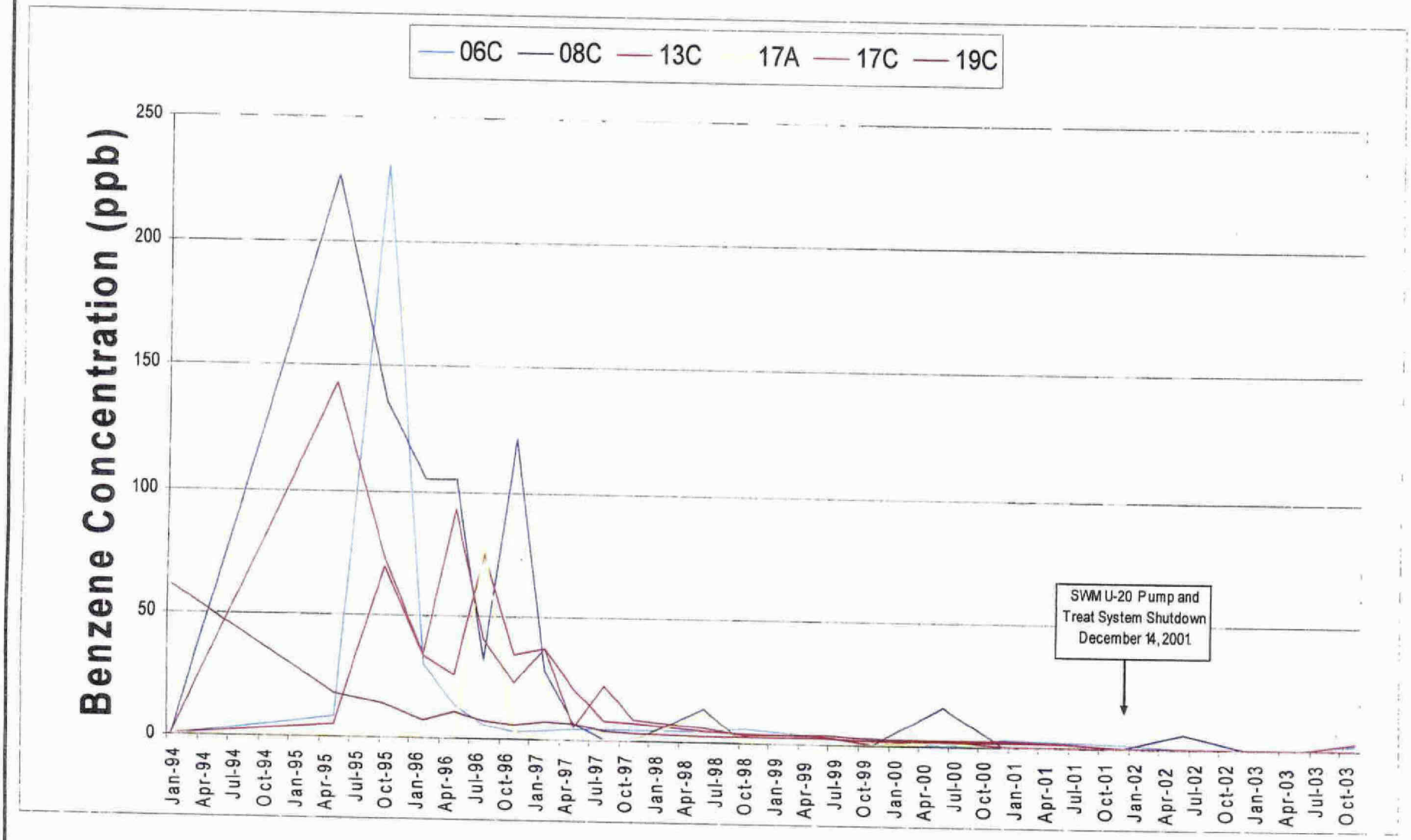
| Boeing Developmental Center<br>Tukwila, Washington | **SWMU-20 Details** | Figure<br>**14** |
|---|---|---|

DFT 001196

Source: S:\Sharedoc\025\093\Nov03 Semiannual Rpt Benzene Chart

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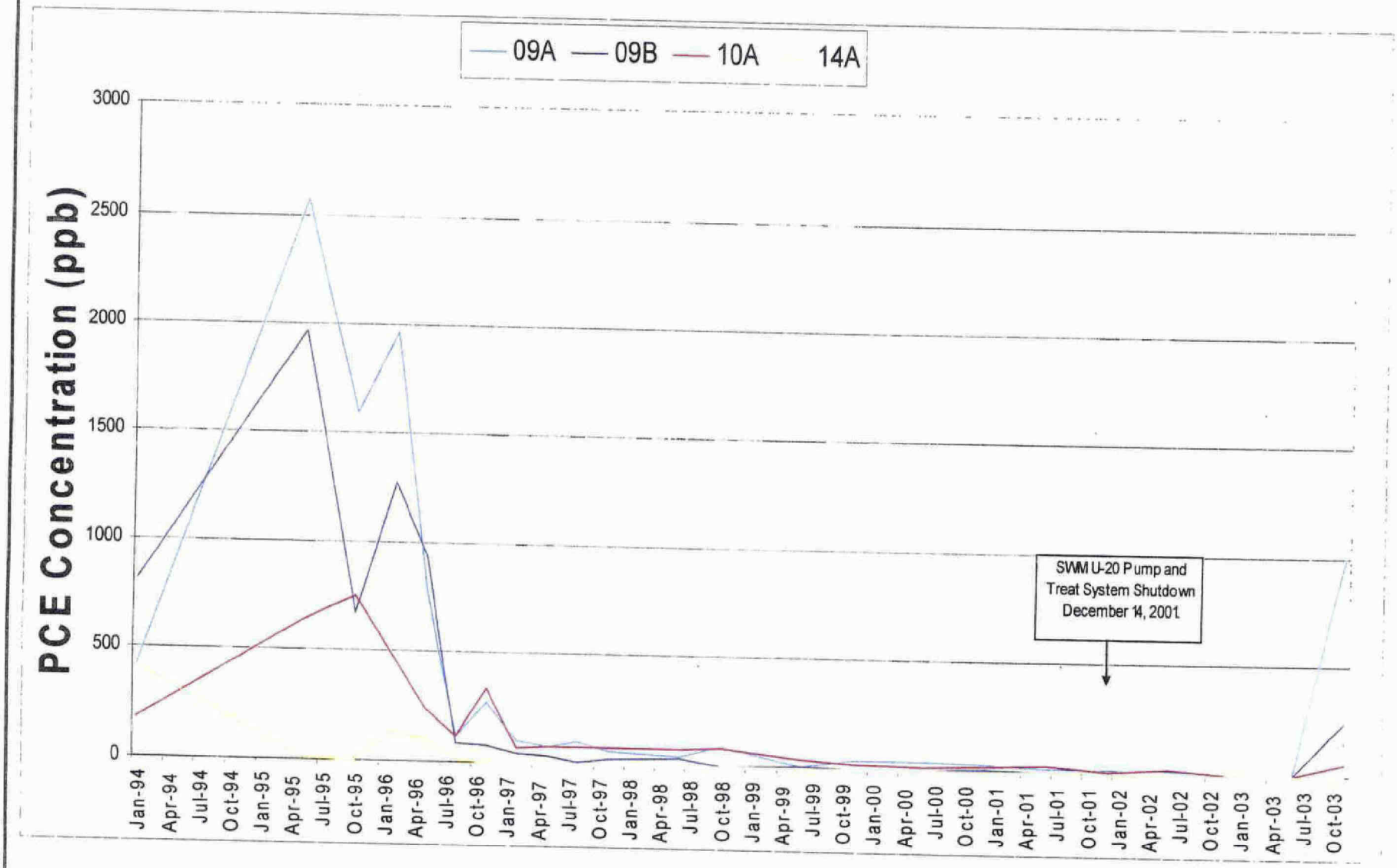
**SWMU-20 Benzene Concentrations**

Figure
15

Source: S:\Sharedoc\025\093\Nov03 Semiannual Rpt PCE Chart

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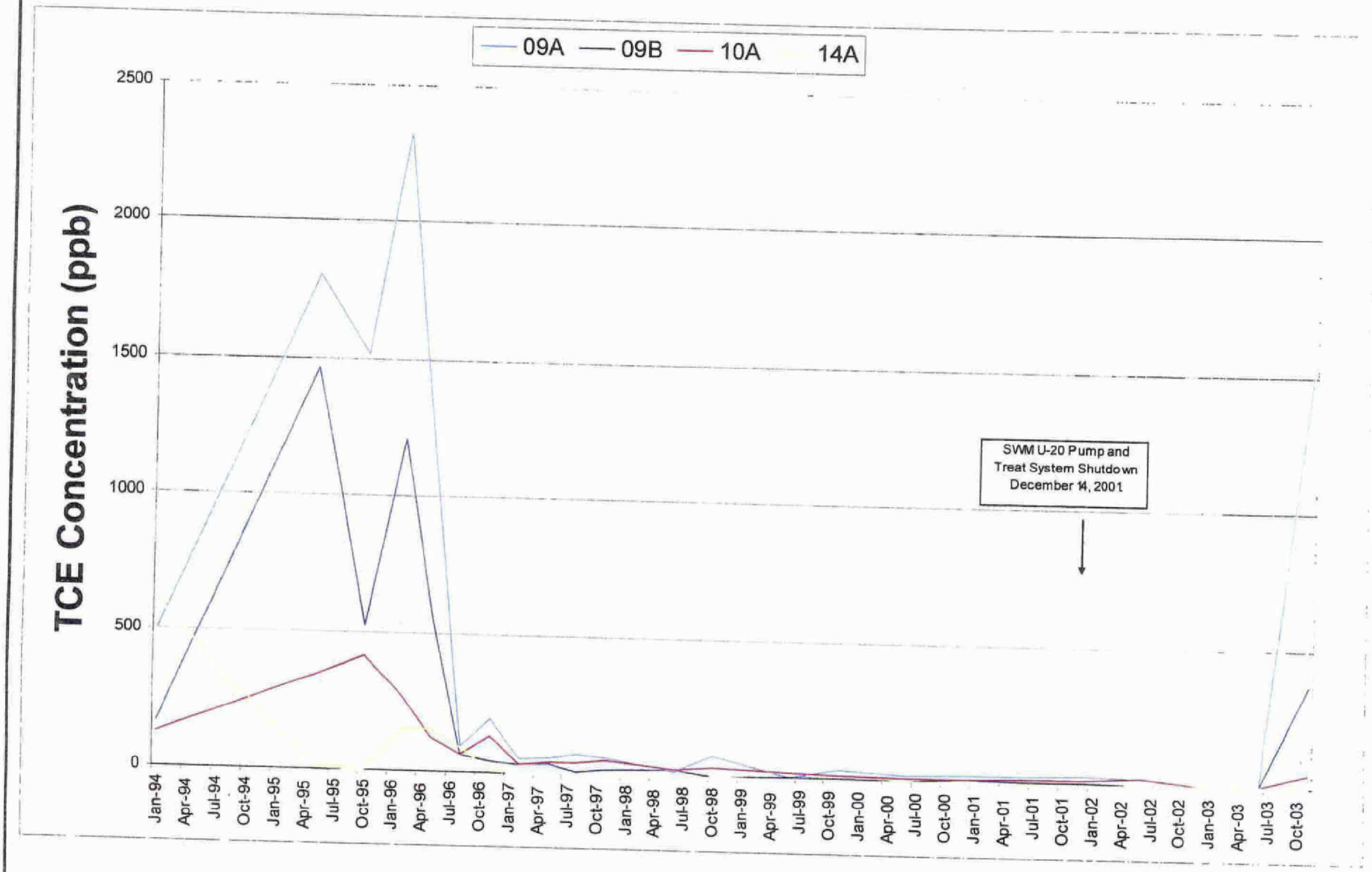
**SWMU-20 PCE Concentrations**

