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HGL
HydroGeoLogic, Inc
Exceeding Expectations

Kansas City Operations

July 8, 2009

Redactions-CBI

Mr. Jim Seiler
AES Project Officer
U.S. Environmental Protection Agency, Region 7
901 North 5th Street
Kansas City, KS 66101

RE: Revised Final Remedial Investigation/Feasibility Study Work Plan for the Garvey Elevator Site, Hastings, Nebraska.
U.S. EPA Region 7 AES Contract No. EP-S7-05-05; Task Order Nos. 0033 and 0034
EPA Task Order Project Officer: Brian Zurbuchen, Ph.D.

Dear Mr. Seiler:

HydroGeoLogic, Inc. (HGL) is submitting two full copies of the revised Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the Garvey Elevator (OU1 and OU2) Site, Hastings, Nebraska. Change pages comprising the revision from final to revised final version were previously submitted to EPA on June 25, 2009. EPA requested distribution of full revised final copies on July 1, 2009.

As requested by EPA, two hard copies of the revised final RI/FS Work Plan submittal will be sent to Laurie Brunner at the Nebraska Department of Environmental Quality. Should you have any questions or comments, please contact us at 913-317-8860.

Sincerely,

[redacted], P.G.
HGL Task Order Manager

[redacted], P.G., CHMM
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Enclosures

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REVISED FINAL
WORK PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR SITE
HASTINGS, NEBRASKA

Prepared for:

U.S. Environmental Protection Agency Region 7
901 North 5th Street
Kansas City, KS 66101

Architect and Engineering Services Contract EP-S7-05-05
Task Order: 033 and 034

June 2009

HydroGeoLogic, Inc

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Prepared for:

U.S. Environmental Protection Agency Region 7
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Kansas City, KS 66101

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June 2009

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LIST OF ACRONYMS AND ABBREVIATIONS

2D	two dimensional
2,4-D	2,4-dichlorophyenoxy acetic acid
AES	Architect and Engineering Services
AGP	AGP Grain Marketing, LLC.
amsl	above mean sea level
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
atm-m^3/mole	atmospheres-cubic meters per mole
bgs	below ground surface
BNSF	Burlington Northern and Santa Fe
CDM	CDM Federal Programs
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic foot per minute
cm/s	centimeters per second
COC	chemical of concern
COPC	chemical of potential concern
CSM	Conceptual Site Model
DFT	dipole flow testing
DNAPL	dense non-aqueous phase liquid
DPT	direct-push technology
DQOs	data quality objectives
EC	electrical conductivity
EDB	ethylene dibromide
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
ºF	degrees Fahrenheit
FFS	Focused Feasibility Study
FS	Feasibility Study
FSP	Field Sampling Plan
ft/day	feet per day

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LIST OF ACRONYMS AND ABBREVIATIONS (continued)

Garvey	Garvey Elevator Site
GET	groundwater extraction and treatment GIS geographic Information System
gpd/ft	gallons per day per foot
gpm	gallons per minute
HGL	HydroGeoLogic, Inc.
HHRA	Human Health Risk Assessment
HI	hazard index
HICA	Hastings Institutional Control Area
HSP	Health and Safety Plan
IDW	investigation-derived waste
K_{oc}	octanol-water partitioning coefficient
K_{ow}	organic carbon-water partitioning coefficient
LDL	low detection limit
LNAPL	light non-aqueous phase liquid
MCL	maximum contaminant level
$\mu g/m^3$	microgram per cubic meter
$\mu g/kg$	microgram per kilogram
$\mu g/L$	microgram per liter
mg/L	milligrams per liter
MNA	monitored natural attenuation
NAD	Naval Ammunition Depot
NAPL	non-aqueous phase liquid
NCP	National Contingency Plan
NDEQ	Nebraska Department of Environmental Quality
NPL	National Priorities List
O&M	operations and maintenance
OU1	Operable Unit 1
OU2	Operable Unit 2
PA/SI	Preliminary Assessment/Site Inspection
PCB	polychlorinated biphenyl
PID	photoionization detector
ppm	parts per million

PRG	preliminary remediation goal
PRP	potentially responsible party
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RA	remedial action
RAGS	Risk Assessment Guidance for Superfund
RAMPA	Remedial Action Program Monitoring Act
RAO	remedial action objective
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
SEWP	System Evaluation Work Plan
SLERA	Screening Level Ecological Risk Assessment
SOP	Standard Operating Procedure
SOW	scope of work
START	Superfund Technical Assessment and Response Team
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TBC	to be considered
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
UST	underground storage tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound

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REVISED FINAL
WORK PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR SITE
HASTINGS, NEBRASKA

1.0 INTRODUCTION

This Work Plan details the data collection activities planned for Operable Unit 1 (OU1) and Operable Unit 2 (OU2) of the Garvey Elevator (Garvey) Site located in Hastings, Nebraska (Figure 1.1). The site is the location of a grain storage facility previously owned by Garvey Elevators, Inc. The site property is currently occupied by AGP Grain Marketing, LLC (AGP). This Work Plan was prepared to support the Remedial Investigation/Feasibility Study (RI/FS) activities that are being conducted by HydroGeoLogic, Inc. (HGL) under Region 7 U.S. Environmental Protection Agency (EPA) Architect and Engineering Services (AES) contract EP-S7-05-05, Task Order 0033 and Task Order 34, as specified in the scopes of work (SOWs). CDM Federal Programs (CDM) is a team subcontractor to HGL on the AES Contract. CDM personnel will have key roles on the Garvey Elevator site project.

Task Order 0033 was awarded for investigation of OU1, which consists of contaminated soils and groundwater on the site property. Task Order 0034 was awarded simultaneously for OU2, which consists of contaminated groundwater off site and downgradient from the source area. The work plan describes the field effort, and data quality control and management for the investigations at both OU1 and OU2. The Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HSP) are provided in the appendices of this Work Plan.

1.1 OBJECTIVES, PURPOSE, SCOPE, AND ORGANIZATION

1.1.1 Project Objectives

The OU1 and OU2 project objectives are:

- Determine the physical characteristics of the site.
- Determine the nature and extent of contamination in affected media at the site that exceed established applicable and or relevant and appropriate Federal or State limits. In the event such limits have not been promulgated for the specific media or contaminant, preliminary estimates of the risk-based levels will be identified.
- Update and refine the source area conceptual site model (CSM) to ensure that the site characterization is completed in sufficient detail for decision making.
- Assess actual and potential exposure pathways through affected media.
- Prepare a human health risk assessment HHRA and a screening level ecological risk assessment (SLERA) that presents an assessment of the risks to human health and the

environment.
- Identify, develop and evaluate potential response alternatives.
- Develop the appropriate amount of data to manage uncertainty and support selection of a site remedy to include in a draft Record of Decision (ROD).
- Prepare a Remedial Investigation report.
- Prepare a Feasibility Study report

1.1.2 Work Plan Purpose and Scope

This Work Plan presents the data collection activities that will be employed to obtain the requisite data to satisfy the project objectives as listed in Section 1.1.1. The FSP and QAPP elements of this Work Plan provide specific details regarding the planned sampling scheme, data quality objectives (DQOs) for both field and laboratory data, and data management procedures.

The scope of these planning documents for the Garvey Site includes the following data evaluation and collection activities:
- Evaluate existing data available for the site and identify data gaps to inform the design of site investigative activities.
- Development of a CSM
- Identify preliminary State and Federal Applicable or Relevant and Appropriate Requirements (ARARs).
- Identify preliminary Remedial Action Objectives (RAOs).
- Present the overall technical approach for determining the nature and extent of soil and groundwater contamination at the site, and for evaluating human health and ecological risk.
- Summarize the site characterization work that will be performed to fill the identified data gaps.

1.1.3 Work Plan Organization

This work plan is organized into seven sections as follows:
- **Section 1 Introduction** presents the scope and objectives of the project, and describes the site in terms of general and regulatory history, and current use.
- **Section 2 Site Background and Setting** describes the physical site setting, including hydrology, geology, and hydrogeology.
- **Section 3 Previous Investigations and Response Actions** discusses the known contaminant sources, describes the known extent of soil and groundwater contamination, and discuss the soil vapor extraction (SVE) and groundwater extraction and treatment (GET) systems currently in place at the site.
- **Section 4 Remedial Investigation Approach and Activities** presents HGL's preliminary identification of Federal and State ARARs and RAOs, and describes the field sampling regime that will be implemented for both OU1 and OU2 to address data gaps.
- **Section 5 Communication, Data Management, and Reporting** describes

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communications among key personnel and stakeholders, and at the field level.
- **Section 6 Schedule** provides a copy of the anticipated schedule.
- **Section 7 References** lists the references during development of this Work Plan.

The appendices include the following:
- **Appendix A** is the FSP. This document presents the field methods and procedures to be employed during the RI field investigations at OU1 and OU2 to provide data that are of known quality and quantity to support decision making.
- **Appendix B** is the QAPP. This document provides the analytical methods and quality assurance/quality control (QA/QC) measures that will be employed to assure that data collected are of acceptable quality and sufficient quantity to support decision making.
- **Appendix C** is the HSP. The HSP provides guidance and procedures to satisfy health and safety requirements. The HSP describes environmental monitoring procedures, personal protection protocols, site safety protocols, medical surveillance guidelines, site control procedures, and emergency response procedures. Potential health and safety risks for the investigation are also identified.

1.2 SITE DESCRIPTION, HISTORY, AND CURRENT USE

1.2.1 Site Description and Current Use

Garvey is located southwest of the city of Hastings in Adams County, Nebraska. The township and range coordinates are NW¼ of Section 23, T7N, R10W. The street address is 2315 West Highway 6, Hastings, NE 68901. Figure 1.2 shows an aerial overview of the elevator property and nearby buildings. The site property is bounded on the north by U.S. Highway 6/34, on the east by the Burlington Northern and Santa Fe (BNSF) railroad track, on the west by Marion Road, and on the south by farmland owned by the Walter Family Trust. The site property currently consists of two land parcels (ID 010003207 and ID 070002308) (Adams County, 2009). The legal description of parcel ID 010003207 is 23-07-10 N1/2 North & West of railroad with exception, 23-7-10 Denver Township ~ known as elevator site and highway frontage (2220) 22.09AC/LT~. The legal description of parcel ID 010003208 is 23-07-10 N1/2 North & West of railroad with exception, 23-7-10 Denver Township, excludes ~elevator site – (including elevator site & highway frontage) ~ (4201) 83.82AC/LT (Adams County, 2009).

The facility is an active 8-million bushel capacity grain elevator currently owned and operated by AGP. Garvey Elevators, Inc. owned the facility from its construction in 1959 until 2005. Garvey Elevators operated the site from 1959 until April 1998, at which time a put through agreement with AGP became effective. In September 2005, Garvey Elevators, Inc., AGP, and EPA entered into an agreement that allowed AGP to purchase the property (USEPA, 2003).

The site property as described above encompasses approximately 106 acres, 22 of which have historically been used for facility operations. The facilities at the Garvey Elevator terminal consist of a concrete elevator head house and elevator, flat storage building, steel storage bins, and associated buildings for facility maintenance, offices and breakroom, and chemical storage. The majority of the remaining 84 acres of property are used for crop production. The

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area surrounding the site is rural with a sparse distribution of residential properties north, east and west of the site. The closest residence is immediately adjacent to northeast boundary of the site property approximately 1,200 feet north of the grain storage elevator.

The EPA "site" is an area of soil and groundwater contamination that consists of the Garvey Elevator property at 2315 West Highway 6, Hastings, Nebraska. This area has been designated by the EPA as OU1.The associated contaminated groundwater plume that extends from the site to approximately three miles east of the site has been designated as OU2. The site layout is shown on Figure 1.2.