Figure
16

DFT 001198

Source: S:\Sharedoc\025\093\Nov03 Semiannual Rpt TCE Chart

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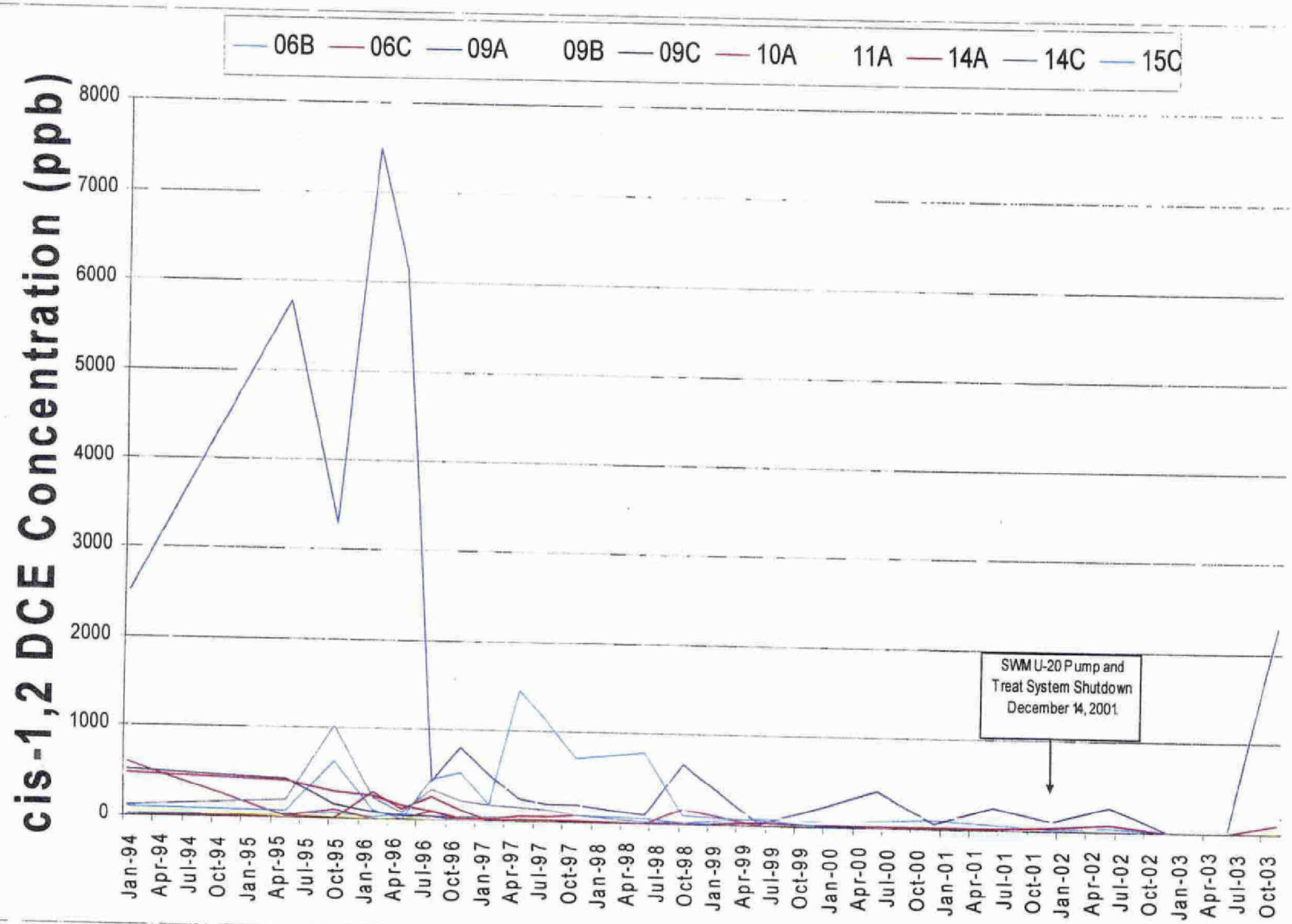
**SWMU-20 TCE Concentrations**

Figure
17

Source: S:\Sharedoc\025\093\Nov03 Semiannual Rpt Cis-1,-DCE Chart




DFT 001200

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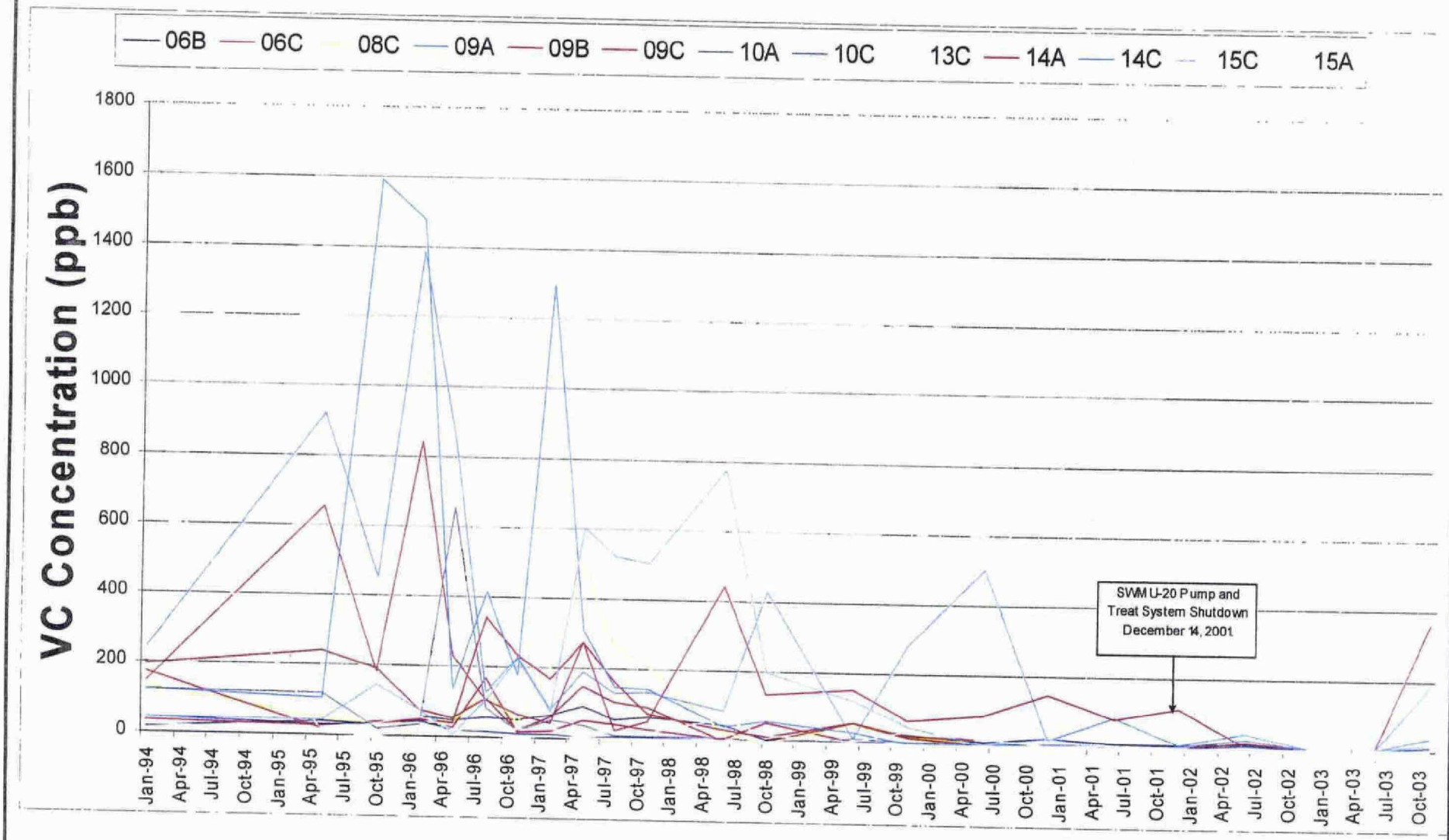
**SWMU-20 Cis-1,2-DCE Concentrations**

Figure 18

Source: S:\Sharedoc\025\093\Nov03 Semiannual Rpt VCChart




DFT 001201

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**SWMU-20 Vinyl Chloride Concentrations**

Figure 19

# TABLE 1
## SWMU-17 SUMMARY OF MONITORING WELLS

| | Method B Preliminary Screening Level Marine Surface Water | Method B Preliminary Screening Level Fresh Surface Water | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|
| **TOTAL ARSENIC (mg/L)** | 0.005 | 0.005 | | | | |
| BDC-05-2 | | | 0.05 U | 0.05 U | 0.001 U | 0.001 U |
| BDC-05-3 | | | 0.05 U | 0.05 U | **0.004** | 0.001 U |
| BDC-05-4 | | | 0.05 U | 0.05 U | **0.011** | **0.018** |
| BDC-05-5 | | | 0.05 U | 0.05 U | **0.002** | **0.001** |
| BDC-05-7 | | | 0.05 U | 0.05 U | **0.002** | 0.001 U |
| **DISSOLVED ARSENIC (mg/L)** | 0.005 | 0.005 | | | | |
| BDC-05-2 | | | 0.05 U | 0.05 U | 0.001 U | 0.001 U |
| BDC-05-3 | | | 0.05 U | 0.05 U | 0.001 U | 0.001 U |
| BDC-05-4 | | | 0.05 U | 0.05 U | 0.001 U | **0.001** |
| BDC-05-5 | | | 0.05 U | 0.05 U | 0.001 U | 0.001 U |
| BDC-05-7 | | | 0.05 U | 0.05 U | 0.001 U | 0.001 U |
| **TOTAL COPPER (mg/L)** | 0.0034 | 0.0089 | | | | |
| BDC-05-2 | | | 0.002 U | **0.002** | **0.002** | 0.002 U |
| BDC-05-3 | | | 0.002 U | **0.003** | **0.004** | **0.002** |
| BDC-05-4 | | | 0.002 U | 0.002 U | 0.002 U | 0.002 U |
| BDC-05-5 | | | **0.003** | **0.004** | **0.004** | **0.003** |
| BDC-05-7 | | | **0.004** | **0.007** | **0.008** | **0.011** |
| **DISSOLVED COPPER (mg/L)** | 0.0034 | 0.0089 (a) | | | | |
| BDC-05-2 | | | 0.002 U | 0.002 U | 0.002 U | 0.002 U |
| BDC-05-3 | | | 0.002 U | 0.002 U | 0.002 U | 0.002 U |
| BDC-05-4 | | | 0.002 U | 0.002 U | 0.002 U | 0.002 U |
| BDC-05-5 | | | 0.002 U | **0.002** | **0.007** | 0.002 U |
| BDC-05-7 | | | **0.003** | **0.004** | **0.004** | **0.005** |
| **TETRACHLOROETHENE (μg/L)** | 9 | 9 | | | | |
| BDC-05-2 | | | **23** | **4.7** | **17** | **6.5** |
| BDC-05-3 | | | **4.1** | **4.4** | **3.3** | **4.5** |
| BDC-05-4 | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| BDC-05-5 | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| BDC-05-7 | | | **13** | **12** | **15** | **20** |

(a) Hardness dependent; hardness assumed to be 75.4 mg/L.
U = Indicates compound was analyzed for, but was not detected at the reported sample detection limit.
Box indicates exceedance of screening level.

DFT 001202

# TABLE 2
## AOC-05 BASELINE GROUNDWATER DATA
## TEMPORARY WELLPOINTS AND INJECTION BORINGS

| | Preliminary Cleanup Levels | GS1-15 EI66H 5/6/2002 | GS2-15 EI66P 5/7/2002 | GS3-15 EI66O 5/7/2002 | ORC1-15 EI66A 5/6/2002 | ORC2-15 EI66B 5/6/2002 | ORC3-15 EI66L 5/7/2002 | ORC4-15 EI66C 5/6/2002 | ORC5-15 EI66D 5/6/2002 |
|---|---|---|---|---|---|---|---|---|---|
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | | | | | |
| Gasoline | 0.8 | 0.25 U | 0.25 U | 0.25 U | 0.25 U | 0.27 | 0.25 U | 1.1 | 0.25 U |
| **BTEX (µg/L)** | | | | | | | | | |
| Benzene | 71 | 1 U | 1 U | 1 U | 6.5 | 1 U | 5.5 | 1 U | 1 U |
| Toluene | 200,000 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Ethylbenzene | 29,000 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1.3 | 1 U |
| m,p-Xylene | NA | 1 U | 1 U | 1 U | 1 U | 13 | 2.2 | 1 U | 1 U |
| o-Xylene | NA | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| Total Xylenes | NA | 2 U | 2 U | 2 U | 2 U | 14 | 3.2 | 2 U | 2 U |
| **Field Parameters** | | | | | | | | | |
| Dissolved Oxygen (mg/L) | NA | 0 | 0 | 0 | -- | 0.99 | 0 | 2.64 | 0 |
| ORP (mV) | NA | 0.8 | 25.5 | 26 | 14.6 | 35.7 | 52.8 | 34.6 | 32.3 |
| Conductivity (uS/cm) | NA | 118 | 481 | 968 | -- | 424 | 244 | 367 | 490 |
| pH | NA | 6.91 | 6.56 | 6.6 | 6.64 | 6.31 | 6.18 | 6.33 | 6.36 |