1.2.2 General Site History

Garvey Elevators began operation as a grain storage facility in 1959. Garvey Elevators, Inc. stated in their responses to the Request for Information Pursuant to Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), that Garvey utilized a liquid mixture of carbon tetrachloride and carbon disulfide (80/20 mix) and as a grain fumigant from 1959-1985 (USEPA, 2003). In interviews conducted by EPA and HGL in October 2008, ethylene dibromide (EDB) also was a minor component of this fumigant mixture (HGL, 2008a). Further information from these interviews is included in Section 4.0

In 1960, Garvey Elevators, Inc., installed an approximately 3,000-gallon above ground storage tank (AST) to the north of the silos to store the liquid fumigant. The fumigant was piped up to the grain gallery from the AST via an underground pipe that exited the subsurface and extended up the north side of the silos to the gallery. Fumigant was applied from the top of the elevator gallery (HGL, 2008a). According to one background document in the project file, a buried portion of this delivery pipe was found to be leaking and was replaced sometime before 1986 when the tank was removed (ENSR, 2005). However, during the 2008 interviews conducted by EPA and HGL, none of the five former employees of Garvey Elevator interviewed could recall replacement of broken piping. However, four of the five interviewees stated that the fittings had leaks, or staining was observed around the tank (HGL, 2008a). The facility ceased use of the liquid fumigant in 1985. Section 4.0 includes a detailed discussion of potential sources, particularly the liquid fumigant AST and piping used to convey the fumigant to the stored grain.

Garvey Elevator was first identified as a source of carbon tetrachloride contamination in 1994 when an on-site water sample collected during a Phase I Environmental Site Assessment (ESA) revealed the presence of carbon tetrachloride at 199 micrograms per liter (μg/L) in an on-site water supply well (Terracon, 1994). This concentration exceeded the EPA Maximum Contaminant Level (MCL) of 5 μg/L. The ESA was conducted at the behest of AGP as part of their due diligence procedures prior to purchasing the Garvey Elevator property. Garvey Elevator subsequently conducted several environmental investigations in the vicinity of the Site to determine the occurrence of carbon tetrachloride in soils and groundwater near the elevator, evaluate remedial alternatives, and estimate the costs of the Remedial Action (RA).

From 1994 through 2007, Garvey installed 47 groundwater monitoring wells, and completed

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numerous soil and soil gas sample borings. In 1999, Garvey installed an SVE system and GET system in response to the soil and groundwater contamination at the site. Garvey also began sampling residential and business wells, and providing alternative water supplies for wells impacted by the carbon tetrachloride released from the site into groundwater.

1.2.3 Regulatory History

As noted above, the release of carbon tetrachloride was first discovered at Garvey during a 1994 Phase I ESA. The chronology of subsequent regulatory actions at the site is summarized below:

- In April 1995, Garvey Elevator entered the Nebraska Department of Environmental Quality's (NDEQ's) Remedial Action Program Monitoring Act (RAPMA) Voluntary Cleanup Program (VCP). While in the VCP, Garvey conducted further site characterization, installed the GET and SVE systems, and provided alternative drinking water sources to impacted residents.
- In April 2003, NDEQ conducted a preliminary assessment/site inspection (PA/SI) of the Garvey Site to assess the threat to human health and the environment and identify the sources of groundwater contamination (TetraTech, 2003).
- In August 2003, Garvey Elevators, Inc. indicated that they would not remediate the entire contaminated groundwater plume while participating in the VCP (USEPA, 2008a).
- On December 9, 2003, NDEQ requested EPA assistance because they were concerned about the ability of Garvey Elevators, Inc. to address the contamination associated with the grain elevator property (USEPA, 2008a).
- On September 14, 2005, the Garvey Elevator Site was placed on the National Priorities List (NPL).
- On September 28, 2005, Garvey Elevators, Inc., AGP, and EPA entered into an agreement to allow proceeds from the sale of the grain elevator to AGP to be used for investigation and site cleanup (USEPA, 2005b).
- In October 2005, Garvey Elevators, Inc. signed an Administrative Order on Consent (AOC) with EPA to conduct RAs and an RI/FS (USEPA, 2005a). In the AOC, Garvey agreed to conduct investigation and source area treatment activities at the Garvey Elevator Site. In a separate Agreement with AGP, Garvey Elevators, Inc. placed money into an escrow account to fund response actions at the site. The AOC and Agreement were issued pursuant to Sections 104, 106(a), 107, and 122 and to Section 102(h)(1) of CERCLA.
- In March 2008, Garvey Elevators, Inc., filed Chapter 7 bankruptcy. EPA has taken over ongoing removal activities including providing alternative water supplies to impacted residents, and operation and maintenance (O&M) of the GET and SVE systems.

1.3 AREA GROUNDWATER CONTAMINATION

Groundwater in the City of Hastings and in the area southeast of the city supplies water for home and business use, and for crop irrigation and livestock watering. The source of most

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groundwater used in the region encompassing the city of Hastings and surrounding communities is the unconsolidated Pleistocene aquifer that extends from the water table at approximately 115 feet below ground surface (bgs) to bedrock at approximately 230 feet bgs. It is an important natural resource in an area with limited surface water availability. This laterally extensive aquifer has generally high transmissivities that can range up to 200,000 gallons per day per foot (gpd/ft) (Keech and Dreeszen, 1968).

As early as 1983, the State of Nebraska had concerns regarding volatile organic compound (VOCs) in groundwater, including commercial grain fumigants that were detected in the Hastings municipal water supply. Municipal supply wells #13 and #14 were taken out of service as a result of contamination, and other contaminated municipal wells have been placed on standby. Community Municipal Services, Inc., a private water supply system formerly servicing the areas east of Hastings, also took two of its three wells off-line due to contamination (USEPA, 2006).

In addition to the Garvey Elevator Site, there are two other NPL sites within or adjacent to the city of Hastings. The Hastings Groundwater Contamination site includes properties within the central industrial area of the City of Hastings and properties situated east of the city limits including the former Naval Ammunition Depot (NAD). The Hastings site was placed on the NPL in 1986. The other NPL site is the West Highway 6 & Highway 281 site, which was placed on the NPL in 2006. The site includes a former chrome plating facility that operated vapor degreasers.

The Hastings Groundwater Contamination site was divided into seven subsites for investigative and remediation purposes based on geographic and contaminant source area characteristics (USEPA, 2006). The seven subsites are: Well No. 3, Colorado Avenue, Second Street, North Landfill, FAR-MAR-CO, South Landfill, and the former NAD (Figure 1.3).

The subsites and their approximate source area locations are as follows:

- Well M-3 Subsite, located between B and 2nd streets and Maple and St. Joseph avenues
- Colorado Avenue Subsite, located just south of 2nd Street and the BNSF rail line
- North Landfill Subsite, located northeast of the intersection of West Highway 6 and Showboat Road
- South Landfill Subsite, located northeast of the intersection of Elm Avenue and J Street, along an abandoned Union Pacific Railroad right-of-way
- Second Street Subsite, located at the intersection of Second Street and Minnesota Avenue
- FAR-MAR-CO Subsite, located east of the North Landfill subsite along West Highway 6
- Naval Ammunition Depot (NAD), located about 2 miles east of the Hastings city limits in an area referred to as the Hastings East Industrial Park

Cleanup of the former NAD is being addressed by the Army Corps of Engineers. The remaining subsites are being addressed by EPA and/or potentially responsible parties under various subsite-specific and "Area-Wide" actions. OU19 is the Area-Wide OU of the Hastings

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Groundwater Contamination site. Additional information regarding the Hastings Groundwater Contamination site and the West Highway 6 and Highway 281 Site can be found in the Administrative Record at the Hastings Public Library (517 W. 4th Street), which is the repository for EPA site information.

The Hastings City Council recognized that "certain contaminants" existed in the groundwater underlying the City of Hastings, and that legislation was necessary and appropriate for the purpose of reducing or eliminating the possibility that humans would come into contact with the contaminants. Therefore, the Hastings City Council enacted Ordinance No. 3754-11/2000 to amend Chapter 32 Article VI, and Chapter 38, of the Hastings City Code, and established the Hastings Institutional Control Area (HICA). The effective date of the ordinance was January 1, 2001. This ordinance is a component of the selected remedy for the Area-Wide OU of the Hastings Groundwater contamination site.

Under the terms of the HICA, existing water wells that fell within the HICA, where groundwater contamination was known to exist, were allowed to remain in place, provided that reasonable safeguards were implemented to prevent human contact with contaminated groundwater. Agricultural irrigation wells and wells for noncontact business use are permissible under the ordinance as long as adequate safeguards are in place to prevent human consumption of water from these wells. No new domestic water wells are allowed to be installed within the HICA.

The ordinance also established the policies and procedures for the registration of all existing water wells, and the requirements for permitting new nonpotable water wells within the HICA and within two miles of the City corporate limits. The geographic area of the HICA, and inferred groundwater plumes from various sites discussed within the HICA, are shown on Figure 1.3.

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FIGURES

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Filename: X:/EPA009/Garvey/RI_FS/Site_Loc_Map.mxd
Project: EP9033.01.46.11
Revised: 05/15/09 CV
Source: ESRI StreetMap USA
Nebraska DNR

HGL HydroGeoLogic, Inc

CDM

Figure 1.1
Site Location Map
Garvey Elevator Site
Hastings, NE

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Figure 1.2
Current Site Map

Legend

- Site Boundary
- Concrete Paved Area
- Buildings
- Gravel Road
- Railroad

0 200 400 800
Feet

N

Filename: X:/EPA009/Garvey/RI_FS/SiteMap.mxd
Project: EP9033.01.46.11
Revised: 05/13/09 CV
Source: ENSR GDB 2008, DNR

United States Environmental Protection Agency
HGL HydroGeoLogic, Inc
CDM

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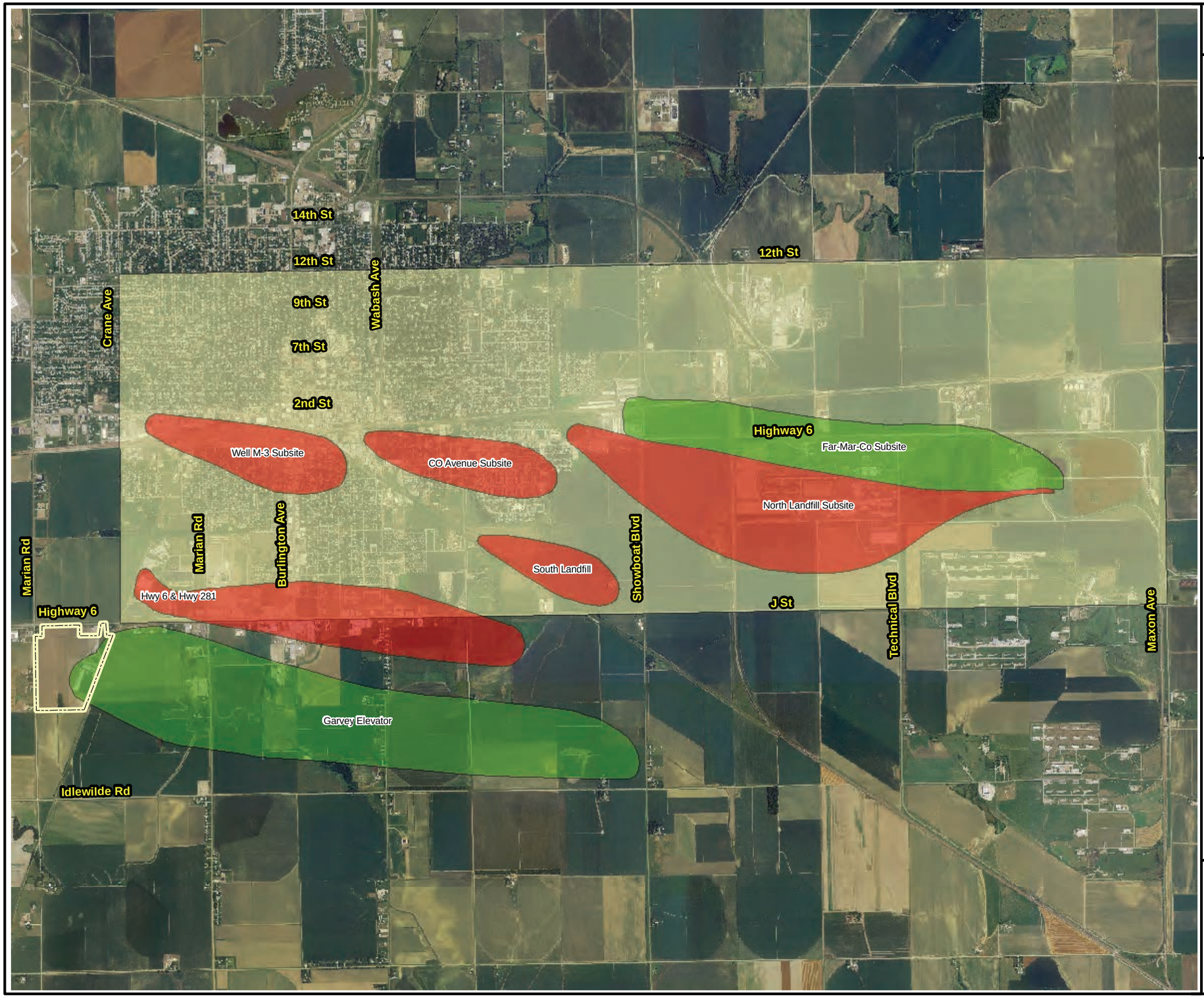
Figure 1.3
Hastings Institutional Control Area and Areas of Groundwater Contamination