DFT 001203

# TABLE 3
## AOC-05 BASELINE AND POST-INJECTION GROUNDWATER DATA
## MONITORING WELLS

| | Preliminary Cleanup Levels | Pre-ORC Injection | Post ORC Injection | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | BDC-103 4/29/2002 EH92C | BDC-103 6/3/2002 EK68C | BDC-103 7/1/2002 EN04C | BDC-103 8/1/2002 EP36C | BDC-103 12/2/2002 FA41C | BDC-103 3/10/2003 FH27C | BDC-103 6/3/2003 FN40C | BDC-103 11/19/2003 GB17D |
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | | | | | |
| Gasoline | 0.8 | 200 | 200 | 240 | 270 | 250 | 180 | 220 | 180 |
| **BTEX (µg/L)** | | | | | | | | | |
| Benzene | 71 | 980 | 960 | 1,300 | 4,600 | 1,400 | 780 | 900 | 850 J |
| Toluene | 200,000 | 16,000 | 17,000 | 16,000 | 18,000 | 15,000 | 13,000 | 10,000 | 8,300 J |
| Ethylbenzene | 29,000 | 5,400 | 5,100 | 5,200 | 5,200 | 5,000 | 5,200 | 5,000 | 4,500 J |
| m,p-Xylene | NA | 20,000 | 20,000 | 20,000 | 19,000 | 22,000 | 20,000 | 20,000 | 18,000 J |
| o-Xylene | NA | 7,000 | 7,100 | 6,800 | 6,600 | 6,900 | 6,700 | 6,600 | 5,500 J |
| Total Xylenes | NA | 27,000 | 27,100 | 26,800 | 25,600 | 28,900 | 26,700 | 26,600 | 23,500 J |
| **Conventional Parameters** | | | | | | | | | |
| N-Nitrate (mg-NL) | | | -- | -- | -- | -- | -- | -- | 0.012 |
| Sulfate (mg/L) | | | -- | -- | -- | -- | -- | -- | 53 |
| Methane (µg/L) | | | -- | -- | -- | -- | -- | -- | 630 |
| **Field Parameters** | | | | | | | | | |
| Dissolved Oxygen (mg/L) | NA | 0.21 | 0.39 | 0.20 | 0.69 | 0.33 | 0.21 | 0.17 | 0.38 |
| ORP (mV) | NA | 44.2 | -110.3 | 4.9 | 36.7 | 143.1 | 27 | 26 | -74.6 |
| Conductivity (uS/cm) | NA | 333 | 315 | 343 | 506 | 573 | 320 | 315 | 496 |
| pH | NA | 6.75 | 6.77 | 6.66 | 6.65 | 6.74 | 6.85 | 6.59 | 6.05 |
| Iron(II) (mg/L) | | | -- | -- | -- | -- | -- | -- | 5.5 |

NA = no preliminary cleanup level available.

U = compound was not detected at given detection limit.

J = indicates the analyte was positively identified, and the concentration listed is an estimate.

-- = Not Measured.

Boxed value indicates concentration above preliminary cleanup level.

DFT 001204

# TABLE 4
## AOC-05 PREVIOUS QUARTERLY GROUNDWATER DATA
## MONITORING WELLS

| | Preliminary Cleanup Levels | Previous Data | | | |
|---|---|---|---|---|---|
| | | BDC-101 6/11/2001 | BDC-101 9/4/2001 | BDC-101 12/3/2001 | BDC-101 3/13/2002 |
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | |
| Gasoline | 0.8 | 3 | 5 | 6.5 | 0.25 U |
| **BTEX (µg/L)** | | | | | |
| Benzene | 71 | 11.9 | 7.13 J | 95 | 1.4 |
| Toluene | 200,000 | 1 U | 10.7 | 1.6 | 1 U |
| Ethylbenzene | 29,000 | 113.1 | 50.4 | 750 | 4.4 |
| Total Xylenes | NA | 109.2 | 53.8 | 650 | 2 U |

DFT 001205

# TABLE 4
## AOC-05 PREVIOUS QUARTERLY GROUNDWATER DATA
## MONITORING WELLS

| | Preliminary Cleanup Levels | Previous Data BDC-103 6/11/2001 | BDC-103 9/4/2001 | BDC-103 12/3/2001 | BDC-103 3/13/2002 |
|---|---|---|---|---|---|
| **Total Petroleum Hydrocarbons (mg/L)** | | | | | |
| Gasoline | 0.8 | 177 | 123 | 120 | 200 |
| **BTEX (µg/L)** | | | | | |
| Benzene | 71 | 875 J | 494 J | 5,100 | 1,700 |
| Toluene | 200,000 | 12,010 | 3,760 | 2,300,000 | 17,000 |
| Ethylbenzene | 29,000 | 1,985 J | 419 J | 10,000 | 4,900 |
| Total Xylenes | NA | 11,430 | 2,636 | 3,400,000 | 26,400 |

NA = no preliminary cleanup level available.
U = compound was not detected at given detection limit.
J = indicates the analyte was positively identified, and the concentration listed is an estimate.
Boxed value indicates concentration above preliminary cleanup level.

DFT 001206

# TABLE 5
## SWMU-20 CUMULATIVE BENZENE CONCENTRATIONS
## (Preliminary Screening Level = 71 μg/L)

| | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 06C | ND | 8.64 | 230.09 | 29.96 | 13.7 | 5.6 | 2.9 | 3.4 | 4.6 | 4.1 | 4.2 | 4.2 | 5.7 | 2.8 | 2.7 | <1.00 | 2.76 | 1.94 | 1.7 | <1.0 | <1.0 | <1.0 | 2.2 |
| 08C | ND | 225.74 | 135.58 | 104.73 | 104.6 | 31.8 | 121 | 27.5 | 6.1 | <4.00 | <4.00 | 13.6 | <5.00 | <1.00 | <2.00 | 15.8 | <2.00 | <1.00 | <1.0 | 5.4 | 4.4 | <3.0 | <5.0 |
| 09A | ND | <1.00 | <5.00 | <500.00 | <50.00 | <3.33 | <10.00 | <4.00 | <5.00 | <1.00 | <4.00 | <1.00 | <10.00 | <1.00 | <10.00 | <10.00 | <5.00 | <1.00 | <1.0 | <1.0 | <1.0 | <15 | <20 |
| 09B | ND | 19.76 | <33.30 | <50.00 | <10.00 | 2.5 | <1.00 | <1.00 | 7.5 | 3.1 | 3.3 | <3.33 | <10.00 | <2.00 | <2.00 | <2.00 | <2.00 | <1.00 | 1.2 | <1.0 | <1.0 | <1.0 | <1.0 |
| 09C | ND | <1.00 | <5.00 | <10.00 | <1.00 | 9.6 | 2.4 | 6.3 | 9.3 | 4.8 | 3.6 | 1.7 | 2.5 | 1.7 | <1.00 | 1.5 | 1.36 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 09D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10A | ND | <1.00 | <5.00 | <50.00 | <10.00 | <1.00 | <3.33 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10C | ND | 1.15 | <5.00 | <5.00 | 1.33 | 1.4 | 1.4 | 1.5 | 1.4 | 1.2 | 1.3 | 1.3 | 1.1 | 1.1 | <1.00 | 1.4 | 1.23 | <1.00 | 1.3 | <1.0 | <1.0 | <1.0 | <1.0 |
| 11A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 12A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13C | ND | 4.88 | 69.66 | 33.56 | 25.76 | 75 | 34.1 | 36.5 | 20.5 | 7.6 | 6.8 | 3.9 | 3.3 | 3 | <1.00 | 2 | 2.31 | 1.16 | <1.0 | <1.0 | 3.6 | 6.9 | 2.7 |
| 14A | ND | <1.00 | <5.00 | <20.00 | <1.00 | <10.00 | <5.00 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14C | ND | <1.00 | <5.00 | <5.00 | 26.44 | 22 | 11.7 | <10.00 | <10.00 | <10.00 | 4.3 | 2.8 | 4.64 | 2.5 | 1.2 | 1.4 | 1.33 | <1.00 | <1.0 | <1.0 | 1.1 | <1.0 | <1.0 |
| 14E | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15A | ND | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 | <1.00 | <1.0 | <1.0 | <1.0 | <5.0 | <5.0 |
| 15C | ND | <1.00 | <33.30 | <5.00 | <1.00 | <3.33 | <1.00 | <2.00 | <10.00 | <10.00 | <10.00 | <3.33 | 5.2 | 5.2 | 5.4 | <1.00 | 4.28 | 2.92 | 3.2 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15D | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 2 | <1.00 | 10.9 | 49.8 | 1.6 | 46.03 | 33.88 | 15 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16C | ND | <1.00 | <5.00 | <10.00 | <1.00 | 3.3 | 31.2 | 11.3 | 14.4 | 18.8 | 1.7 | 15 | 8.3 | 10 | 6.4 | 7.8 | 4.33 | 4.99 | 4.5 | 1.7 | 2.6 | 1.2 | 2.8 |
| 17A | ND | <1.00 | <5.00 | <5.00 | <1.00 | 78.8 | 2.7 | <1.00 | <1.00 | <1.00 | <1.00 | 11.2 | <1.00 | <1.00 | <1.00 | 1.5 | <1.00 | NT | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 17C | ND | 142.64 | 73.23 | 34.26 | 92.46 | 40.6 | 22.5 | 36.6 | 4.7 | 21.8 | 8.53 | 5.6 | 2.7 | 3.7 | 2.4 | 2.1 | NT | <1.00 | NT | NT | NT | NT | NT |
| 17D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 18A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 18C | 14 | 8.77 | 5.28 J | <5.00 | 5.79 | 5.4 | 3.1 | 3.6 | 4 | 2.9 | 2.7 | 1.5 | 1.4 | 1.5 | <1.00 | 1.1 | 1.26 | <1.00 | <1.0 | <1.0 | <1.0 | 2.2 | <1.0 |
| 18D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19A | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19C | 61 | 17.57 | 13.44 | 7.14 J | 10.46 | 6.8 | 5.6 | 6.8 | 6.2 | 3.4 | 2.9 | 2.2 | 1.8 | 1.8 | 1.3 | 1.2 | 1.43 | 1.3 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 19D | 3.9 | 3.60 | <5.00 | <5.00 | 2.42 | 2.2 | 1.6 | 1.9 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20C | ND | <1.00 | <5.00 | <5.00 | <1.00 | 1.1 | <1.00 | 1.1 | 1.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | 1.1 | <1.0 |
| 20D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 21A | NT | NT | NT | NT | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |
| 21C | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |

NT = Not Tested.

ND = Not Detected.

J = Indicates the analyte was positively identified, and the concentration listed is an estimate.

Source: S:|Sharedoc\025\093\Nov03 Semiannual Rpt\swmu20_nov03_sum Summary.

DFT 001207

# TABLE 6
## SWMU-20 CUMULATIVE TETRACHLOROETHENE CONCENTRATIONS
## (Preliminary Screening Level = 9 μg/L)

| | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 27 | 5.87 | 14.4 | 9.62 J | 26.18 | 13.7 | 14.3 | 21.5 | 21.3 | 17 | 16.9 | 18.9 | 16.3 | 22.6 | 2.3 | 6 | 10.19 | 2.6 | 2.4 | 10 | 10 | 7.9 | 3.9 |
| 06C | 22 | <1.00 | <10.00 | <10.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 08C | 16 | <1.00 | <5.00 | <5.00 | <3.33 | <10.00 | 13.5 | <5.00 | <4.00 | <4.00 | <4.00 | 7.8 | <5.00 | <1.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.0 | <1.0 | <1.0 | <3.0 | <5.0 |
| 09A | 420 | 2568.3 | 1589 | 1970 | 785.7 | 114 | 272 | 98 | 76 | 96.9 | 56.6 | 39.4 | 94 | 5.1 | 38 | 40 | 36.6 | 12.65 | 16 | 14 | 540 | 1800 | 1000 |
| 09B | 820 | 1972.7 | 668.1 | 1266 | 934.6 | 78.9 | 75.9 | 44.3 | 35 | 10.9 | 21.5 | 31.3 | <10.00 | 6.74 | 3.6 | <2.00 | 6.62 | 1.18 | 2.1 | <1.0 | <1.0 | 1.0 | 250 |
| 09C | ND | 11.32 | <5.00 | <10.00 | 1.24 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 09D | 8.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10A | 180 | 635.8 | 754 E | 468.85 | 242.1 | 114 | 342 | 67.5 | 77.8 | 76.5 | 70.3 | 72.5 | 86.4 | 38 | 21.5 | 16.6 | 21.63 | 30.3 | 11 | 24 | 24 | 34 | 58 |
| 10C | 6.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 11A | 5.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 12A | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13A | 10 | 4.17 | <5.00 | <5.00 | 6.82 | 3 | 2.1 | 3.2 | 2.1 | 1.7 | 1.5 | 1.6 | 1.3 | <1.00 | <1.00 | 1.2 | <1.00 | <1.00 | 1.6 | 2.7 | 2.4 | 3.4 | 3.0 |
| 13C | 5.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14A | 410 | 4.42 | <5.00 | 133.57 | 96.06 | 11.2 | <5.00 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14C | 7.2 | 9.02 | 10.53 | 8.64 J | 5.44 | 6.1 | <1.00 | <10.00 | <10.00 | <10.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14E | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15A | 11 | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 | <1.00 | <1.0 | <1.0 | <1.0 | <5.0 | <5.0 |
| 15C | 13 | <1.00 | <33.30 | <5.00 | <1.00 | 1.1 | <1.00 | <2.00 | <10.00 | <10.00 | <10.00 | <3.33 | <1.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15D | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16A | 1.6 | 1.10 | <5.00 | <5.00 | <1.00 | 1.7 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 | 1.64 | 1.03 | 1.3 | 2.3 | 2.2 | <1.00 | <1.00 | <1.0 | <1.0 | 1.2 | 1.2 | 1.1 |
| 16C | ND | <1.00 | <5.00 | <10.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 17A | 36 | 1.39 | <5.00 | <5.00 | 1.55 | <1.00 | 1.3 | 2.7 | 1.90 J | 2.2 | <1.00 | 2.6 | 2.4 | 2.5 | 2.1 | 2.6 | 4.15 | NT | <1.0 | 3.8 | 4.6 | 4.6 | 4.8 |
| 17C | 36 | <1.00 | <5.00 | <5.00 | <1.00 | 1.6 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 17D | 46 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 18A | 5.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 18C | 4.6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 18D | 4.6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19A | 6 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19C | 6.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 19D | 9.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20A | 3.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20C | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 20D | 4.3 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 21A | NT | NT | NT | NT | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |
| 21C | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |

NT = Not Tested.