Legend

- Site Boundary
- Hastings Institutional Control Area
- Approximate CCL_4/EDB Groundwater Contamination Plume
- Approximate Chlorinated Solvent Groundwater Contamination Plume

N

0 1,500 3,000 6,000
Feet

Filename: X:/EPA009/Garvey/RI_FS/ Institutional_Control_Area_GW_Contamination.mxd
Project: EP9033.01.46.11
Revised: 5/13/09 CV
Source: NDEQ, 1996; Hastings Utilities, 2005, Nebraska DNR Draft RI Report W. Hwy 6 & Hwy 281, Nov. 2008

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2.0 SITE BACKGROUND AND SETTING

2.1 PHYSICAL SETTING AND LAND USE

The site is located within the Loess Plains, a portion of the Great Plains physiographic province. The topography of the area is relatively flat, with a slight slope to the east-southeast (Figure 2.1) (USGS 1969, revised 1983). The Platte River valley lies 15 miles north of the site and flows to the northeast, and the Little Blue River valley lies 10 miles to the south and flows toward the east.

Surface soils in the vicinity of the site consist of silt-loam (USDA, 1974). The elevation is approximately 1,930 feet above mean sea level (amsl). The Hastings area is underlain by approximately 200 to 240 feet of unconsolidated Pleistocene Age deposits lying unconformably on Upper Cretaceous Age Niobrara Formation, an argillaceous chalk and limestone formation containing interbedded layers of chalky shale (Condra et al., 1947 and Dreeszen et al., 1973). Ground water is generally encountered at depths between 100 and 130 feet bgs.

Surrounding land use is primarily agricultural with a mixture of urban and industrial use to the north and east. Land use along the Highway 6 corridor north of the site is primarily zoned commercial and industrial. Figure 2.3 shows the zoning designations of the site and surrounding properties. The nearest residential developments are approximately 1 mile to the northeast and east. However, isolated residences lie within ½ or ¾ of a mile from the site. The zoning designations of the properties affected by ground water contamination associated with the site include the following:

- A – Agricultural
- I-1 – Light Industrial
- I-2 – Heavy Industrial
- R-1 – Urban Single-family residential

Hastings is situated within the Little Blue Natural Resources District. Under the provisions of the Rules and Regulations for Enforcement of this district, the site is within a Wellhead Protection Area; therefore, wells that pump more than 50 gallons per minute (gpm) can not be installed without first being permitted (Layne GeoSciences, 1997). Though there are expected to be some private wells in use within the affected area, businesses and residences having wells that are known to be contaminated have been placed on alternative water supplies.

2.2 REGIONAL CLIMATE

The City of Hastings is located in Adams County, Nebraska. Nebraska's climate is typical of the interior of large continents in the middle latitudes and large seasonal variations in both temperature and precipitation are common. The temperature and precipitation data that follows was drawn from *Comparative Climatic Data for the United States through 2007* (National Climatic Data Center, www.ncdc.noaa.gov). The U.S. Climate Normals Data report is a compilation of normals, means, and extremes for climatological elements for weather reporting

stations throughout the United States. Climatological normals are defined in the report as "30-year average values that are updated decennially."

For the period from 1971 to 2000, the Hastings 4N, NE station experienced normal daily maximum temperatures ranging from 33.6 degrees Fahrenheit (°F) in January to 87.9 °F in July, and "normal daily minimum temperatures" ranging from 13.6 °F in January to 64.2 °F in July. The highest recorded temperature was 110 °F and the lowest was -23 °F. The mean number of days per year with temperatures at or below 32 °F was 143.2, and the mean number of days per year with temperatures at or above 90 °F was 41.6.

For the period from 1971 to 2000, the normal precipitation in inches ranged from 0.55 in January to 4.59 in May, with an annual average of 27.94 inches. The mean number of days per year with precipitation of 0.01 inches or more was 84.5, and snowfall averaged 26.5 inches per year.

2.3 HYDROLOGY

The local drainage basin consists of gently rolling loess plains and small meandering streams that occupy wide shallow valleys. The nearest named perennial surface water feature to the site is Pawnee Creek, which is located about 0.5 miles south-southeast of the site (Figure 2.1).

There are no storm drains on the site; therefore, surface water drainage generally follows typography. Drainage is poor in the area north of the silos in the area of the maintenance and storage buildings and office because the site sets on a generally flat area that likely ponds water. Drainage to the east is curtained by the railroad tracks, which diverts surface waters on the very eastern portion of the site property between the rail spur and the railroad tracks northward towards Highway 6 (Figure 2.2). The area surrounding the flat storage grain building in the middle of the property drains surface water to the south-southwest from both the east and west. Eventually the runoff enters a broad nondescript drainageway that discharges to Pawnee Creek approximately 4,600 feet from the south boundary of the site property. The west side of the immediate facility area drains into the cropland in the western portion of the site property, where runoff is eventually diverted south in a drainageway that bisects the crop field (Figure 2.2). A small pond lies at the end of this drainageway at the property boundary. It is not know if this pond is perennial.

Regionally, surface water flow is toward the south-southeast to the Little Blue River, which is about 8 miles south of the City of Hastings.

2.4 GEOLOGY

2.4.1 Regional Geology

Adams County lies adjacent to the north-south axis of the Salina Basin which formed by the deformation of crystalline Precambrian rocks. The Salina Basin extends from central Nebraska into north-central Kansas. The thickest sedimentary rock accumulations in Nebraska are found

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within the Salina basin (Miller and Appel, 1997). The Precambrian rocks are overlain by the Upper Cretaceous Age Niobrara Formation, which consists of yellow and light- to dark-gray marine chalky shale and chalk. The Niobrara surface in the area slopes uniformly to the southwest at an approximate gradient of 0.01 foot per foot. In the north-central portion of Adams County the Niobrara Formation is overlain by the Upper Cretaceous Age Pierre Shale, which can be described as a gray to black marine shale and a chalky shale. The uppermost portions are weathered and contain gray silty clay (Woodward Clyde, 1990). The Tertiary Ogallala Formation only occurs as buried knobs in the south and western portions of Adams County (Keech and Dreeszen, 1968).

The Adams county area is underlain by approximately 100 to 500 feet of unconsolidated deposits of Pleistocene age lying unconformably on Pierre Shale, or Niobrara Formation where the Pierre Shale is absent. The Niobrara Formation is an argillaceous chalk and limestone containing interbedded layers of chalky shale (ERM, 2003). The weathered surface of the Niobrara Formation has the appearance of massive clay rather than shale or limestone.

The unconsolidated deposits consist of the Peoria Loess, Loveland Loess, and other Pleistocene sand and gravel deposits. The Peoria and Loveland loess consist of silts and clayey silts that were deposited during the Wisconsin and Illinois glaciations, respectively. An interglacial soil named the Loveland Soil separates the loess units (ERM, 2003). Pleistocene sands and gravels occur below the loess units and range in thickness from 130 to 200 feet. These are stream-deposited sands and gravels containing thick, regionally discontinuous layers of clay and silt. Gravel beds occur within this unit and can be as thick as 10 feet. The local groundwater table usually occurs within this unit.

2.4.2 Site-Specific Geology

The general geology underlying the Garvey Elevator site is summarized in the following paragraphs based on the Site Characterization Report (HWS, 1995) and the Preliminary Assessment/Site Inspection (PA/SI) report (Tetra Tech EM, 2003).

Unconsolidated materials from the ground surface to approximately 70 feet bgs consist largely of loess and interbedded alluvium; silt, clay, and fine sand deposits that occur as single stratigraphic components or in various admixtures. Paleosols (a buried soil representing a former ground surface) may also be present within the loess deposits.

Locally, the Pleistocene loess is composed of two units: the Wisconsin-age Peoria Loess, and the Illinoisan-age Loveland Formation. The Loveland is generally sandier than the Peoria and shows greater Paleosol development. Loveland sediments are also generally redder in color than the Peoria sediments.

Pleistocene sands and gravels occur below the surficial loess and alluvium and extend to the bedrock surface. The Pleistocene sands and gravels are stream deposits that may contain thin discontinuous layers of silt and clay. The sands tend to become coarser with increasing depth and gravel beds up to 10 feet thick have been reported. The groundwater surface or static

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water level occurs within this unit.

Two clay layers are reported to occur within the Pleistocene sands and gravels underlying the Garvey Elevator site; one at approximately 130 feet bgs and the second at approximately 150 feet bgs. The clay layers are reported to vary in thickness from 1 to 7 feet and are not found east of the site.

ENSR, the most recent contractor for Garvey, installed four monitoring wells to the east of the east property boundary along the railroad tracks in Spring 2007. They did not distinguish a fine-grained unit at any depth. However, the logs for well boreholes MW-19, MW-20, and MW-31, show very fine sand with silt between 130 feet to 135 feet bgs. Additionally, ENSR was logging the boreholes every 2.5 feet to 5 feet, not continuously, and may not have identified the finest-grained portion of a "fine-grained unit".

At the West Highway 6 & Highway 281 site, approximately ½ to ¾ of a mile to the northeast, a single fine-grained unit of variable composition and thickness was encountered within the Pleistocene deposit. The fine-grained unit was encountered at depths ranging from 114.8 to 130 feet bgs, with an average depth of 123.8 feet bgs. This singular fine-grained unit was observed from the site to approximately 2.9 miles downgradient to the southeast. Electrical conductivity (EC) logs and core samples indicated that the unit consisted of silt, clay, silty clay, clayey silt, or clayey sand, and the thickness ranged from 0.5 to 6.5 feet bgs depending on location.

Figure 2.4 illustrates a generalized hydrostratigraphic column based on the 1995 HWS Site Characterization report and the 2008 HGL RI report for the West Highway 6 & Highway 281 Site located north of Garvey Elevator approximately 0.25 mile.

2.5 HYDROGEOLOGY

2.5.1 Regional Hydrogeology

Hastings is located in the Little Blue River Natural Resource District (Steele and Wigley, 1992). Depth to ground water in the Hastings area is typically about 100 feet bgs with localized zones of perched ground water that can occur as shallow as 7 to 10 feet bgs (Layne, 1997). The regional ground water flow generally follows the direction of the Little Blue River toward the east to southeast (NDEC, 1980).

The principal aquifer for Hastings is the Pleistocene aquifer. The aquifer is typically 100 to 150 feet thick in the Hastings area (NDEC, 1980). The Pleistocene aquifer is composed of unconsolidated sand and gravel that extends from about 100 feet bgs to the top of the Niobrara Formation which is about 233 feet bgs (HGL, 2008b).

Groundwater from the Pleistocene aquifer in the Hastings area is used for municipal, domestic, and agricultural use. Due to high use of the Pleistocene aquifer, the water table has dropped more than 20 feet between pre-1950s and 1992 (Steele and Wigley, 1992).