ND = Not Detected.

J = Indicates the analyte was positively identified, and the concentration listed is an estimate.

Source: S:|Sharedoc\025\093\Nov03 Semiannual Rpt\swmu20_nov03_sum Summary.

DFT 001208

# TABLE 7
## SWMU-20 CUMULATIVE TRICHLOROETHENE CONCENTRATIONS
### (Preliminary Screening Level = 81 μg/L)

| | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 4.2 | 3.57 | 6.00 J | <5.00 | 7.37 | 3.5 | 2.5 | 4.9 | 4.7 | 4.6 | 6.5 | 3.5 | 2.6 | 4.54 | 2.2 | 4.7 | 8.71 | 5.83 | 4.7 | 5.9 | 4.5 | 2.9 | 1.0 |
| 06C | 1.6 | <1.00 | 31.36 | <10.00 | <1.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 91.6 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 08C | 21 | 3.16 | <5.00 | <5.00 | <3.33 | <10.00 | 26.2 | <5.00 | <4.00 | <4.00 | <4.00 | 26.6 | <5.00 | <1.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.0 | <1.0 | <1.0 | <3.0 | <5.0 |
| 09A | 500 | 1796.5 | 1507 | 2318 | 1160 | 90.8 | 191 | 49.3 | 51.1 | 69.2 | 56.4 | 15.4 | 77 | 3.5 | 35 | 23 | 24.3 | 25.21 | 32 | 24 | 580 | 990 | 1500 |
| 09B | 160 | 1463 | 524.7 | 1206 | 554 | 58.6 | 35.2 | 28.7 | 31.5 | 4.9 | 15.4 | 20.65 | <10.00 | 7.5 | 4.8 | 2.6 | 11.2 | 5.79 | 4.8 | 2.5 | 12 | 9.7 | 370 |
| 09C | ND | 19.41 | <5.00 | <10.00 | 3.54 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 09D | 2.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10A | 120 | 333.23 | 411 E | 268.41 | 115.3 | 56.7 | 128 | 28.4 | 38.2 | 36.6 | 48.8 | 23.8 | 33.9 | 19.2 | 14 | 8.3 | 13.11 | 17.02 | 18 | 24 | 29 | 32 | 49 |
| 10C | 3.9 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 11A | 7 | 2.41 | <5.00 | <5.00 | 2.54 | 1.9 | 1 | <1.00 | <1.00 | 1.2 | 1.6 | <1.00 | 1.03 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | 1.9 | 2.2 | 2.2 | 2.8 |
| 12A | 5.5 | 1.13 | <5.00 | <5.00 | <1.00 | 1.7 | 1.2 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13A | 31 | 12.23 | <5.00 | 9.57 J | 16.52 | 3.4 | 3.4 | 2 | 1.5 | 2.9 | 3 | 1.1 | 1.7 | 1.8 | 2.3 | 2.4 | 2.12 | 1.28 | <1.0 | 3.4 | 3.3 | 3.9 | 3.8 |
| 13C | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14A | 600 | 6.25 | <5.00 | 151.58 | 146.72 | 84.1 | 2.8 | <4.00 | <2.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14C | 6.6 | 14.41 | 21.93 | 13.33 | 7.61 | 12.5 | <1.00 | <10.00 | <10.00 | <10.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 14E | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15A | 7.5 | <1.00 | <5.00 | <5.00 | <5.00 | <2.00 | <1.00 | <4.00 | <2.00 | <1.00 | <2.00 | <3.33 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 | <1.00 | <1.0 | <1.0 | <1.0 | <5.0 | <5.0 |
| 15C | 12 | <1.00 | <33.30 | <5.00 | <1.00 | 7.5 | <1.00 | <2.00 | 12 | <10.00 | <10.00 | <3.33 | <1.00 | <2.00 | <2.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15D | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16A | 4.4 | 5.02 | <5.00 | <5.00 | 2.57 | 4 | 2.1 | 2.6 | 2 | 1.9 | <1.00 | <1.00 | <1.00 | 1.01 | 1.4 | 1.2 | 1.08 | <1.00 | <1.0 | <1.0 | 1.5 | 1.3 | 1.2 |
| 16C | ND | <1.00 | <5.00 | <10.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 17A | 7.2 | 17.42 | 17.04 | <5.00 | 7.28 | <1.00 | 9.8 | 17.5 | 4.9 | 18 | 2 | <1.00 | 12.4 | 11.1 | 11.5 | 6.6 | 13.99 | nt | 5.9 | 7.4 | 7.5 | 7.4 | 7.9 |
| 17C | 2.1 | <1.00 | <5.00 | <5.00 | <1.00 | 14.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 17D | 2.3 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 18A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 18C | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 18D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19A | 1.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT. | NT | NT |
| 19C | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 19D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20A | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20C | 1.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 20D | 1.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 21A | NT | NT | NT | NT | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |
| 21C | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |

NT = Not Tested.

ND = Not Detected.

J = Indicates the analyte was positively identified, and the concentration listed is an estimate.

Source: S:|Sharedoc\025\093\Nov03 Semiannual Rpt\swmu20_nov03_sum Summary.

DFT 001209

# TABLE 8
## SWMU-20 CUMULATIVE CIS-1,2-DICHLOROETHENE CONCENTRATIONS
## (No Preliminary Screening Level)

| | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 23 | 43.71 | 53.75 | 29.45 | 58.31 | 46.3 | 30.5 | 37.4 | 60.9 | 61.8 | 76.4 | 66.7 | 9.9 | 70.1 | 49.7 | 71.5 | 91.77 | 63.94 | 27 | 40 | 23 | 13 | 11 |
| 06C | 7.9 | 14.57 | 99.09 | <10.00 | 1.01 | 107 | 1.9 | 3.1 | 22.1 | 28.3 | 12.3 | 1.1 | 181 E | <2.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 08C | 44 | 14.95 | <5.00 | 5.55 J | 8 | 1.1 | 37.6 | <5.00 | 37.3 | 46.1 | 42.3 | 38.4 | <5.00 | 1.1 | <2.00 | 3.2 | <2.00 | <1.00 | <1.0 | <1.0 | <1.0 | <3.0 | <5.0 |
| 09A | 2500 | 5790.9 | 3286 | 7484 | 6143 | 443 | 816 | 520 | 258 | 206.E | 199 | 94.3 | 680 | 15.5 | 187 | 421 | 60.75 | 266.6 | 100 | 280 | 1600 | 2300 | 2300 |
| 09B | 940 | 5010.4 | 1307 E | 3407 E | 1521 | 207 | 142 | 164 E | 510 | 35.1 | 111 | 939 E | 178 | 122.04 | 41.2 | 102.4 | 135.2 | 112.3 | 100 | <180 | 180 | 140 | 850 |
| 09C | 520 | 431.66 | 159.69 | 70 | 33.67 | 29.8 | 1.6 | 4.6 | 2.6 | 2 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | 6.7 | 2.7 | 4.1 | 8.9 |
| 09D | 5.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10A | 470 | 421.26 | 297 E | 249.16 | 159.2 | 90.1 | 17.8 | 29 | 66.1 | 58.5 | 74.1 | 29.3 | 6.9 | 33.3 | 20.6 | 10.6 | 14.14 | 14.09 | 36 | 80 | 110 | 88 | 98 |
| 10C | 14 | 1.93 | <5.00 | <5.00 | 1.01 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | 3.7 | 3.3 | 14 | 6.2 |
| 11A | 54 | 15.86 | 10.82 | 7.17 J | 10.27 | 9.3 | 6.4 | 4.9 | 6.6 | 6.1 | 4.2 | 2.8 | 2.3 | 2.1 | 1.1 | 1.5 | 1.55 | 1.27 | 2.1 | 6.0 | 12 | 17 | 18 |
| 12A | 20 | 2.30 | 17.5 | <5.00 | 1.09 | 9.5 | 6.6 | <1.00 | 6.1 | 3.7 | 3 | 1.7 | 1.7 | 1.8 | 1.03 | 1.9 | 2.07 | 1.46 | 2.2 | 1.8 | 3.3 | 1.4 | 4 |
| 13A | 8.2 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.6 | <1.00 | <1.00 | 1.2 | 1.3 | 1.2 | 1.2 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13C | 16 | 1.14 | <5.00 | <5.00 | <1.00 | 1.3 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | 1.4 | <1.0 |
| 14A | 590 | 15.50 | 9.83 J | 294.36 | 115.94 | 249 | 114 | 6.4 | 24.2 | 18.3 | 9.5 | 4.9 | 3.7 | 7 | 3.2 | 3.8 | <1.00 | <1.00 | <1.0 | <1.0 | 7.2 | 23 | 170 |
| 14C | 110 | 187.91 | 1017.8 | 237.4 | 70.06 | 326 | 211 | 183 | 163 | 136 | 82.7 | 25.6 | 21.7 | 6.2 | <1.00 | 1.2 | 2.83 | 1.64 | <1.0 | 1.5 | 2.4 | 31 | 13 |
| 14E | 1.1 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15A | 9.1 | 3.29 | <5.00 | <5.00 | <5.00 | 3.6 | 3.5 | 4.5 | 5 | 5.5 | 5.5 | 15.65 | <10.00 | <1.00 | <10.00 | <10.00 | <10.00 | 4.99 | 4.9 | 2.8 | 2.8 | <5.0 | <5.0 |
| 15C | 92 | 69.14 | 640.52 | 93.62 | 1.47 | 463 | 532 | 187 | 1470 | 1100 | 719 | 785 E | 90.5 | 53.2 | 28.4 | 1.01 | 2.53 | <1.00 | 1.1 | <1.0 | <1.0 | 2.9 | 5.7 |
| 15D | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16A | 5.5 | 12.63 | 5.38 J | <5.00 | 25.39 | 12 | 3.2 | 6.2 | 2.4 | 1.7 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.76 | 1.82 | 2.6 | <1.0 | 1.2 | 2.4 | 1.3 |
| 16C | 14 | 11.83 | 6.24 J | <10.00 | 5.66 | 2.6 | 1.6 | 1.6 | 1.13 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 17A | 4.3 | 1.38 | <5.00 | <5.00 | 1.09 | <1.00 | 1.4 | 1.2 | 2.90 J | 4.13 | <1.00 | 2.3 | 3.8 | 4.1 | 4.3 | 2.3 | 2.1 | NT | 2 | <1.0 | 1.0 | 1.4 | 1.6 |
| 17C | 5.3 | <1.00 | <5.00 | <5.00 | 1.19 | 1.6 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 17D | 1.8 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 18A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 18C | 1.3 | 2.02 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | 1.8 | 2.8 | 1.9 | 2.1 | 1.3 | 1.59 | 1.42 | <1.0 | <1.0 | <1.0 | 1.7 | <1.0 |
| 18D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19A | 2.4 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19C | 1.7 | 1.17 | <5.00 | <5.00 | 1.37 | 1.3 | <1.00 | <1.00 | 1.2 | 1.2 | 1.2 | 2 | 1.2 | 1.4 | <1.00 | 1.03 | <1.00 | 1.01 | <1.0 | <1.0 | <1.0 | <1.0 | 1 |
| 19D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20C | 16 | 7.34 | 6.06 J | <5.00 | 2.46 | 2.5 | 2.1 | 1.9 | 1.6 | <1.00 | <1.00 | <1.00 | 1.5 | <1.00 | <1.00 | 1.3 | <1.00 | 1.09 | 1.1 | <1.0 | 1.3 | 2.1 | 1.6 |
| 20D | 1.8 | 2.22 | <5.00 | <5.00 | 46.38 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 21A | NT | NT | NT | NT | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |
| 21C | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.0 | <1.0 | 1.3 | NT | NT |

NT = Not Tested.

ND = Not Detected.

J = Indicates the analyte was positively identified, and the concentration listed is an estimate.

Source: S:|Sharedoc\025\093\Nov03 Semiannual Rpt\swmu20_nov03_sum Summary.

DFT 001210

# TABLE 9
## SWMU-30 CUMULATIVE VINYL CHLORIDE CONCENTRATIONS
## (Preliminary Screening Level = 525 μg/L)

| | Jan-94 | May-95 | Oct-95 | Feb-96 | May-96 | Aug-96 | Nov-96 | Feb-97 | May-97 | Aug-97 | Nov-97 | Jun-98 | Oct-98 | Jun-99 | Nov-99 | Jun-00 | Dec-00 | Jun-01 | Dec-01 | Jun-02 | Dec-02 | Jun-03 | Nov-03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06B | 13 | 36.53 | 31.8 | 52.29 | 44.78 | 54.5 | 49.4 | 63.7 | 88.7 | 55 | 62.7 | 46.3 | 4.2 | 48.4 | 25.9 | 8 | 21.58 | 10.62 | 8.9 | 12 | 11 | 8.4 | 17 |
| 06C | 30 | 20.89 | 34.09 | 38.34 | 22.06 | 164 | 12 | 18.3 | 50.3 | 39.5 | 26.1 | 6 | 54.6 | 4.4 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 08C | 130 | 42.13 | 32.69 | 35.33 | 35.96 | 129 | 41.2 | 201 | 488 | 256 | 210 | 20.6 | <5.00 | 49.7 | 21.4 | 2.4 | <2.00 | <1.00 | <1.0 | <1.0 | <1.0 | <3.0 | <5.0 |
| 09A | 240 | 917.05 | 449 | 1385 | 844.9 | 124 | 228 | 80.9 | 185 | 127 | 135 | 83.8 | 425 | 14 | 278 | 499 | 17.95 | 86.44 | 7.8 | 46 | 150 | 120 | 180 |
| 09B | 140 | 648.6 | 175.6 | 836 | 228.2 | 104 | 62.6 | 41.7 | 270 | 20.9 | 50.7 | 439.56 | 132 | 152.36 | 66.6 | 82.6 | 146.7 | 78.9 | 110 | 7.6 | 27 | 19 | 360 |
| 09C | 190 | 233.79 | 185 E | 71.74 | 50.13 | 106 | 19.4 | 59.8 | 147 | 102.5 | 87.8 | 1.1 | <1.00 | 59 | 16.4 | <1.00 | <1.00 | <1.00 | <1.0 | 18 | 8.6 | 5.6 | 8.0 |
| 09D | ND | 1.37 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 10A | 120 | 116.25 | 16.12 | 31.6 | 651.2 | 80.9 | 16.7 | 48.2 | 33.4 | 9.8 | 8.8 | 8.7 | 1.3 | 12.1 | 3.5 | 3 | 3.32 | 3.32 | 2.9 | 28 | 54 | 36 | 9.1 |
| 10C | 39 | 28.29 | 33.16 | 40.41 | 18.69 | 11.6 | 10.1 | 9 | <1.00 | 4.3 | 3.8 | 1.7 | 1.6 | 2.8 | 1.4 | 2.1 | <1.00 | <1.00 | <1.0 | 8.4 | 15 | 15 | 8.8 |
| 11A | 39 | 26.80 | 8.37 J | 12.14 | 14.04 | 3.8 | 1.8 | <1.00 | <1.00 | <1.00 | 3.4 | <1.00 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 12A | 14 | <1.00 | 17.16 | <5.00 | <1.00 | 2.9 | 8.6 | <1.00 | 9.4 | 6.7 | 1.1 | 1.3 | <1.00 | 2.7 | 1.06 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13A | 12 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 13C | 760 | 3.03 | <5.00 | 15.24 | 11.48 | 3.6 | 1.9 | 2.5 | 2.2 | <1.00 | <1.00 | 1 | 1.6 | 1.8 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | 1.6 | 3.3 | 4.9 | 2.2 |
| 14A | 170 | 11.38 | 30.32 | 44.4 | 36.4 | 339 | 232 | 162 | 270 | 158 | 70 | 29.1 | 13.74 | 58.2 | 20.9 | 19.7 | <1.00 | <1.00 | <1.0 | <1.0 | 69 | 28 | 240 |
| 14C | 120 | 103.49 | 1587.3 | 1477 | 134.78 | 414 | 175 | 1296 | 307 | 148 | 144 | 39.4 | 56.4 | 30.2 | <1.00 | <1.00 | 4.67 | 1.21 | <1.0 | <1.0 | 4.4 | 50 | 35 |
| 14E | 10 | 1.43 | <5.00 | <5.00 | <1.00 | 1.3 | <1.00 | <1.00 | 1.3 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 15A | 16 | 13.84 | 31.2 | 54.62 | 19.45 | 19.4 | 23 | 20.4 | 23.5 | 17.4 | 18.6 | 61.61 | 17.2 | 2.9 | 37 | 16 | <10.00 | 3.86 | 1.8 | 2.0 | 3.3 | <5.0 | <5.0 |
| 15C | 38 | 38.79 | 142.38 | 69.81 | 5.12 | 104 | 220 | 69 | 598 | 519 | 500 | 772 E | 194 E | 121.2 | 49.2 | 1.4 | 21.32 | <1.00 | 1.5 | <1.0 | 1.3 | 5.6 | 16 |
| 15D | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | 8.6 | 5.2 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16A | 6 | 9.18 | <5.00 | <5.00 | 8.42 | 4.4 | <1.00 | <1.00 | 2.2 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 16C | 15 | 23.46 | 38.59 | 45.16 | 31.71 | 20.8 | 11.8 | 11.3 | 9.1 | 3 | <1.00 | 1.4 | <1.00 | 1.9 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | 1.4 | 3.8 | 2.6 |
| 17A | ND | <1.00 | <5.00 | <5.00 | <1.00 | 1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 17C | 10 | 2.32 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 17D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | <1.00 | NT | NT | NT | NT | NT |
| 18A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 18C | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | 1.1 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 18D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 19C | 5.5 | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| 19D | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20A | ND | <1.00 | <5.00 | <5.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 20C | 47 | 20.12 | 12.63 | 13.77 | 8.32 | 6.7 | 3.4 | 3.3 | 3.4 | <1.00 | <1.00 | 1.6 | 1.8 | <1.00 | 1.9 | <1.00 | 1.06 | <1.00 | <1.0 | 1.4 | 2.7 | 4.0 | 3.1 |
| 20D | ND | 6.98 | <5.00 | <5.00 | 31.12 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | NT | NT | NT | NT | NT |
| 21A | NT | NT | NT | NT | <1.00 | | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.0 | <1.0 | <1.0 | NT | NT |
| 21C | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT | <1.00 | <1.0 | <1.0 | <1.0 | nt | nt |

NT = Not Tested.

ND = Not Detected.

J = Indicates the analyte was positively identified, and the concentration listed is an estimate.

Source: S:|Sharedoc\025\093\Nov03 Semiannual Rpt\swmu20_nov03_sum Summary.

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# TABLE 10
## VAPOR INTRUSION MODELING RESULTS BASED ON CONSERVATIVE ASSUMPTIONS FOR BUILDINGS 9-90 AND 9-101 BOEING DEVELOPMENTAL CENTER

Groundwater Concentrations (ug/L)

| Location | Date | PCE | TCE | cis-1,2-DCE | Vinyl Chloride | Naphthalene |
|---|---|---|---|---|---|---|
| 09A | Jun-03 | 1800 | 990 | 2300 | 120 | 75 U |
| 09A | Nov-03 | 1000 | 1500 | 2300 | 180 | 1 U |
| 10A | Jun-03 | 34 | 32 | 88 | 36 | 5 U |
| 10A | Nov-03 | 58 | 49 | 98 | 9.1 | 5 U |
| 11A | Jun-03 | 1 U | 2.2 | 17 | 1 U | 5 U |
| 11A | Nov-03 | 1 U | 2.8 | 18 | 1 U | 5 U |
| 12A | Jun-03 | 1 U | 1 U | 1.4 | 1 U | 5 U |
| 12A | Nov-03 | 1 U | 1 U | 4 | 1 U | 5 U |
| 13A | Jun-03 | 3.4 | 3.9 | 1 U | 1 U | 5 U |
| 13A | Nov-03 | 3 | 3.8 | 1 U | 1 U | 5 U |
| 14A | Jun-03 | 1 U | 1 U | 23 | 28 | 5 U |
| 14A | Nov-03 | 1 U | 1 U | 170 | 240 | 5 U |
| 15A | Jun-03 | 5 U | 5 U | 5 U | 5 U | 370 |
| 15A | Nov-03 | 5 U | 5 U | 5 U | 5 U | 490 |
| 16A | Jun-03 | 1.2 | 1.3 | 2.4 | 1 U | 5 U |
| 16A | Nov-03 | 1.1 | 1.2 | 1.3 | 1 U | 5 U |
| 17A | Jun-03 | 4.6 | 7.4 | 1.4 | 1 U | 5 U |
| 17A | Nov-03 | 4.8 | 7.9 | 1.6 | 1 U | 5 U |
| 18A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 18A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 19A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 1.54 |
| 19A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 20A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 5.48 |
| 20A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 21A | Jun-02 | 1 U | 1 U | 1 U | 1 U | 5 U |
| 21A | Dec-02 | 1 U | 1 U | 1 U | 1 U | 5 U |
| Distribution (assumed): | | Lognormal | Lognormal | Lognormal | Lognormal | Lognormal |
| Number of Samples: | | 26 | 26 | 26 | 26 | 26 |
| Frequency of Detection: | | 38% | 46% | 54% | 23% | 15% |
| Maximum Detection: | | 1800 | 1500 | 2300 | 240 | 490 |
| Mean: | | 112.85 | 100.90 | 194.08 | 24.66 | 39.50 |
| Standard Deviation: | | 395.65 | 344.62 | 621.23 | 60.27 | 117.05 |
| Mean (log-transformed data): | | 1.19 | 1.30 | 1.75 | 1.07 | 1.70 |
| Std Deviation (log-transformed data): | | 2.09 | 2.03 | 2.39 | 1.84 | 1.56 |
| Geometric Mean: | | 3.28 | 3.67 | 5.74 | 2.91 | 5.50 |
| t-statistic (normal dist only) : | | | | | | |
| H-statistic: | | 4.11 | 4.03 | 4.60 | 3.71 | 3.29 |
| UCL95: | | 161 | 148 | 894 | 61 | 52 |
| Exposure Point Concentration: | | 161 | 148 | 894 | 61 | 52 |
| | | | | | | Cumulative Health Risk Indices |
| Building 9-90 Risk Summary: | | | | | | |
| Indoor Air Excess Cancer Risk: | | -- | -- | -- | 1E-06 | -- | 1E-06 |
| Indoor Air Hazard Quotient: | | -- | -- | -- | 4E-03 | -- | 4E-03 |
| Building 9-101 Risk Summary: | | | | | | |
| Indoor Air Excess Cancer Risk: | | 2E-07 | 4E-06 | -- | 6E-07 | -- | 5E-06 |
| Indoor Air Hazard Quotient: | | -- | 2E-03 | 7E-03 | 2E-03 | 5E-04 | 1E-02 |

U = compound was not detected at given detection limit.
-- = Not Measured.

Notes:
1. Groundwater concentrations shown in bold are those that were detected at or above the laboratory reporting limit.
2. Shaded cells identify carcinogenic risk exceeding acceptable levels for a single substance (1E-06) or multiple substances (1E-05) or noncarcinogenic risk exceeding acceptable levels for a single substance (hazard quotient less than or equal to 1) or multiple substances (hazard index less than or equal to 1).
3. Groundwater concentrations represented in this table include Zone A data collected from the most recent available year of sampling events. In most cases, this data was collected in June and November of 2003. In some cases (i.e., wells 18A, 19A, 20A, and 21A), semiannual sampling has been discontinued due to a history of nondetect sample results. The most recent year of available data (i.e., semiannual data from 2001 or 2002) was used to characterize groundwater quality at these wells.
4. Vapor intrusion modeling for Building 9-90 evaluated for vinyl choride only based on lack of detection of other VOCs at monitoring wells adjacent to Building 9-90.