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Transmissivity ranges from more than 200,000 gpd/ft in the central part of the county, to less than 50,000 gpd/ft in the northeastern corner and southernmost portions of the county (Keech and Dreeszen, 1968).

2.5.2 Site-Specific Hydrogeology

The Garvey Elevator site is situated in the southwestern portion of Hastings and lies approximately 1,500 feet outside the legal boundary of the HICA (enacted by the City of Hastings under Ordinance No. 3754 of the Hastings City Code). Groundwater typically occurs between 110 to 115 feet bgs at the site. HWS determined that three aquifer zones exist at the site based on the lithologic descriptions for their monitoring well boring logs. These three aquifer zones have previously been referred to as the upper, medial, and lower zones (Figure 2.4) (HWS, 1995).

The upper aquifer zone is unconfined and extends from about 115 feet bgs to 130 feet bgs. The upper fine-grained unit forms the base of the upper aquifer (Figure 2.4). The medial aquifer zone extends from the bottom of the upper fine-grained unit to the top of the lower fine-grained unit at approximately 150 feet bgs. The lower aquifer zone is believed to be from approximately 155 feet bgs to 240 feet bgs. The weathered shale of the Niobrara formation forms the base of the aquifer.

There is a discrepancy between HWS and ENSR with regard to the fine-grained units, as was noted above in Section 2.4.2. HWS noted both fine-grained units were present, while ENSR indicated neither existed. Based on HGL's review of the available lithologic information, it is believed that the upper fine-grained unit is present; however, there may be no distinction between the middle and lower aquifers at the site. HWS also noted in their report, that neither fine-grained unit was present to the east of the Garvey site. HGL did find the upper fine-grained unit to be present east of the Highway 6 and Highway 281 Site in the area north and east of the Garvey Elevator Site. These hydrostratigraphic questions and discrepancies will require resolution during the RI.

According to HWS, groundwater flow in all aquifer zones is to the east-southeast based on water levels in the site monitoring wells (HWS, 1995). Based on four pumping tests with various configurations, pumping rates, and durations, HWS concluded that the hydraulic conductivity in the upper aquifer was approximately 100 feet per day (ft/day), and was approximately 270 ft/day in the medial and lower aquifers.

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FIGURES

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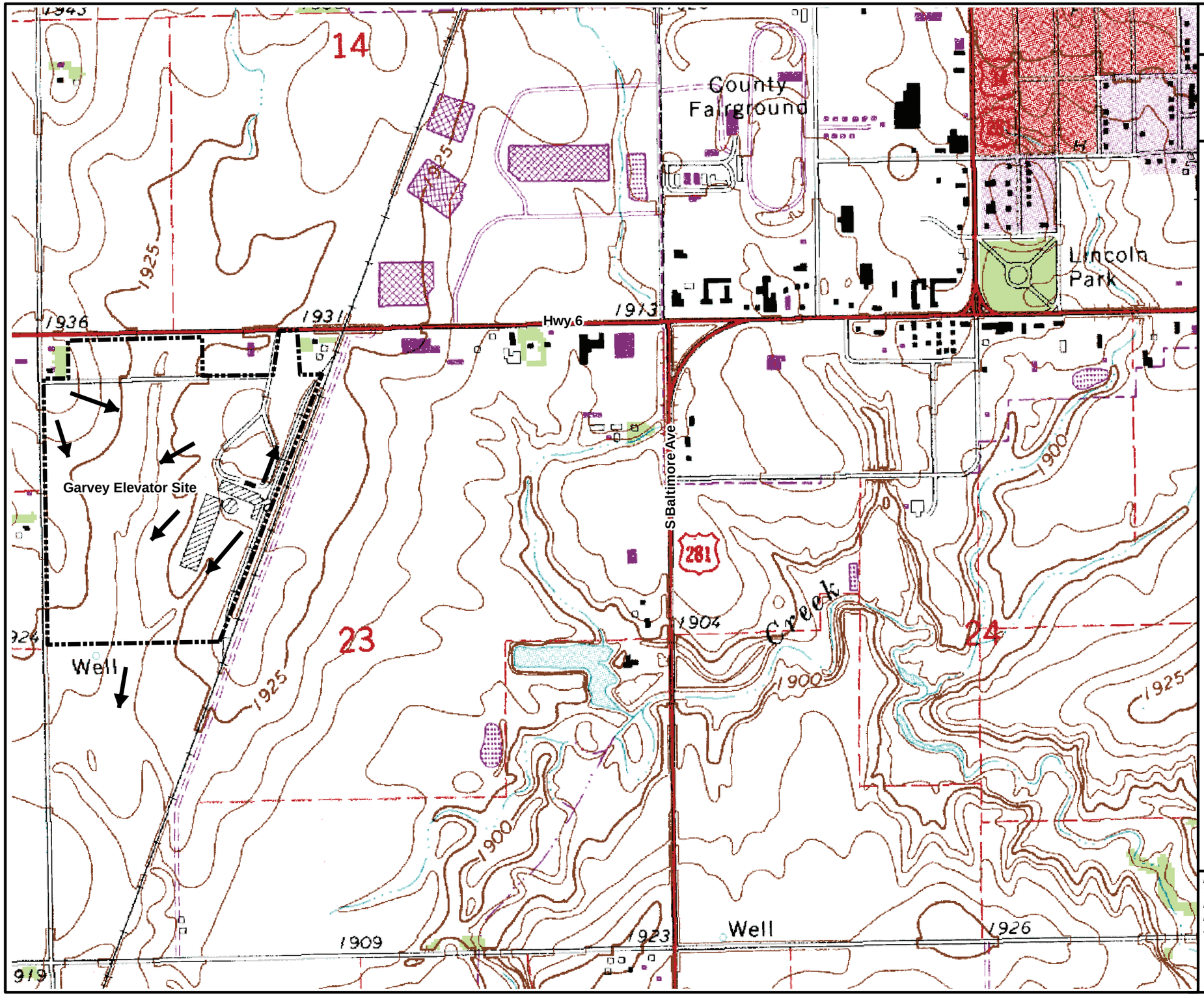
Figure 2.1
Garvey Elevator Site
Topography/Hydrology

Legend

Site Boundary

Surface Water Flow



0 450 900 1,800

Feet

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Project: EP9033.01.46.11
Revised: 05/15/09 CV
Source: USGS, 1983

United States Environmental Protection Agency

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CDM

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HGL—Work Plan, Remedial Investigation/Feasibility Study, Garvey Elevator Site—Hastings, NE

Figure 2.2
On-Site Drainage

Legend

- Site Boundary
- Culverts
- Buildings
- Former Steel Grain Bin
- Concrete Paved Area
- Gravel Road
- Railroad
- Drainageways

0 150 300
Feet

N

Filename: X:/EPA009/Garvey/RI_FS/OnSite_Drainage.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

United States Environmental Protection Agency

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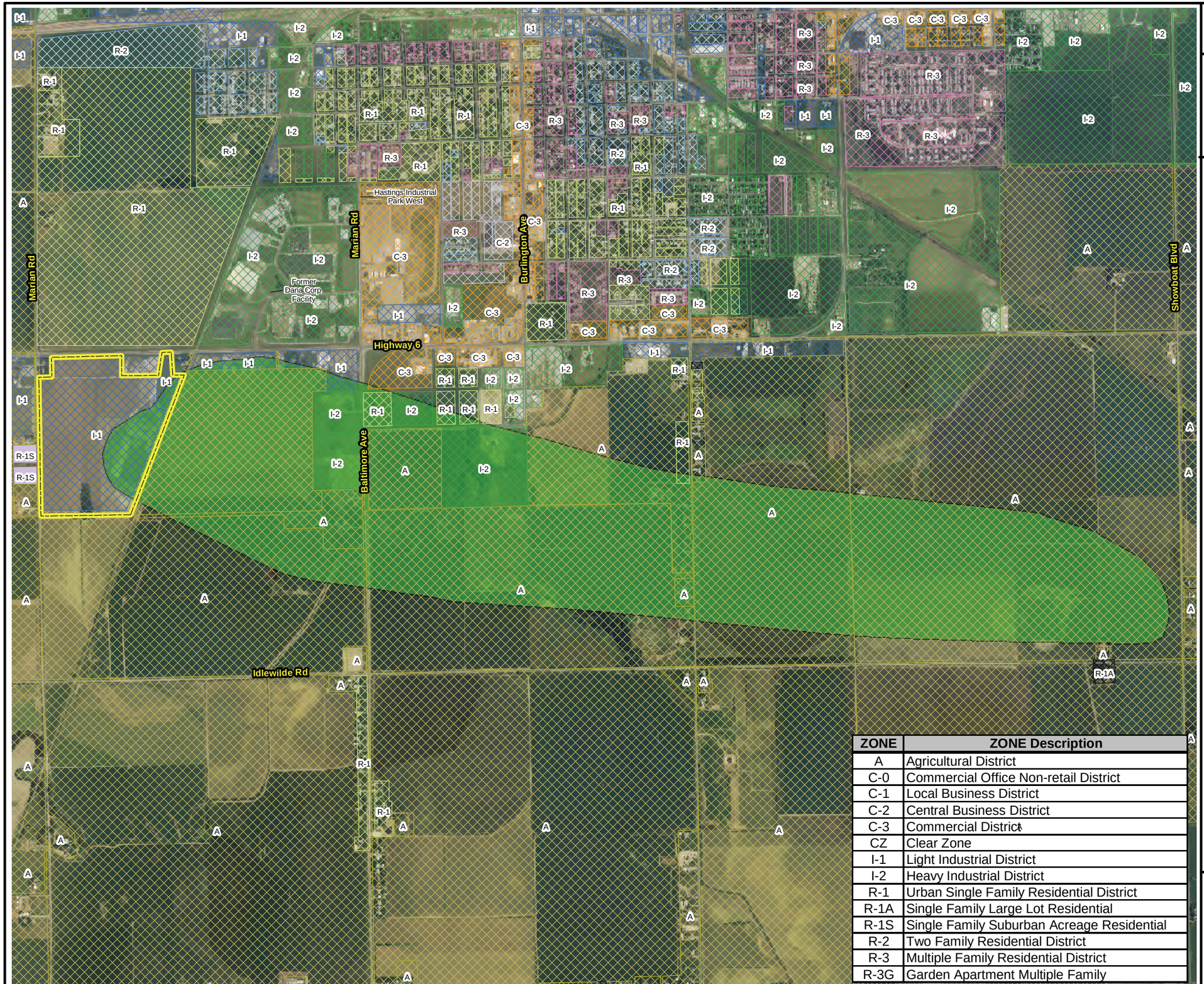
Figure 2.3
Zoning Areas Affected by Groundwater Contamination



ZONE	ZONE Description
A	Agricultural District
C-0	Commercial Office Non-retail District
C-1	Local Business District
C-2	Central Business District
C-3	Commercial District
CZ	Clear Zone
I-1	Light Industrial District
I-2	Heavy Industrial District
R-1	Urban Single Family Residential District
R-1A	Single Family Large Lot Residential
R-1S	Single Family Suburban Acreage Residential
R-2	Two Family Residential District
R-3	Multiple Family Residential District
R-3G	Garden Apartment Multiple Family

Legend

Approximate Chlorinated Solvent Groundwater Contamination Plume

Site Boundary

Zones

- A
- C-2
- C-3
- I-1
- I-2
- R-1
- R-1A
- R-1S
- R-2
- R-3

N

0 800 1,600 3,200

Feet

Filename: X:/EPA009/Garvey/RI_FS/Affected_Zoning_Areas.mxd
Project: EP9033.01.46.11
Revised: 05/14/08 CV
Source: NDEQ, 1996; Nebraska DNR Hastings Utilities, 2005,

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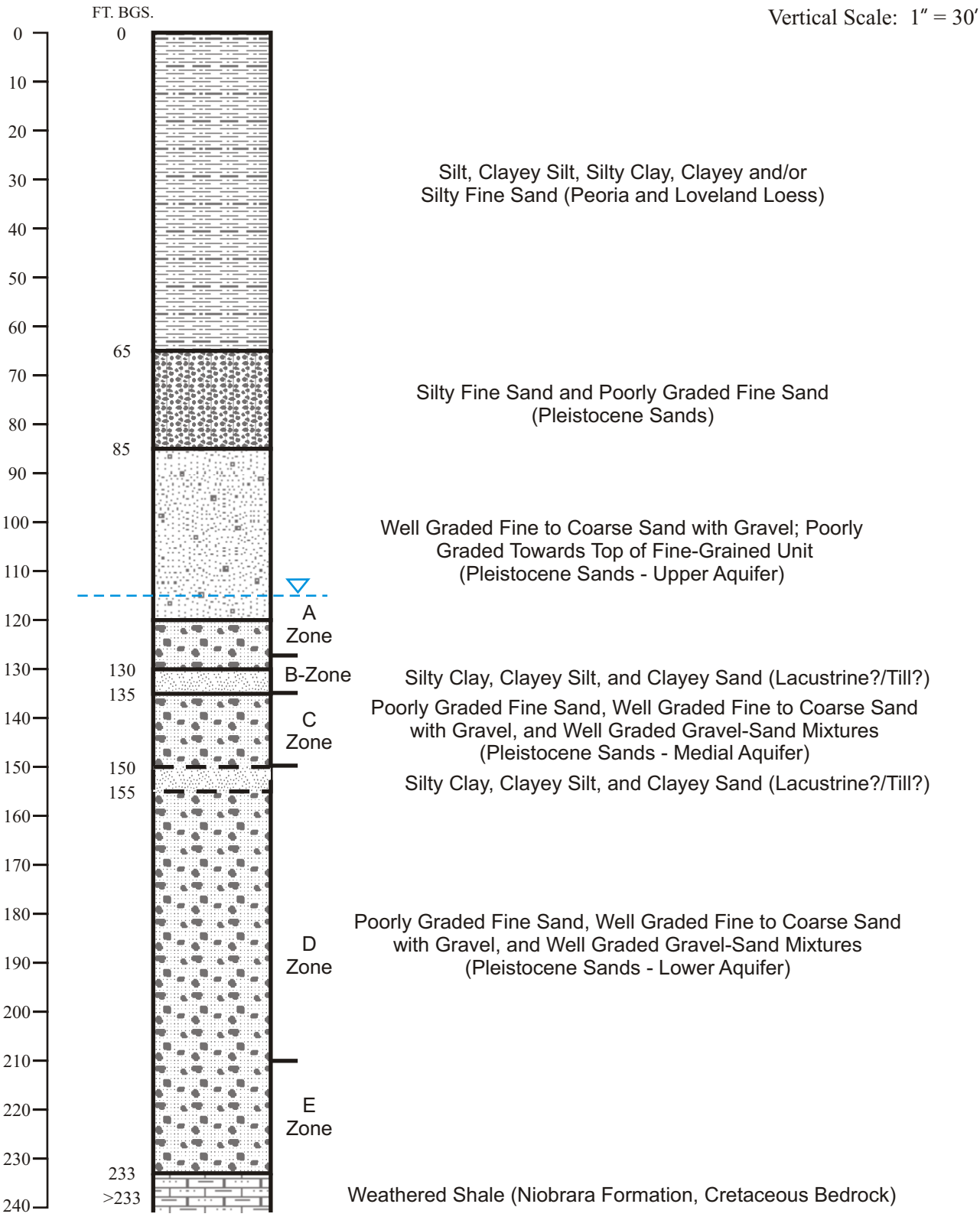

Filename: X:/EPA009/Garvey/RI-FS/
General_Hydrostratigraphic_Column.cdr
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: HGL

HGL HydroGeoLogic, Inc

Note
A Zone: Water Table Zone, Upper Aquifer
B Zone: Uppermost Fine-Grained Unit/ Base of Upper Aquifer
C Zone: Medial Aquifer
D Zone: Upper Portion of the Lower Aquifer
E Zone: Lower Portion of the Lower Aquifer

Figure 2.4
Generalized Hydrostratigraphic Column
(Based on Boring Logs from HWS,1995 and HGL, 2008)

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3.0 PREVIOUS INVESTIGATIONS AND RESPONSE ACTIONS

3.1 KNOWN AND POTENTIAL SOURCE AREAS

A primary on-site source area for the carbon tetrachloride has been identified at the Garvey Elevator site from previous investigations. This source area is the location of the former liquid fumigant AST that held carbon tetrachloride and carbon disulfide. A leak in the underground carbon tetrachloride distribution piping between the tank and the elevator silos structure was reported to be the principal cause of the soil and groundwater contamination at the site. The tank was formerly located on the north side of the grain silos, with underground piping extending south to the silo and then up the outer wall of the silo. Figure 3.1 illustrates potential source areas.

The tank and distribution piping were installed in 1960 and decommissioned and removed from the site in 1986. Site characterization work conducted by HWS in 1995 identified the vadose zone soil beneath the Garvey elevator site as an ongoing groundwater contaminant source. Previous employees have indicated that a leak in the distribution piping had occurred, but Garvey had no knowledge of what year or how much product was lost before the leak was repaired (Garvey, 2003). Also, during an interview with HGL and EPA in Fall 2008, a former employee stated that the fitting between the piping and tank leaked. He said the fitting was replaced when the leak increased from drips to a steady stream (HGL, 2008a).

In addition to carbon tetrachloride, other pesticides are, or were, used at the site. The 2003 PA/SI conducted by NDEQ included the following table of previous and current pesticide use at the site, and the locations where these chemicals were stored (Table 3.1). This information is based on the response to the CERCLA 104E request letter submitted to Garvey Elevator as part of the PA/SI activities. (TetraTech, 2003; Garvey, 2003).

There also are potential sources of contamination that were identified during the Phase I ESA, but were not assessed during that investigation. These source areas include (Figure 3.1):

- A 500-gallon diesel fuel AST
- Ground mounted electrical transformers exhibiting oil stained surfaces and lacking clear labeling regarding polychlorinated biphenyl (PCB) content of dielectric oil
- Pesticide storage building
- Multiple locations where various containers of roofing materials, paints, and petroleum products are stored
    - Shop Building
    - Machine Room
    - Outdoor Drum Storage

A detailed discussion of known and potential source areas and their associated contaminants of concern and potential contaminants of concern is provided in Section 4.0 below.

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3.2 NATURE AND EXTENT OF CONTAMINATION

This section provides an overview of the nature and extent of contamination at the site as interpreted from analytical results published in reports of previous investigations conducted by the potentially responsible party (PRP), EPA, or NDEQ. Subsections are organized by media: surface soils, subsurface soils, soil gas, and groundwater. The discussion focuses on carbon tetrachloride, chloromethane, chloroform, dichloromethane, carbon disulfide, and EDB. These are the primary chemicals of concern (COCs) at the site. Any previous PRP-lead response actions, NDEQ-lead site investigations, and EPA-lead removal actions are described within each subsection (if applicable). A chronological listing of previous contamination investigations conducted at the Garvey Elevator Site is provided in Table 3.2.

It should be noted that the PRP and ENSR did not generate a report detailing their soil, soil gas, and groundwater investigation. Data collected for Garvey by ENSR was made available to HGL as unfinalized, unassembled background information. However, the majority of PRP activities were documented to EPA in a series of monthly progress reports.

3.2.1 Surface Soils

To date no surface soil samples (0 to 6 inches) have been collected at the site. Therefore, it is not known if surface soils at the site have been impacted by site-related contaminants.

3.2.2 Subsurface Soil

In June 1994, the PRP contractor HWS collected subsurface soil samples from 24 locations at a depth of 8 to 10 feet bgs. The Site Characterization report stated only that trace VOCs were detected in these soil samples (HWS, 1995). The PRP also collected 23 soil samples during the installation of the two vapor test wells, and stated eight samples contained carbon tetrachloride with the maximum concentration at 884 micrograms per kilogram (μg/kg) (HWS, 1995). The highest carbon tetrachloride concentration shown on the 1995 Site Characterization report Table 6 was 440 μg/kg, recorded at 101 feet bgs in SVE-D located between the former liquid fumigant AST and the silos.

Based on soil samples and the soil gas samples results discussed below, the PRP concluded that carbon tetrachloride was present in on-site soils over a 502,655 square-foot area and down to the water table (HWS, 1995). Attachment 1 contains the soil data and soil boring locations from the 1995 Site Characterization report. On the data table, the SVE, SVM, and P sample locations are shown only on Figure 14 in Attachment 2. The SG and SP sample locations are shown on both Figure 14 and Figure 16 in Attachment 2.

Based on background information, it appears that in August 2007 the PRP contractor (ENSR) collected subsurface soil samples from seven of eight borings (red triangles indicated on Figure 1 in Attachment 2). No data were available for location DPT28. The samples were collected from various depths in each boring between 1 foot and 115 feet bgs. On Table 1 in

Attachment 2, the "Sample Description" indicates the location, depth from ground surface, and type of sample. For example, the 1-foot deep field sample from boring DPT7 is described as SO07D001SA, where "SO" indicates a soil boring, "07" indicates location DPT7, "D001" indicates 1-foot, and SA indicates a field soil sample (rather than a type of QC sample) (ENSR/AECOM, 2006).

These samples were analyzed in a mobile laboratory for carbon tetrachloride, chloromethane, EDB, carbon disulfide, methylene chloride, and chloroform. All results were nondetect for these target analytes (Data Table in Attachment 2).

Based on the combined soil sample data from the PRP-lead investigations, a soil source area does exist in the area of the former fumigant AST. However, the low levels carbon tetrachloride observed in soils in this source area do not indicate the presence of a significant residual contaminant source.

3.2.3 Soil Gas

The first soil gas data from the Garvey Elevator site was obtained by the PRP in Fall 1994, when a soil gas survey was conducted as part of the site characterization investigation (HWS, 1995). Soil gas samples were collected from 32 locations (SG-1 to SG-32) at a depth from 9 feet to 18 feet bgs. At three locations (SP-1 to SP-3) vertical profiling was conducted at three sample intervals: 8 feet to 10 feet bgs, 18 feet to 20 feet bgs, and 28 feet to 30 feet bgs. Table 6 and Figure 16 of the 1995 Site Characterization Report, which tabulate and illustrate the soil gas data, are provided in Attachment 1. The samples were analyzed in the field using GC/MS headspace methods (HWS, 1995).

As illustrated by Figure 16 in Attachment 1, the highest carbon tetrachloride concentrations, those greater than 20 μg/L, are centered between the elevator silos and the shop building where the former carbon tetrachloride AST was situated. It should be noted that 20 μg/L converts to 20,000 micrograms per cubic meter ($\mu g/m^3$); the conversion factor is 1 μg/L to 1,000 $\mu g/m^3$. The vertical profile boring SP-1 completed in the area of the former tank had a concentration above 29 μg/L at the deepest sample interval (28 feet to 30 feet bgs.). The entire area from the north side of the silos to the north side of the shop area, and trending east and west along the entire length of the silos had carbon tetrachloride concentrations in soil gas exceeding 10 μg/L. This 10 μg/L area also extended south beneath two-thirds of the flat storage building. The presence of carbon tetrachloride above 10 μg/L also extended north and west of the primary source area past the facility's west perimeter gravel drive.

Based on the results of their soil sampling effort discussed above, and the soil gas results, the PRP concluded that carbon tetrachloride was present in the vadose zone down to the water table (HWS, 1995).

From Fall 2006 to Spring 2007, the PRP contractor ENSR collected soil gas from every 10 feet from 10 feet bgs to 100 feet bgs, and at 115 feet bgs, at approximately 19 locations. Eleven figures illustrating these data are provided in Attachment 3; one figure was constructed

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for each 10-foot interval and the 115-foot sample depth. At 10 feet bgs, the only soil gas detection was 1,000 $\mu g/m^3$ in DPT7 located immediately south of the silos between the flat storage grain building and the large circular grain bin.