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# TABLE 11
## SIMULATED VAPOR INTRUSION MODELING RESULTS BASED ON MORE REALISTIC ASSUMPTIONS FOR BUILDING 9-101 BOEING DEVELOPMENTAL CENTER

Groundwater Concentrations (ug/L)

| Location | Date | PCE | TCE | cis-1,2-DCE | Vinyl Chloride | Naphthalene |
|---|---|---|---|---|---|---|
| 09A | Jun-03 | 1800 | 990 | 2300 | 120 | 75 U |
| 09A | Nov-03 | 1000 | 1500 | 2300 | 180 | 1 U |
| 10A | Jun-03 | 34 | 32 | 88 | 36 | 5 U |
| 10A | Nov-03 | 58 | 49 | 98 | 9.1 | 5 U |
| 11A | Jun-03 | 1 U | 2.2 | 17 | 1 U | 5 U |
| 11A | Nov-03 | 1 U | 2.8 | 18 | 1 U | 5 U |
| 12A | Jun-03 | 1 U | 1 U | 1.4 | 1 U | 5 U |
| 12A | Nov-03 | 1 U | 1 U | 4 | 1 U | 5 U |
| 13A | Jun-03 | 3.4 | 3.9 | 1 U | 1 U | 5 U |
| 13A | Nov-03 | 3 | 3.8 | 1 U | 1 U | 5 U |
| 14A | Jun-03 | 1 U | 1 U | 23 | 28 | 5 U |
| 14A | Nov-03 | 1 U | 1 U | 170 | 240 | 5 U |
| 15A | Jun-03 | 5 U | 5 U | 5 U | 5 U | 370 |
| 15A | Nov-03 | 5 U | 5 U | 5 U | 5 U | 490 |
| 16A | Jun-03 | 1.2 | 1.3 | 2.4 | 1 U | 5 U |
| 16A | Nov-03 | 1.1 | 1.2 | 1.3 | 1 U | 5 U |
| 17A | Jun-03 | 4.6 | 7.4 | 1.4 | 1 U | 5 U |
| 17A | Nov-03 | 4.8 | 7.9 | 1.6 | 1 U | 5 U |
| 18A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 18A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 19A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 1.54 |
| 19A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 20A | Jun-01 | 1 U | 1 U | 1 U | 1 U | 5.48 |
| 20A | Dec-01 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 21A | Jun-02 | 1 U | 1 U | 1 U | 1 U | 5 U |
| 21A | Dec-02 | 1 U | 1 U | 1 U | 1 U | 5 U |
| Theoretical | Theoretical | 1 U | 1 U | 1 U | 1 U | 5 U |

| | | | | | |
|---|---|---|---|---|---|
| Distribution (assumed): | Lognormal | Lognormal | Lognormal | Lognormal | Lognormal |
| Number of Samples: | 5200 | 5200 | 5200 | 5200 | 5200 |
| Frequency of Detection: | 0.19% | 0.23% | 0.27% | 0.12% | 0.08% |
| Maximum Detection: | 1800 | 1500 | 2300 | 240 | 490 |
| Mean: | 1.56 | 1.50 | 1.97 | 1.12 | 5.17 |
| Standard Deviation: | 28.55 | 24.91 | 45.18 | 4.50 | 8.47 |
| Mean (log-transformed data): | 0.01 | 0.01 | 0.01 | 0.01 | 1.61 |
| Std Deviation (log-transformed data): | 0.17 | 0.17 | 0.21 | 0.15 | 0.11 |
| Geometric Mean: | 1.01 | 1.01 | 1.01 | 1.01 | 5.00 |
| t-statistic (normal dist only) : | | | | | |
| H-statistic: | 1.69 | 1.69 | 1.70 | 1.68 | 1.67 |
| UCL95: | 1.02 | 1.02 | 1.04 | 1.02 | 5.04 |
| Exposure Point Concentration: | 1.02 | 1.02 | 1.04 | 1.02 | 5.04 |

| | | | | | | Cumulative Health Risk Indices |
|---|---|---|---|---|---|---|
| Building 9-101 Risk Summary: | | | | | | |
| Indoor Air Excess Cancer Risk: | 1E-09 | 3E-08 | -- | 1E-08 | -- | 4E-08 |
| Indoor Air Hazard Quotient: | -- | 2E-05 | 8E-06 | 3E-05 | 5E-05 | 1E-04 |

U = compound was not detected at given detection limit.
-- = Not Measured.

Notes:
1. Groundwater concentrations shown in bold are those that were detected at or above the laboratory reporting limit.
2. Shaded cells identify carcinogenic risk exceeding acceptable levels for a single substance (1E-06) or multiple substances (1E-05) or noncarcinogenic risk exceeding acceptable levels for a single substance (hazard quotient less than or equal to 1) or multiple substances (hazard index less than or equal to 1).
3. Groundwater concentrations represented in this table include Zone A data collected from the most recent available year of sampling events. In most cases, this data was collected in June and November of 2003. In some cases (i.e., wells 18A, 19A, 20A, and 21A), semiannual sampling has been discontinued due to a history of nondetect sample results. The most recent year of available data (i.e., semiannual data from 2001 or 2002) was used to characterize groundwater quality at these wells.
4. 2,173 iterations of identical theoretical data for assumed clean areas beneath Building 9-101 are hidden from this table for viewing clarity.

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# 1.0 INTRODUCTION

This document presents a work plan to conduct active remediation at Solid Waste Management Unit (SWMU) -20 at the Boeing Developmental Center in Tukwila, Washington. The BDC is a Resource Conservation and Recovery Act (RCRA) corrective action site with remedial activities conducted under the Washington State Department of Ecology (Ecology) Voluntary Cleanup Program (VCP). Preparation of this work plan was authorized under Work Order No. ENV-G-04DC-019.

Groundwater at SWMU-20 contains the dissolved volatile organic compounds (VOCs) tetrachloroethene (PCE), trichloroethene (TCE), and breakdown products cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride. PCE and TCE were released from a former vapor degreaser located in Building 9-101 (Figure A-1) (Landau Associates 2002). A groundwater treatment system was operated at SWMU-20 between Fall 1993 and December 14, 2001, when the system was shut down to evaluate natural attenuation as a remedial alternative to achieve cleanup objectives. Based on rebound of VOC concentrations in a number of monitoring wells that are located in the immediate vicinity of the former vapor degreaser, Boeing has proposed active remediation by enhanced *in situ* reductive dechlorination through electron donor amendment (Landau Associates 2003). This work plan describes injection of electron donors sodium lactate and vegetable (soybean) oil emulsion and outlines groundwater monitoring to be performed before and after injection.

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# 2.0 ELECTRON DONOR AMENDMENT

This section describes the general objectives of electron donor amendment, evaluates existing reductive dechlorination and redox conditions in SWMU-20, and describes proposed injection at SWMU-20.

## 2.1 GENERAL OBJECTIVES

Electron donor amendment is designed to enhance and maintain the reducing aquifer conditions required for reductive dechlorination of PCE, TCE, and associated breakdown products. Electron donor amendment stimulates reducing aquifer conditions that are required for reductive dechlorination, and provides organic carbon needed for bacterial growth. Hydrogen provided by fermentation of organic carbon reduces aquifer conditions. Hydrogen is the electron used to replace chlorine atoms on the chlorinated hydrocarbon compound through reductive dechlorination. Following donor amendment to an aquifer, ubiquitous aerobic and anaerobic bacteria utilize the hydrogen to consume any electron acceptors that may be present in the aquifer, including dissolved oxygen (DO), nitrate, manganese (IV), iron (III), sulfate, and $CO_2$. These electron acceptors are consumed in sequentially-occurring redox processes (chemical or biochemical processes in which electrons are transferred) known as oxygen reduction, nitrate reduction (denitrification), iron reduction, sulfate reduction, and $CO_2$ reduction (methanogenesis). Electron acceptors are consumed in this order because the use of each successive electron acceptor releases less energy, and bacteria preferentially use electron acceptors that provide the greatest energy return. Upon depletion of dissolved oxygen, an aquifer is anaerobic and becomes more reducing with the depletion of each successive electron acceptor.

Chlorinated compounds (e.g., PCE, TCE, cis-1,2-DCE, and vinyl chloride) are electron acceptors in the process known as reductive dechlorination. In successive steps of reductive dechlorination, individual chlorine atoms on the chlorinated hydrocarbon compound are replaced with hydrogen from the electron donor. Through reductive dechlorination, PCE is reduced to sequential breakdown products TCE, cis-1,2-DCE, vinyl chloride, ethene, and ethane, which ultimately degrades to $CO_2$ and water. Each sequential breakdown step requires more highly reducing conditions than the previous step (i.e., cis-1,2-DCE reduction to vinyl chloride requires more reducing conditions than TCE reduction to cis-1,2-DCE). PCE and TCE are highly oxidized (chlorinated) compounds that can be degraded under slightly reducing conditions (nitrate and iron reducing conditions), while reductive dechlorination of less oxidized breakdown products cis-1,2-DCE and vinyl chloride, requires sulfate-reducing to methanogenic conditions (Lu et al. 2001, ITRC 1998).

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## 2.2 EXISTING CONDITIONS AT SWMU-20

Naturally-occurring reductive dechlorination processes are ongoing at SWMU-20, as evidenced by the incidence of PCE and TCE breakdown products cis-1,2-DCE and vinyl chloride (Landau Associates 2002, 2003). Observed reductive dechlorination indicates an existing source of organic carbon, sulfate-reducing to methanogenic aquifer redox conditions, and the presence of bacteria required for complete reductive dechlorination.

Reductive dechlorination in SWMU-20 is currently supported by naturally-occurring organic carbon. Total organic carbon (TOC) concentrations of 247 mg/kg to 1,456 mg/kg were measured in soil samples collected previously during the installation of five SWMU-20 monitoring wells. These soil samples were collected at depths ranging from 20 to 37.5 ft below ground surface (BGS) within Duwamish River alluvium (Landau Associates 1992).

The occurrence of vinyl chloride at SWMU-20 indicates sulfate-reducing to methanogenic redox conditions and the presence of bacteria required for complete reductive dechlorination. Reductive dechlorination of cis-1,2-DCE to vinyl chloride requires sulfate reducing to methanogenic conditions (Lu et al. 2001, ITRC 1998). While bacteria capable of reductive dechlorination of PCE and TCE are ubiquitous and varied in the environment, *Dehalococcoides* bacteria capable of cis-1,2-DCE dechlorination to vinyl chloride are less commonly occurring (Ellis et al. 2000). An extensive survey of *Dehalococcoides* at multiple contaminated sites indicated that the bacterium was present at all sites where complete reductive dechlorination of TCE occurred and, conversely, the survey did not find *Dehalococcoides* at any sites where reductive dechlorination was stalled at cis-1,2-DCE (Major et al. 2003).

Donor injection has significantly enhanced reductive dechlorination at a similar site where naturally-occurring organic carbon is present and reductive dechlorination was previously occurring. A pilot test injection of sodium lactate enhanced reductive dechlorination at the nearby former Boeing Electronics Manufacturing Facility (EMF) within Boeing Plant 2, where baseline sampling indicated sulfate-reducing to methanogenic redox conditions and production of ethene. Over the four-month period following sodium lactate injection, total VOC concentrations decreased 85 to 92 percent at three injection wells, and decreased 94 percent at a monitoring well located 75 ft downgradient. The cell density of *Dehalococcoides* bacteria also increased two to four orders of magnitude compared to baseline (PPC 2004).

## 2.3 INJECTION AT SWMU-20

Electron donor consisting of food-grade sodium lactate and vegetable oil emulsion will be injected at wells in the immediate vicinity of the former vapor degreaser. The combined application of soluble (fast-release) sodium lactate and relatively insoluble (slow-release) vegetable oil is designed to address both downgradient impacts and residual source material in the release area.

Sodium lactate and vegetable oil emulsion will be mixed with groundwater pumped from extraction wells E1 and E2 (Figure A-1) to form dilute solutions for injection at wells MW-9A, MW-9B, MW-9C, MW-6B, MW-6C, and a new A-Horizon well to be installed near MW-6B and MW-6C. In accordance with Washington Administrative Code (WAC 173-218) the site will be registered with Ecology's Underground Injection Control (UIC) program. Given the large volume injections described in the following section, groundwater pumped from E1 and E2 is preferred over tap water to avoid dilution and/or dispersion of the plume, and to avoid the introduction of highly oxygenated water. United Stated Environmental Protection Agency (EPA) policy allows for reinjection of groundwater extracted from a contaminated area, provided groundwater is treated to substantially reduce hazardous constituents prior to reinjection, with reduction of hazardous constituents occurring prior to or following injection (EPA 2000).