At 20 feet bgs, DPT7 had 390 $\mu g/m^3$, and DPT10 contained 833 $\mu g/m^3$. DPT10 is located north of the silos near the shop building. Between 20 feet and 40 feet bgs the area above 500 $\mu g/m^3$ expands to include a portion of the flat storage building to the south (Attachment 3 Figures for 30 feet bgs and 40 feet bgs). At 50 feet bgs, an area of carbon tetrachloride in soil gas above 2,500 $\mu g/m^3$ is centered on DPT7, with the 1,000 $\mu g/m^3$ and 500 $\mu g/m^3$ isoconcentration lines spreading out to the southeast to the east of the flat storage and underneath and to the east of the entire footprint of the silos.

At 60 feet and 70 feet bgs, the long axis of the 2,500 $\mu g/m^3$ isoconcentration area extends north and south of the silos throughout the majority of the property where the grain elevator facility buildings are situated. At 70 feet bgs, the highest carbon tetrachloride concentration (6,900 $\mu g/m^3$) was observed in DPT13 located approximately 150 feet north of the shop building.

In general, from 80 feet bgs to 115 feet bgs, there are three hot spots of carbon tetrachloride: one is situated east of the southern portion of the flat storage; the second is centered on DPT7, and the third is located north-northeast of the main area of buildings to the east of the scale. In this area to the east of the scale, carbon tetrachloride was detected at 79,900 $\mu g/m^3$ in DPT17. This was the highest concentration observed at 80 feet. At 115 feet, the highest carbon tetrachloride concentration (18,800 $\mu g/m^3$) was observed at DPT13.

Based on the soil gas sampling discussed above, it generally appears that the upper 50 feet beneath the facility has minimal carbon tetrachloride in soil gas. At 50 feet, the data indicates that an area of low concentrations is present beneath the west end of the silos in the general area of known carbon tetrachloride contamination. Below 50 feet to 80 feet, the area of relatively higher carbon tetrachloride concentrations increases in size to include the flat storage building the area to the east towards the rail lines. Below 80 feet there are more isolated carbon tetrachloride hot spots in the soil vapor. It should be noted that the approximate upper 65 feet of subsurface material consists of finer-grained silts and clays with fine sands. These deposits will inhibit lateral movement of contamination.

The only area identified by shallow soil gas sampling as a carbon tetrachloride source is in the vicinity of the former fumigant AST. The other two areas of higher carbon tetrachloride concentrations in soil gas are north of the buildings in the vicinity of the scale house, and south of the buildings on the southeastern portion of the property. The source of these hot spots is unknown. When soil gas samples are collected near the water table, it is likely that the soil gas data shows greater influence from volatilization of VOCs from the impacted groundwater. Also, the sediments from approximately 65 feet bgs to the water table at approximately 115 feet bgs, consist of sands with varying amounts of fines. These sediments will allow greater dispersal of contaminants in soil gas laterally then the loess units comprising the shallow

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sediments. The approximate upper 65 feet of the subsurface consists of the Peoria and Loveland loess, which will inhibit movement of soil gas. It is possible that a higher soil gas sampling density in shallow soils, or placement of sample borings at potential source areas, may reveal other carbon tetrachloride source areas. If other source areas were to be identified, their inclusion in the CSM might better explain the elevated carbon tetrachloride concentrations observed in other areas in the deeper unsaturated sediments.

3.2.4 Groundwater

In 1995, the PRP contractor HWS installed a network of 36 monitoring wells in the upper, medial, and lower aquifer both on site and off site (HWS, 1995). The well designations indicate the following: A-wells are completed across the water table and B-wells are completed at the uppermost fine-grained unit, both of these zones are in the upper aquifer. C-wells are completed in the medial aquifer between the upper and lower fine-grained units. D-wells are complete in the upper portion of the lower aquifer, and E wells are completed in the lower portion of the lower aquifer (Figure 2.4).

The initial analytical results included in the 1995 Site Characterization report show that carbon tetrachloride was detected in 19 of the 36 wells. The highest concentration (29,943 μg/L) was detected in MW-3B located north of the shop building approximately 250 feet. Carbon tetrachloride was detected above its MCL of 5 μg/L crossgradient approximately 800 feet north and northwest of the facility buildings. It also was detected above the MCL approximately 4,800 feet downgradient to the southeast.

Part of the site background information provided to HGL included analytical data from roughly 2002 and 2004 that was illustrated by the PRP contractor ENSR. Figure 1 in Attachment 4 illustrates the data from approximately 2002, and shows that numerous private wells downgradient to the southeast of the site have been contaminated with carbon tetrachloride. The extent of contamination that can likely be attributed to Garvey Elevator appears to extend at least 2.9 miles downgradient to the east-southeast. Figure 2 in Attachment 4 depicts the results from a 2004 annual monitoring well sampling event. The carbon tetrachloride at most locations had decreased significantly from the 1995 HWS detections. For instance, at MW3B where carbon tetrachloride was detected at 29,943 μg/L in 1995, it was detected at a decreased concentration of 280 μg/L in 2004.

In 2007, PRP contractor ENSR conducted vertical profiling of carbon tetrachloride in groundwater at the site. As the Figures in Attachment 4 depict (System Evaluation Work Plan [SEWP] Phase 1 Direct Push Technology [DPT] investigation), at 120 feet carbon tetrachloride concentrations exceeding 50 μg/L were noted in two areas. The first area is located in proximity to the former fumigant AST; however, no borings were completed between the west end of the shop building (DPT10), and DPT22D between the railroad spur and railroad tracks, which is the area immediately downgradient of the former tank. The second area of higher groundwater contamination is directly east of the MW-3 well cluster where high carbon tetrachloride concentrations have previously been observed (ENSR/AECOM, 2007).

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At 130 feet bgs, the carbon tetrachloride concentration increases around DPT22D, where 626 μg/L was observed. There were no other 130-foot interval samples collected to the west, but to the north and south, concentrations drop off to below 10 g/L with 80 feet. Below 130 feet bgs, concentrations in the DPT samples did not exceed 50 μg/L.

PRP contractor ENSR also collected samples from the existing and new monitoring wells installed. However, the EPA Superfund Technical Assessment and Response Team (START) contractor, TetraTech, sampled the wells most recently in August 2008, the results for which were included in a Removal Assessment (TetraTech, 2009). Therefore, these more recent results will be discussed and evaluated. It should be noted that ENSR redesignated several of the HWS monitoring wells to conform more closely with the aquifer zone and screened interval designations outlined in the HWS report. ENSR also followed the HWS convention when identifying the screened zones in the multilevel monitoring wells they installed in 2007. Attachment 5 consists of the ENSR multilevel well construction diagrams.

Figures 3.2, 3.3, and 3.4 illustrate the August 2008 analytical results collected from the Garvey Elevator monitoring wells (USEPA, 2008b). Carbon tetrachloride was detected in 24 of 43 groundwater samples collected from the new multilevel wells and the existing monitoring wells at concentrations ranging from 0.54 μg/L to 690 μg/L. The highest concentration was observed in MW-4B located approximately 275 feet downgradient to the southeast of the former carbon tetrachloride AST (Figure 3.2). B-wells are completed in the upper aquifer at the top of the uppermost fine-grained unit.

In the upper aquifer (A and B wells), the highest carbon tetrachloride contamination is present at MW-4B and MW-3B, which indicates that downward migration of the contamination is likely retarded to some extent by the uppermost fine-grained unit. These data are also consistent with hot spots in the soil gas. It is likely that the on site water supply well previously in service and located north of the MW-3 well cluster, and Municipal Well #13 located northeast on the north side of Highway 6 have influenced the contamination northward when they were both on line. As illustrated in Figure 3.2 and Figure 3.3, the contamination appears to be migrating downward the farther downgradient it migrates. At MW-18, the A-well is non-detect for carbon tetrachloride, while the C-well sample contained 34 μg/L. A comparison of the upper aquifer data (Figure 3.2) and the medial aquifer data (Figure 3.3) also shows a broadening of the plume laterally. Again, it is likely that this is the result of the hydraulic influence of pumping of the municipal well.

In the D-zone, the carbon tetrachloride contamination as defined by the monitoring wells appears to be narrow, as illustrated on Figure 3.4, but is present past the downgradient most monitoring well cluster MW-18.

Low levels of the carbon tetrachloride degradation compound chloroform were detected in six samples. The highest concentration (5.7 μg/L) was detected in MW-31A. The only other target VOC detected was carbon disulfide, which was observed at low levels in three samples:

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MW-30D, MW-30E, and MW-31A. Chloromethane, dichloromethane, and EDB were not detected in any samples.

3.2.5 Sediment and Surface Water

To date no surface water or sediment samples have been collected at the site. Therefore, it is not known if the drainageways and the small pond on site have been impacted by site-related contaminants.

3.3 EXISTING SOURCE CONTROLS

An SVE and GET system were installed by the PRP at the site while it was under State oversight. These systems were installed in 1998, and began operation in 1999. The SVE system consists of 11 SVE wells and the GET system includes 8 recovery wells and 2 injection wells. Figure 3.5 illustrates the groundwater extraction well and SVE well locations. Since the bankruptcy of Garvey Elevators, Inc., EPA has been maintaining and operating the systems.

3.3.1 SVE System

Garvey Elevator installed an SVE system to treat on-site contaminated soils within the vadose zone at the site. The SVE system currently consists of eight functioning SVE extraction wells. Initially, carbon tetrachloride levels in the extracted soil vapor required treatment with a catalytic oxidation system before being discharged to the atmosphere. After four months of operation, the carbon tetrachloride levels had dropped significantly and the catalytic oxidation unit was taken off-line because the contaminated vapors no longer required treatment before release. The piping from the SVE wells converges into the rear of the shop building where the oxidation unit and vent pipe are located (Figure 3.5). In September 2000, the system was reduced to just one well: SVE-7 (ENSR, 2006). In March 2001, the system was shutdown because of the low concentrations being recovered (ENSR, 2006). In May 2004, the system was restarted. Between 2004 and 2008, the system operated intermittently. Since November 2008, the SVE system has been fully operational.

SVE wells SVE-1 through SVE-8 are screened between from 20 feet to 50 feet bgs, and are considered the shallow wells. The three deep SVE wells are SVE-09 to SVE-11, and are screened from 60 to 110 feet bgs. For unknown reasons, SVE-02, SVE-05, and SVE-06 were not connected to the system (ENSR/AECOM, 2006). The system was constructed with a blower capacity of 200 cubic feet per minute (cfm) for the shallow wells, and a 600 cfm blower for the deep wells. Current flow rates are not available.

In general, the wells are installed around the area of the former carbon tetrachloride AST, and the area to the east toward the railroad tracks, and north of the elevator silos. SVE-07 is located nearest the location of the former carbon tetrachloride AST. Three SVE wells (SVE-01, SVE-02, and SVE-09) are located north of the shop building north of former AST location.

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3.3.2 GET System

Garvey Elevator also installed the GET system in 1998, which commenced operation in 1999 with the SVE system. The objective of the GET system was to prevent contaminated groundwater from migrating off site. The system includes eight groundwater recovery wells, a packed tower air stripper, and two injection wells. Since this system came on-line in 1999, it has been operational only sporadically due to various system malfunctions and mechanical problems. As shown on Figure 3.5, the extraction wells are located in a rough north-south trending line downgradient to the east of the source areas, except for RW-05. RW-05 is located in close proximity to the location of the former carbon tetrachloride AST.

Five of the extraction wells (RW-01, RW-02, RW-03, RW-04, and RW-05) are screened in the upper aquifer (A and B zones) between approximately 116 feet to 130 feet bgs. Each of these shallow extraction wells has 10-foot screens (EMCON, 1998). The remaining three extraction wells (RW-06, RW-07, and RW-08) are completed in the medial aquifer (C zone) from approximately 135 feet to 150 feet bgs. These deeper extraction wells have 15-foot screens. All eight wells have 0.040-inch slot, stainless steel screens (EMCON, 1998). Each shallow well was outfitted with pumps rated at a capacity of approximately 40 gallons per minute (gpm) at 245 feet of total head. The pumps installed in the deeper wells were rated at a capacity of 100 gpm at 260 feet of total head (ENSR/AECOM, 2006). The extracted water from the wells is piped through a 500 gpm capacity packed tower carbon air stripper and discharged back into the groundwater system through two injection wells (I-1 and I-2) (Figure 3.5). The 10-inch diameter injection wells are screened in the lower aquifer (D and E zones) from 175 feet to 230 feet bgs (ENSR/AECOM, 2006). The injection wells are located west and upgradient of the contaminant source areas in the agricultural field on the western portion of the site property.

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TABLES

Table 3.1
Former and Current Chemical Use
Garvey Elevator Site
Hastings, NE

Trade Name	Chemical Name or Composition	Use	Dates Used	Product Storage Location
Liquid 80-20 (MaxKill 10)	80% Carbon Tetrachloride, 17-18% Carbon Disulfide 1% ethylene Dibromide	Grain Fumigant Insecticide	1959 to 1985	3,000-gallon above ground tank
Weevil-Cide Pellets Gastoxin Pellets PhosFume Pellets Fumitoxin Pellets	Aluminum Phosphide	Grain Fumigant Insecticide	1968 to present	Chemical Shed
Methyl Bromide (trade name unknown)	Methyl Bromide	Grain Fumigant Insecticide	2000 to present	Not stored on site
Max Kill Malathion	Liquid Malathion	Insecticide	1959 to 1997	Chemical Shed
Ultra/Roundup	glyphosate	Herbicide	Unknown to present	Chemical Shed
Weedone® Brand LV6 Landmaster	2-4-Dichlorophenoxy Acetic acid (2,4-D)	Herbicide	1959 to present	Chemical Shed
Drakeol GD-LP DUOprime Oil DS-L	Light Mineral Oil	Grain Dust Suppressant	1988 to present	8,000-gallon above ground tank

Sources: Garvey, 2003; HGL, 2008a

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Table 3.2
Previous Investigations
Garvey Elevator Site
Hastings, NE

Study	Media	Objectives/ Tasks	Period	Reference
Phase I Environmental Site Assessment	Soil GW	On site survey; records review; interviews; sampling of tap water from on site water well	May 1994	Terracon, 1994
Site Characterization	Soil Soil Gas GW	Characterize CCl_4 in soil and groundwater near elevator; evaluate RAs; installation of monitoring wells, SVE well (2), VMP (32), RW (1); aquifer testing, SVE pilot study; groundwater modeling	October 1995	HWS, 1995
SVE and GET systems Installation	Soil Gas GW	Installation of SVE wells (8), and RWs (8); pack tower air stripper and reinjection in two deep wells; start operation 1999	Fall 1998	EMCON, 1998*
NDEQ PA/SI	GW	Collect information regarding groundwater contamination and evaluate threat to HHE; Well survey; sampling of monitoring and domestic wells; review of background documents; CERCLA 104E request for Garvey Elevators, Inc.	April 2003	TetraTech, 2003
System Evaluation; Removal Action and RI/FS	Soil Soil Gas GW	Additional characterization of source area to assist in evaluation of SVE and GETS effectiveness	October 2005 to early 2008	ENSR Monthly Activity Reports, 2006-2007.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CCl_4 Carbon tetrachloride
GET Groundwater extraction and treatment
HHE Human health and environment
N/A Not applicable
NDEQ Nebraska Department of Environmental Quality
PA/SI Preliminary Assessment/Site Inspection
RAs Remedial Alternatives
RI/FS Remedial Investigation/Feasibility Study
RW Groundwater recovery well
SVE Soil vapor extraction
VMP Vapor monitoring point
GW Groundwater
* No specific document available for reference, reference to this activity or study was made in another document

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FIGURES

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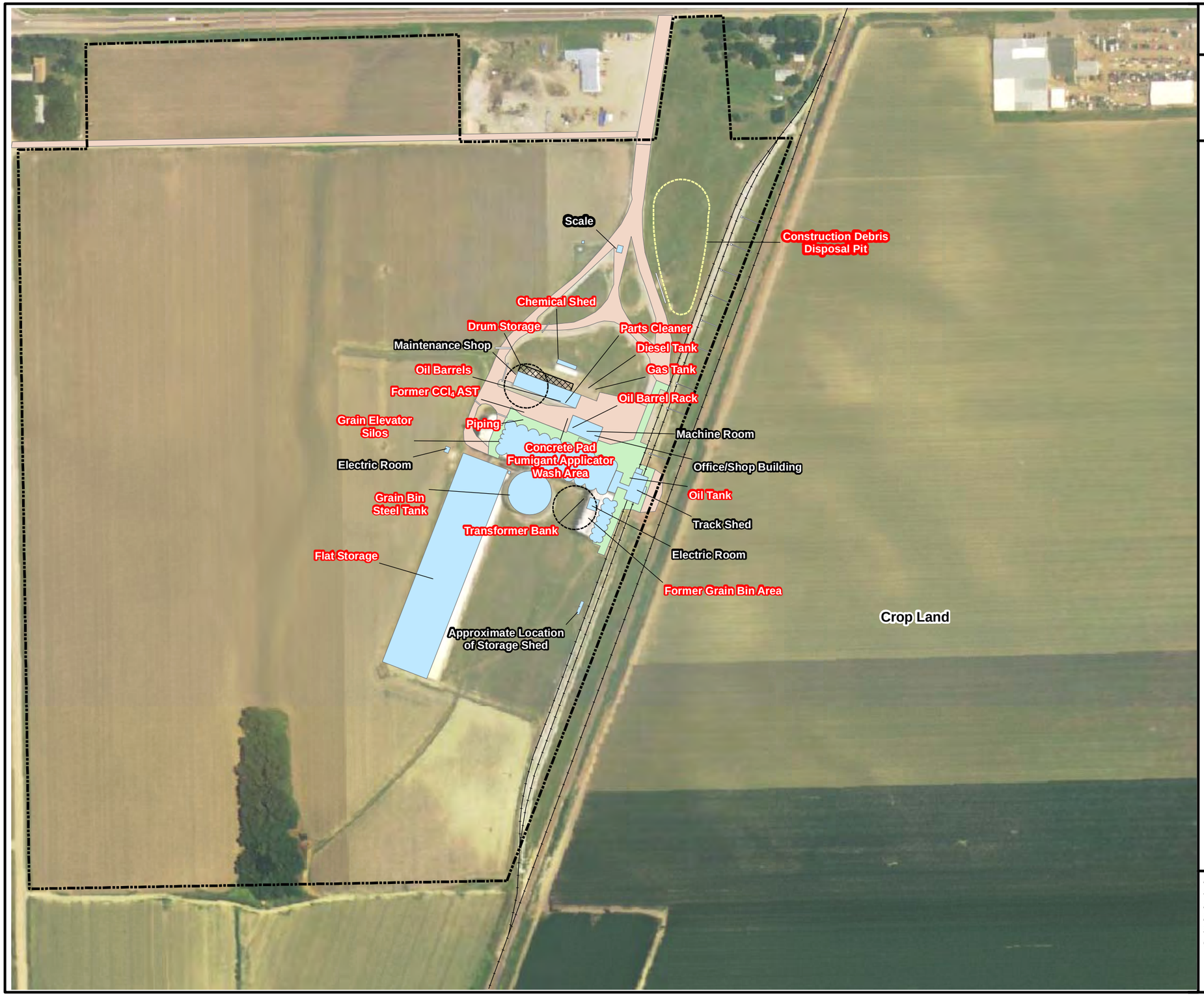

HGL—Work Plan, Remedial Investigation/Feasibility Study, Garvey Elevator Site—Hastings, NE

Figure 3.1
Source Area Map

Legend

- Site Boundary
- Culverts
- Buildings
- Former Steel Grain Bin
- Concrete Paved Area
- Gravel Road
- Railroad

Potential Source Areas

N

0 150 300 600

Feet

Filename: X:/EPA009/Garvey/RI_FS/SourceArea_Fig3-1.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008; DNR; Garvey, 2003

United States Environmental Protection Agency

HGL HydroGeoLogic, Inc

CDM

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Figure 3.2
August 2008 Historical Groundwater Data Map for the A/B Groundwater Zone

Legend

- Garvey Property Boundary
- —5— Carbon Tetrachloride Contour
- ⊗ Assumed Location of Multi-Level Wells Installed by ENSR
- ⊠ Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Domestic Water Wells
- Monitoring Well
- ▲ Recovery Wells
- ▲ Municipal Well
- (64) Carbon Tetrachloride Concentration in µg/L
- (ND) Non Detect

N

0 375 750 1,500

Feet

Filename: X:/EPA009/Garvey/RI_FS/Historical_GW_AB-Zone.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

HGL HydroGeoLogic, Inc CDM

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Figure 3.3
August 2008 Historical Groundwater Data Map for the C Groundwater Zone

Legend

- Site Boundary
- Assumed Location of Multi-Level Wells Installed by ENSR
- Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Domestic Water Wells
- Monitoring Well
- Recovery Wells
- Municipal Well
- —5— Carbon Tetrachloride Contour
- (340) Carbon Tetrachloride Concentration in µg/L
- (ND) Non Detect

N

0 370 740 1,480

Feet

Filename: X:/EPA009/Garvey/RI_FS/Historical_GW_C_Zone.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

HGL HydroGeoLogic, Inc CDM

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Figure 3.4
August 2008 Historical Groundwater Data Map for the D/E Groundwater Zone

Legend

- ⊗ Assumed Location of Multi-Level Wells Installed by ENSR
- ⊠ Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Domestic Water Wells
- Monitoring Well
- ▲ Recovery Wells
- ▲ Municipal Well
- —5— Carbon Tetrachloride Contour
- Garvey Property Boundary
- (9.8) Carbon Tetrachloride Concentration in µg/L
- (ND) Non Detect

N

0 375 750 1,500

Feet

Filename: X:/EPA009/Garvey/RI_FS/Historical_GW_D_E_Zones.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

HGL HydroGeoLogic, Inc CDM

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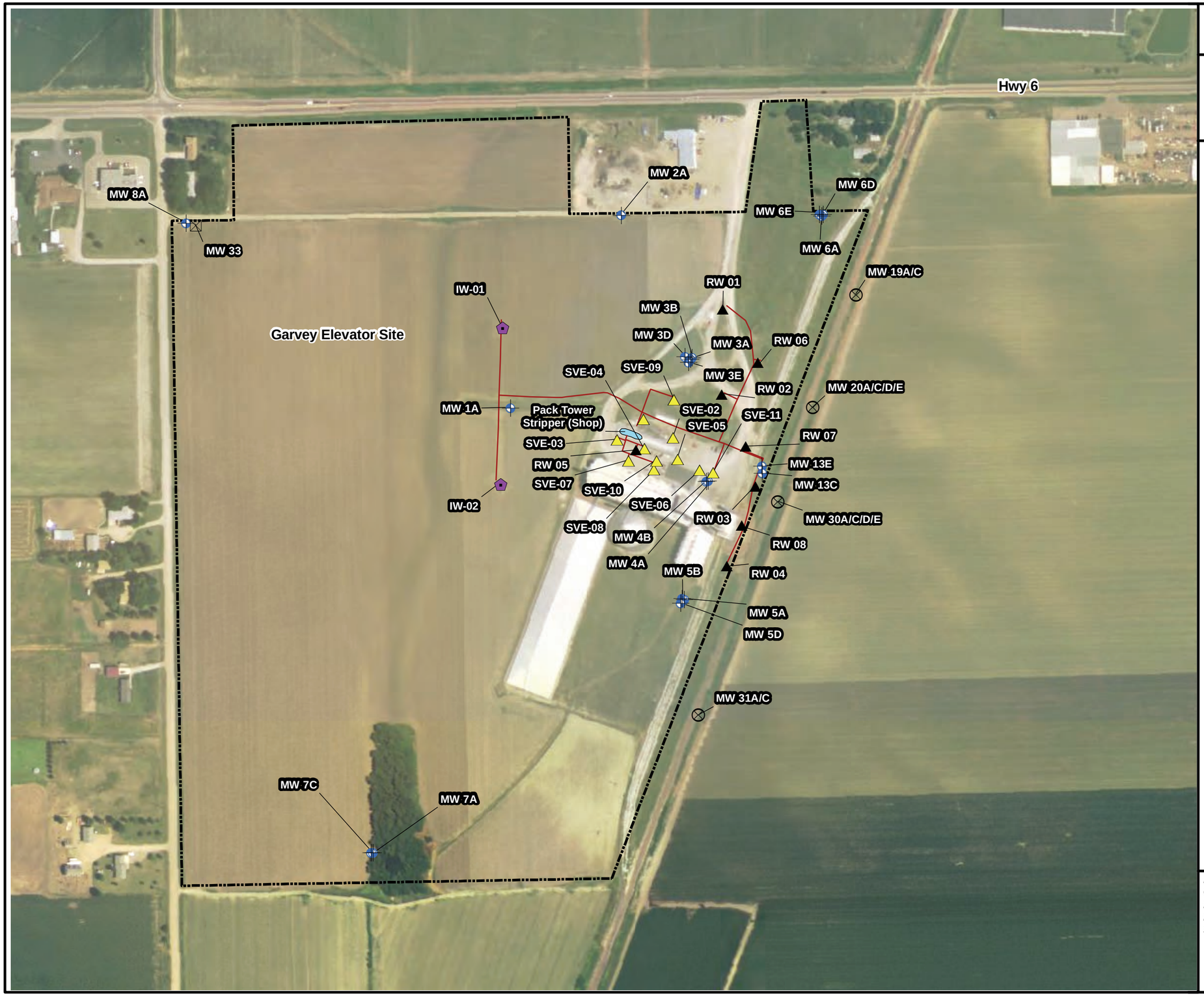
Figure 3.5
Existing GET and SVE Systems