### 2.3.1 SODIUM LACTATE INJECTION

Sodium lactate is an innocuous, food-grade amendment that has been widely used as an electron donor for injection to groundwater. Sodium lactate is the salt of lactic acid. Lactate occurs naturally in milk, and is used by the dairy industry during fermentation processes used to manufacture buttermilk, yogurt, and other dairy products. Sodium lactate is completely soluble in groundwater causing it to move with the flow of groundwater. Although the advance of lactate is somewhat retarded due to consumption, any retardation is expected to be less than of the VOC compounds targeted for remediation. Lactate is fermented to hydrogen and intermediates, including propionate and pyruvate, which also ferment to hydrogen.

Groundwater pumped from extraction well E2 will be used to dilute sodium lactate for injection into monitoring wells MW-9A, MW-9B, and MW-9C (Figure A-1). Approximately 5000 gallons of groundwater will be mixed with 550 gallons (10 drums) of 60 percent sodium lactate solution to create a 6 percent solution for injection. Monitoring wells MW-9A, MW-9B, and MW-9C are screened from 11 to 21.5 ft, 22 to 27 ft, and 29 to 39.5 ft, respectively (Figure A-2). Due to an observed decrease in concentration with depth (Landau Associates 2002, 2003), 50 percent of the solution (3025 gallons) will

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be injected at well MW-9A and 25 percent (1512 gallons) will be injected at each of wells MW-9B, and MW-9C.

### 2.3.2 VEGETABLE OIL INJECTION

Vegetable oil is an innocuous, food-grade amendment that has been widely used as an electron donor for injection to groundwater. Soybean oil is typically used because of its low cost relative to other vegetable oils. The concentrated emulsion to be used at SWMU-20 is composed of soybean oil (50 percent by volume), lactic acid (4 percent by volume), water, and food-grade emulsifying agents. The emulsion has a reported oil droplet size of 0.5 micron, which will allow the oil droplets to pass through pore spaces in the aquifer and move out radially from the injection points. These very small oil droplets will adsorb to soil particles as they move with groundwater flow, forming a permeable barrier of vegetable oil at residual saturation within the aquifer. Over time, oil will break down to hydrogen and intermediate volatile organic acids that will move downgradient with groundwater flow for stimulation of reductive dechlorination.

Groundwater pumped from extraction well E1 will be used to dilute the vegetable oil emulsion for injection into monitoring wells MW-6B, MW-6C, and a new A-Horizon well to be installed just upgradient (east) of the former vapor degreaser (Figure A-1). As an A-Horizon monitoring well is not present near wells MW-6B and MW-6C, we propose to construct a new well screened from 10 to 20 ft BGS for injection and monitoring (Figure A-2). The new well will allow donor injection to the A Horizon beneath the former vapor degreaser. Although the depth to groundwater was approximately 13 ft BGS near the former degreaser in November 2003, groundwater has been observed in the past at depths above the base of the former degreaser, indicating seasonal saturation of underlying soil (Landau Associates 2002). Existing monitoring wells MW-6B and MW-6C are screened below the A Horizon at depths of 22 to 27.5 ft and 30 to 40.5 ft, respectively (Figure A-2). Approximately 4750 gallons of groundwater will be mixed with 257 gallons of concentrated emulsion (50 percent oil) to create an injection solution containing 2.5 percent oil. Due to an observed decrease in VOC concentrations with depth (Landau Associates 2002, 2003), 50 percent of the solution (2500 gallons) will be injected at the new A-horizon well and 25 percent (1250 gallons) will be injected at each of wells MW-6B, and MW-6C. The created permeable barrier of vegetable oil is designed to provide a steady supply of hydrogen to potential source material beneath the former degreaser and to the area near wells MW-9A and MW-9B, where some of the highest VOC concentrations have been observed.

The new A-Horizon well (to be identified as MW-6A) will be located inside Building 9-101 near the east end of the former vapor degreaser. Well MW-6A will be constructed of threaded 2-inch diameter schedule PVC casing and screen. The screen (0.010-in slot size) will extend from 10 to 20 ft BGS, and a

sandpack consisting of 10/20 sand will extend from 8 to 20 ft BGS. An annular seal will be constructed of hydrated bentonite chips from 1.5 to 8 ft BGS, and the well will be completed with a flush-mount monument.

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# 3.0 GROUNDWATER MONITORING

Groundwater monitoring will be performed at SWMU-20 wells to evaluate the effects of donor injection and to evaluate the need for subsequent donor amendment. Prior to injection, groundwater monitoring will be performed at regularly sampled SWMU-20 wells and new well MW-6A to establish baseline conditions. Subsequent to donor injection, regular semiannual monitoring will be performed and select SWMU-20 wells will also be sampled quarterly.

Groundwater monitoring will consist of groundwater sampling for measurement of field parameters and laboratory analysis. Oxidation reduction potential (ORP), pH, DO, and dissolved ferrous iron (iron II) will be measured in the field. Samples will also be submitted for laboratory analyses of VOCs, total organic carbon (TOC), sulfate, ethene, ethane, and methane. Field and laboratory methods are listed for each parameter in Table A-1, along with a brief description of the information obtained from each parameter. Analytical Resources Inc. (ARI) of Seattle, Washington will perform or subcontract the remaining analyses under their existing contract with Boeing.

## 3.1 BASELINE MONITORING

The purpose of baseline monitoring is to evaluate VOC concentrations and aquifer redox conditions prior to donor amendment. Baseline monitoring will be performed at regularly sampled SWMU-20 wells and new well MW-6A during the next semiannual sampling event scheduled for June 2004.

## 3.2 FOLLOWING ELECTRON DONOR AMENDMENT

Following electron donor injection, monitoring will be conducted at SWMU-20 wells to evaluate the effectiveness of injected donor at stimulating more reduced aquifer redox conditions and enhanced reductive dechlorination. Monitoring results will also be used to evaluate the need for subsequent injections of vegetable oil and/or sodium lactate electron donor. Regular semiannual monitoring will be performed at SWMU-20 wells. Quarterly monitoring will be performed at the six injection wells (the new A-Horizon well MW-6A, MW-6B, MW-6C, MW-9A, MW-9B, and MW-9C) and at downgradient well MW-14A and crossgradient well MW-10A, where rebound of one or more VOCs has been observed since shutdown of the groundwater treatment system.

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# 4.0 DATA EVALUATION

The primary measure of enhanced reductive dechlorination will be an ultimate decrease in the concentrations of PCE, TCE and breakdown products cis-1,2-DCE and vinyl chloride. The rate and effectiveness of enhanced reductive dechlorination will be assessed through changes in concentrations of PCE, TCE and breakdown products. PCE breakdown products TCE, cis-1,2-DCE, and vinyl chloride may initially increase, then decrease in concentration.

Aquifer redox conditions will be evaluated based on ORP, and concentrations of DO, iron II, sulfate, and methane. Three degrees of aquifer redox (aerobic, transitional, and anaerobic and reducing) will be evaluated as follows (Beil et al. 2002):

| | |
|---|---|
| Aerobic | DO > 1 mg/L, ORP > 0 mV |
| Transitional | DO < 1 mg/L, ORP > 0 mV |
| Anaerobic and Reducing | DO < 1 mg/L, ORP < 0 mV |

As described in Section 2.2, current conditions appear to be sulfate-reducing to methanogenic, which is considered anaerobic and reducing. DO and ORP are often less-than-reliable indicators of redox conditions as they are difficult to measure consistently and accurately. Therefore, aquifer redox conditions will also be evaluated based on observed iron-reducing conditions (increasing concentrations of iron II), sulfate-reducing conditions (decreasing concentrations of sulfate), and methanogenesis (increasing concentrations of methane).

Increasing TOC concentrations are considered the most reliable indicators of the downgradient extent of electron donor. Observed changes in other parameters may result from aquifer changes that occurred upgradient and were carried by groundwater flow to downgradient monitoring locations. Concentrations of TOC above background indicate the presence of volatile organic acids with hydrogen available to enhance reductive dechlorination at the monitoring location. TOC groundwater concentrations of less than 10 mg/L are considered to be TOC depleted (Maierle and Cota 2001).

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# 5.0 SCHEDULE

We propose to install the new A-Horizon well (MW-6A) during May 2004 so it can be included in baseline sampling to be conducted during semiannual monitoring in June 2004. Following collection of baseline data, donor injection will be completed in June or July 2004. Regular semiannual monitoring will continue to be performed in December and June. Select wells will also be monitored quarterly in September and March (Section 3.2). Based on monitoring data, subsequent injections of electron donor may be required, which would need two to four days for each event.

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# 6.0 REPORTING

Monitoring results will be provided in semiannual groundwater monitoring reports regularly prepared for the Developmental Center.

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# 7.0 USE OF THIS REPORT

This Work Plan has been prepared for the exclusive use of the Boeing Company for specific application to SWMU-20 at the Boeing Developmental Center. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

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

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CLJ/JRN/tam/pcs

DFT 001225

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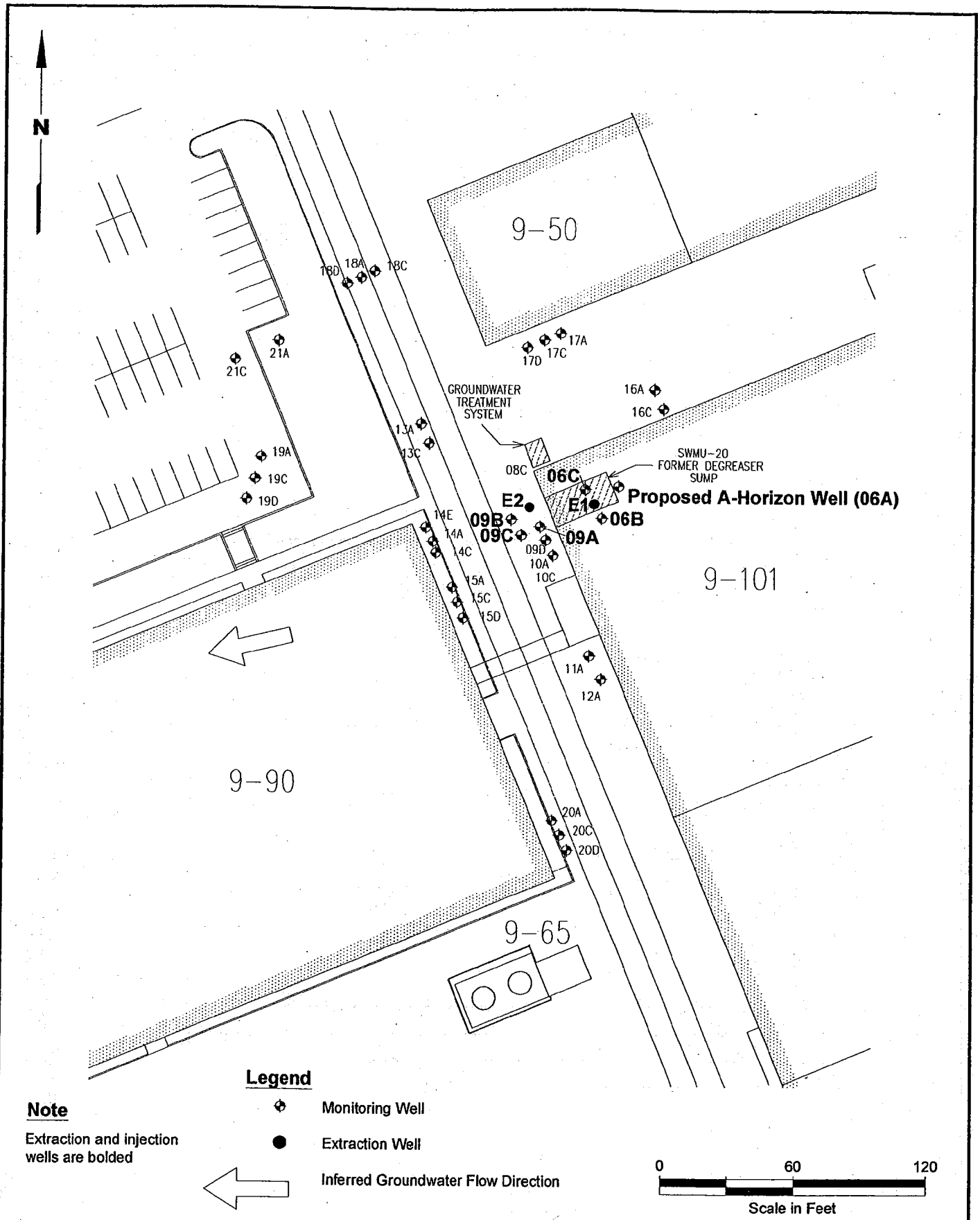
DFT 001226




**Note**

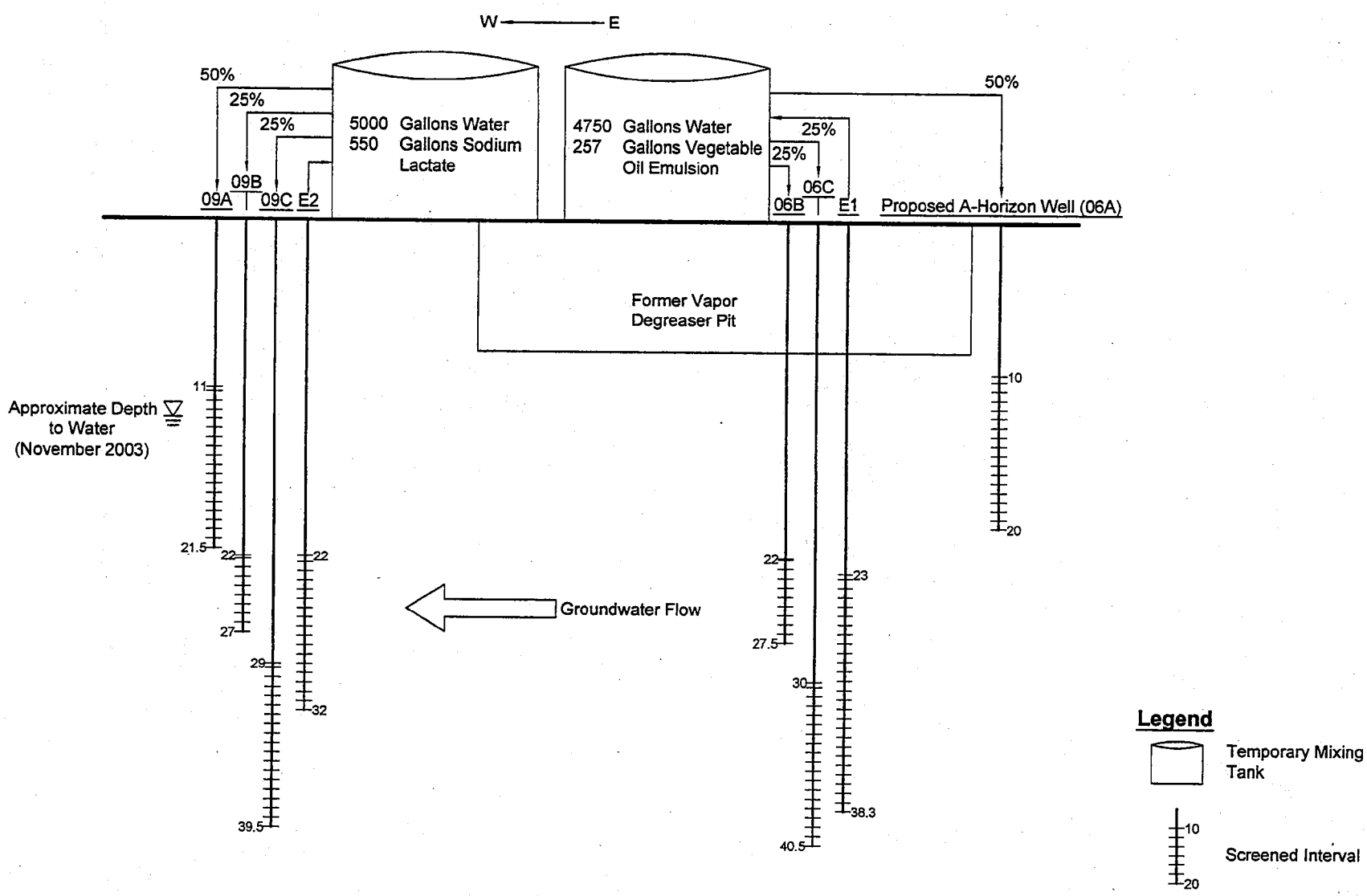
Extraction and injection wells are bolded

Boeing/Developmental Center/Rmd Action Workplan | T:\025\093\040\Rmd Action Workplan\FigA-1.dwg (A) "Figure A-1" 3/10/2004

LANDAU ASSOCIATES

| Boeing Developmental Center<br>Tukwila, Washington | SWMU-20 | Figure<br>A-1 |
|---|---|---|

DFT 001227




0 10 20
Approximate Scale in Feet

LANDAU ASSOCIATES

Boeing Developmental Center
Tukwila, Washington

**Cross Section of Injection and Extraction Wells**

Figure
A-2

DFT 001228

# TABLE A-1
## BOEING DEVELOPMENT CENTER SWMU-20
## GROUNDWATER MONITORING PARAMETERS

| Field Parameters | Information Provided |
|---|---|
| Dissolved Oxygen (DO)<br>[field meter and single-use reactive ampoules] (a) | Aquifer is considered anaerobic at DO concentrations less than 1.0 mg/L. |
| Oxidation Reduction Potential (Redox)<br>[field meter] (a) | Negative values indicate reducing conditions. |
| pH<br>[field meter] (a) | May decrease due to injected donor. Ideal for reductive dechlorination in the range of 6 to 8. |
| Iron(II) [Hach test kit] | Concentrations above background indicate iron reducing conditions. |
| **Laboratory Analyses** | **Information Provided** |
| Volatile Organic Compounds (VOCs)<br>[Method 8260]<br>[3-40 ml VOA-HCl] (b) | Concentrations of chlorinated VOCs and breakdown products are indicative of reductive dechlorination and pathways. |
| Total Organic Carbon (TOC)<br>[Method 415.1][250 ml Amber-H2SO4] | Will increase due to arrival of volatile fatty acids released from injected sodium lactate and vegetable oil. |
| Sulfate<br>[IC Method E300][500 ml poly] | Decreasing concentrations indicate sulfate reducing conditions. |
| Ethene/Ethane/Methane<br>[Method 8015 Mod]<br>[3-40 ml VOA] (b) | Concentrations of ethene and ethane are indicative of reductive dechlorination and pathways. Increasing methane concentrations indicate methanogenic conditions. |

Notes:
(a) Measured using a flow-through cell.
(b) Care to be taken during sample collection to minimize aeration and volatilization.

# Building 9-90

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 127184 | 1.61E+02 | Tetrachloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 12000 | 5300 | 850 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001231

RESULTS SHEET - BUILDING 9-90

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 2.00E+05 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 4.1E-07 | NA |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001232

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 127184 | 1.61E+02 | Tetrachloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001233

RESULTS SHEET - BUILDING 9-101

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 2.00E+05 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 1.9E-07 | NA |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001234

GW-[illegible]
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_w$ (µg/L) | Chemical |
|---|---|---|
| 79016 | 1.48E+02 | Trichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001235

RESULTS SHEET - BUILDING 9-101

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 1.47E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 4.3E-06 | 2.3E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 156592 | 8.94E+02 | cis-1,2-Dichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001237

RESULTS SHEET - BUILDING 9-101

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.50E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 6.7E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 75014 | 6.12E+01 | Vinyl chloride (chloroethene) |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001239

RESULTS SHEET - BUILDING 9-101

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 8.80E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 6.2E-07 | 1.6E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001240

# Building 9-101 Simulation

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 127184 | 1.02E+00 | Tetrachloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001242

RESULTS SHEET - BUILDING 9-101 SIMULATED

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 2.00E+05 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 1.2E-09 | NA |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001243

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 91203 | 5.20E+01 | Naphthalene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END



DFT 001244

RESULTS SHEET - BUILDING 9-101

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.10E+04 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 4.8E-04 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001245

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 79016 | 1.02E+00 | Trichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001246

RESULTS SHEET - BUILDING 9-101 SIMULATED

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 1.47E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 2.9E-08 | 1.6E-05 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DFT 001247

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 156592 | 1.04E+00 | cis-1,2-Dichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ (g/cm-s$^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001248

RESULTS SHEET - BUILDING 9-101 SIMULATED

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.50E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 7.8E-06 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 75014 | 1.02E+00 | Vinyl chloride (chloroethene) |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001250

RESULTS SHEET - BUILDING 9-101 SIMULATED

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 8.80E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 1.0E-08 | 2.7E-05 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001251

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 91203 | 5.04E+00 | Naphthalene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ (g/cm-s$^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 29000 | 23000 | 1550 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001252

RESULTS SHEET - BUILDING 9-101 SIMULATED

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.10E+04 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 4.7E-05 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 79016 | 1.48E+02 | Trichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 12000 | 5300 | 850 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001254

RESULTS SHEET - BUILDING 9-90

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 1.47E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 9.4E-06 | 5.0E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 156592 | 8.94E+02 | cis-1,2-Dichloroethylene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 12000 | 5300 | 850 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001256

RESULTS SHEET - BUILDING 9-90

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.50E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 1.5E-02 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 75014 | 6.12E+01 | Vinyl chloride (chloroethene) |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ ($g/cm\text{-}s^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 12000 | 5300 | 850 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END



DFT 001258

RESULTS SHEET - BUILDING 9-90

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 8.80E+06 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| 1.4E-06 | 3.8E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001259

GW-ADV
Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

**OR**

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

| ENTER Chemical CAS No. (numbers only, no dashes) | ENTER Initial groundwater conc., $C_W$ (µg/L) | Chemical |
|---|---|---|
| 91203 | 5.20E+01 | Naphthalene |

MORE ↓

| ENTER Average soil/ groundwater temperature, $T_S$ (°C) | ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (cm) | ENTER Depth below grade to water table, $L_{WT}$ (cm) | ENTER Thickness of soil stratum A, $h_A$ (cm) | ENTER Thickness of soil stratum B, (Enter value or 0) $h_B$ (cm) | ENTER Thickness of soil stratum C, (Enter value or 0) $h_C$ (cm) | ENTER Soil stratum directly above water table, (Enter A, B, or C) | ENTER SCS soil type directly above water table | ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability) | OR | ENTER User-defined stratum A soil vapor permeability, $k_v$ ($cm^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Totals must add up to value of $L_{WT}$ (cell G28) | | | | | | | |
| 10 | 15 | 300 | 125 | 175 | 0 | B | SI | S | | |

MORE ↓

| ENTER Stratum A SCS soil type (Lookup Soil Parameters) | ENTER Stratum A soil dry bulk density, $\rho_b^A$ ($g/cm^3$) | ENTER Stratum A soil total porosity, $n^A$ (unitless) | ENTER Stratum A soil water-filled porosity, $\theta_w^A$ ($cm^3/cm^3$) | ENTER Stratum B SCS soil type (Lookup Soil Parameters) | ENTER Stratum B soil dry bulk density, $\rho_b^B$ ($g/cm^3$) | ENTER Stratum B soil total porosity, $n^B$ (unitless) | ENTER Stratum B soil water-filled porosity, $\theta_w^B$ ($cm^3/cm^3$) | ENTER Stratum C SCS soil type (Lookup Soil Parameters) | ENTER Stratum C soil dry bulk density, $\rho_b^C$ ($g/cm^3$) | ENTER Stratum C soil total porosity, $n^C$ (unitless) | ENTER Stratum C soil water-filled porosity, $\theta_w^C$ ($cm^3/cm^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1.66 | 0.375 | 0.054 | SI | 1.35 | 0.489 | 0.167 | | Error | Error | Error |

MORE ↓

| ENTER Enclosed space floor thickness, $L_{crack}$ (cm) | ENTER Soil-bldg. pressure differential, $\Delta P$ (g/cm-s$^2$) | ENTER Enclosed space floor length, $L_B$ (cm) | ENTER Enclosed space floor width, $W_B$ (cm) | ENTER Enclosed space height, $H_B$ (cm) | ENTER Floor-wall seam crack width, w (cm) | ENTER Indoor air exchange rate, ER (1/h) | ENTER Average vapor flow rate into bldg. OR Leave blank to calculate $Q_{soil}$ (L/m) |
|---|---|---|---|---|---|---|---|
| 15 | 40 | 12000 | 5300 | 850 | 0.1 | 0.5 | |

MORE ↓

| ENTER Averaging time for carcinogens, $AT_C$ (yrs) | ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs) | ENTER Exposure duration, ED (yrs) | ENTER Exposure frequency, EF (days/yr) | ENTER Target risk for carcinogens, TR (unitless) | ENTER Target hazard quotient for noncarcinogens, THQ (unitless) |
|---|---|---|---|---|---|
| 70 | 30 | 30 | 250 | 1.0E-06 | 1 |
| | | | | Used to calculate risk-based groundwater concentration. | |

END

DFT 001260

RESULTS SHEET - BUILDING 9-90

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

| Indoor exposure groundwater conc., carcinogen (µg/L) | Indoor exposure groundwater conc., noncarcinogen (µg/L) | Risk-based indoor exposure groundwater conc., (µg/L) | Pure component water solubility, S (µg/L) | Final indoor exposure groundwater conc., (µg/L) |
|---|---|---|---|---|
| NA | NA | NA | 3.10E+04 | NA |

INCREMENTAL RISK CALCULATIONS:

| Incremental risk from vapor intrusion to indoor air, carcinogen (unitless) | Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless) |
|---|---|
| NA | 1.2E-03 |

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

DFT 001261