Legend

- Site Boundary
- Pack Tower Stripper
- GET and SVE System Piping
- Recovery Wells
- Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Assumed Location of Multi-Level Well Installed by ENSR
- Injection Well
- Soil Vapor Extraction Well
- Monitoring Well

Note: Recovery Wells RW-5 and RW-6 are not Operational.

N

0 185 370 740

Feet

Filename: X:/EPA009/Garvey/RI_FS/GET_SVE.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

United States Environmental Protection Agency

HGL HydroGeoLogic, Inc

CDM

4.0 CONCEPTUAL SITE MODEL

4.1 HISTORICAL SOURCES OF CONTAMINATION

The Garvey Elevator Site began operation as a grain storage facility in 1959. The site has not been used for any purpose other than grain storage. The known constituents used at the facility include, but are not limited to, the fumigant mixture of carbon tetrachloride, carbon disulfide, and a minor amount of EDB. This fumigant mixture is known as 80-20 fumigant.

The primary sources of contamination are the former liquid 80-20 fumigant AST and the underground carbon tetrachloride distribution piping between the tank and the elevator silos. Apparently, a buried portion of the underground delivery pipe was found to be leaking and was replaced sometime before 1986. Several other potential sources of contamination associated with the grain elevator also are present on site. Figure 3.1 illustrates known and potential contaminant source areas identified at the Garvey Elevator Site. These sources are discussed in the following subsections. The primary documents used to describe the potential sources include the responses to the Request for Information Pursuant to Section 104 of CERCLA, and the interviews conducted by EPA and HGL during October 2008 (Garvey, 2003; HGL, 2008a). Other documents are cited as necessary in the potential source area descriptions and histories discussed below.

4.1.1 Former Liquid Fumigant AST/Piping

Garvey Elevator began applying a liquid fumigant mixture of 80 percent carbon tetrachloride and 20 percent carbon disulfide in 1959. The fumigant was piped underground from an AST to the side of the silo, lifted up the side of the silo through piping to the top of the silo where it was distributed via hoses to the individual silos. During the interviews, interviewees stated that the fittings both on top of the silos and at the tank leaked, and had to be repaired or replaced at least once a year.

The 3000-gallon fumigant AST was installed in 1960 and removed in 1986. No documentation of the removal is available. The liquid fumigant was purchased and delivered by the truckload. It was transferred from a liquid bulk fumigant truck into the AST in approximately 2,500-gallon batches.

A former Garvey Elevator Superintendent and Area Manager stated during his 2008 interview that the fumigant used was MaxKill 10. He said it was 80 percent carbon tetrachloride, 17 percent to 18 percent carbon disulfide, and 1 percent EDB. According to a chemical profile of MaxKill 10, it consists of 70.5 percent (by mass) carbon tetrachloride; 16.5 percent carbon disulfide; 6.6 percent 1,2-dibromoethane (EDB); and 6.4 percent dichloromethane (Scorecard Pollution Information Site, 2009). The former Garvey Elevator Superintendent stated that early formulations did not include EDB. The other former Garvey Elevator Superintendent interviewed indicated that EDB was not a component of the 80/20 fumigant formulations used at the site.

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Previous reports of investigations at Garvey Elevator have stated that sometime between 1960 and 1985, when 80-20 fumigant was used, the underground portion of the piping from the tank to the silo began leaking and was replaced. According to the 2003 NDEQ PA/SI report, previous employees of the elevator indicated that the underground piping began leaking and was repaired, but the date of the repair and the amount of liquid 80-20 fumigant lost could not be determined (TetraTech, 2003). The previous Terracon Phase I ESA report and the HWS Site Characterization report do not mention a piping leak and repair (Terracon, 1994; and HWS, 1995). According to the Garvey 104E response, Garvey Elevators, Incorporated was not aware of leaks, spills or a release, until they received the 1994 Phase I ESA analytical results showing the presence of carbon tetrachloride in the on-site water supply well (Garvey, 2003).

In 2005, ENSR submitted a document to the attorneys for Garvey Elevator that included a summary of actions relating to the carbon tetrachloride contamination at the site (ENSR, 2005). The information was based on discussions with current and former Garvey employees, environmental reports, and ENSR's knowledge of the site. This document stated that a release of 80-20 fumigant was observed in the mid-1970s at the ground surface where the trucks drove over the underground piping from the tank to the side of the silo. When the soil around the piping was excavated, breaks in the line were observed at the tank and next to the elevator. The document further states that the piping was completely replaced at this time (ENSR, 2005). This document also noted that minor leaks and drips were reported to have occurred during the operational period of the tank and piping. This document goes on to state that the AST and piping were removed in 1986, and the excavated soils were placed back in the trench.

During the 2008 interviews conducted by EPA and HGL, none of the five former employees interviewed could recall replacement of broken piping. However, four of the five interviewees stated that the fittings had leaks, or staining was observed around the tank. One former employee stated that leaks at the tank fittings would start as drips then progress to a steady stream, at which point maintenance personnel would replace the fitting to reduce the leak. Another employee stated the same information about the fitting leaks, and said the leaks were repaired by maintenance about once a year.

Soil samples collected by HWS in the area of the former AST and piping have shown only trace levels of carbon tetrachloride below 1 mg/kg (HWS, 1995). ENSR did not collect soil samples in the area of the former AST and piping. Additionally, no samples have been collected immediately adjacent to the north side of the silos where the underground piping extended from the AST to the silos.

In soil gas collected by HWS, the highest carbon tetrachloride concentrations, those greater than 131 μg/m3, were centered between the elevator silos and the shop building where the former carbon tetrachloride AST was situated (HWS, 1995). ENSR collected soil gas from boring DPT 10 located between the former AST and the Quonset shop building. Concentrations ranged from below 1,000 $\mu g/m^3$ at 20 feet bgs up to 10,000 $\mu g/m^3$ near the water table at 115 feet bgs.

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The data indicate that the liquid 80-20 fumigant constituent carbon tetrachloride has been released to the environment in the area of the former fumigant storage AST. Based on historical information, the release mechanisms are long-term leaks from the AST fittings, and likely a break in the underground piping that caused a catastrophic release of the fumigant to soils directly beneath tank and piping. Based on the soil gas sampling, the contamination extends to the water table at approximately 115 feet bgs. However, the presence of carbon tetrachloride in soil gas near the water table also can be indicative of volatilization of carbon tetrachloride migrating in groundwater.

4.1.2 Grain Elevator Silos

The main silos aligned east to west were constructed in 1959. The silos at the east end of facility aligned north to south were constructed in 1962. Past and present fumigants used in the silos include:

- Liquid 80-20 fumigant used from 1959 to 1985
- Aluminum phosphide used from 1968 to present
- Liquid malathion used from 1959 to 1997
- Methyl bromide used from 2000 to present

The liquid 80-20 fumigant was pumped to the gallery that ran over the top of the silos, routed to the application piping, and into the top of the specific silo(s) needing application of the fumigant. A former employee told EPA and HGL during an October 2008 interview that fumigant would spill from the hoses on top of the elevator when they were disconnected from the fittings every couple off silos. The usual dosage of liquid 80-20 fumigant varied from 1 to 2 gallons per 1,000 bushels, and was applied to the surface of the grain at the top of the silo(s) requiring treatment. The 104E response indicated that the number of grain treatments using the 80-20 fumigant would have been less than is listed below for aluminum phosphide, but each application would have consumed more 80-20 fumigant per treatment. Specifically, the liquid 80-20 fumigant was used when it was colder because aluminum phosphide pellets react less readily to form phosphine gas.

The aluminum phosphide fumigant was added in pellet form, which reacts with moisture to form phosphine gas (and ammonia and carbon dioxide) to control and treat infestations. The pellets were loaded into and dispensed from applicators situated at the elevator headhouse on the east side of the main silos. The dosage varied from 200 to 225 pellets per square feet. Between 1997 and 2002, the number of applications of aluminum phosphide treatments per year varied from 10 to 59. The number of treatments required is based on weather conditions, volume of grain handled, grain conditions upon arrival, and different types of grain.

The 104E response did not elaborate on the process for liquid malathion application, except to state that it also was sprayed into empty grain storage areas prior to introduction of the grain as an infestation preventative measure. No further information was available regarding the application of this chemical, volume used per application, or its frequency of use.

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According to the 104E response, the methyl bromide was applied by an outside contractor. It was pumped into the stored grain in gaseous form. No further information was available regarding the application of this chemical, volume used per application, or its frequency of use.

Because of the widespread nature of carbon tetrachloride in soil gas, and the close proximity of the liquid fumigant AST to the silos, it is difficult to ascertain whether the silos themselves are a source of carbon tetrachloride contamination. Also, sampling directly beneath the silos is not possible.

If carbon tetrachloride has been released from the silos, the release mechanism would be seepage of carbon tetrachloride through the concrete bottom of the silos, or through possible cracks in the concrete.

4.1.3 Flat Storage

Based on the 104E response, it appears that the flat storage building was constructed in 1959 with the main silos. The floor of the building is flat and made of concrete. According to the response document, liquid 80-20 fumigant was probably not used in the flat storage structure. During the October 2008 interviews, a former employee stated that 80-20 fumigant was not applied to grain within the flat storage buliding, but only when grain was augered into the building from the main silos. He said the grain augered into the flat storage building was wet from the carbon tetrachloride-laden fumigant. The former employee stated that only aluminum phosphide and malathion were directly applied in this building. However, the former Garvey Elevator Superintendent and Area Manager said that the 80-20 fumigant was not applied at the auger to the flat storage building. It is possible that the former employee meant that the only way the 80-20 fumigant was introduced into the flat storage was when grain treated in the main silos was moved into flat storage via the auger, rather than that treatment occurred specifically at the time that the augering took place.

The interviewees and the Garvey Elevator 104E response both agree that aluminum phosphide, malathion, or both were applied to grain in the flat storage building.

Carbon tetrachloride was detected in soil gas adjacent to the northeast corner of the flat storage building at ENSR boring DPT7. This boring also is adjacent to the steel grain bin (Figure 3.1). Carbon tetrachloride also was detected in soil gas in borings completed in the open area east of the flat storage. The shallow (8 feet to 10 feet bgs) soil samples collected adjacent to the flat storage building by HWS did not show the presence of carbon tetrachloride in soil samples, though the number of samples collected was limited. The floor of this building lies at approximately 8 feet below grade. Therefore, the available soil data may not have been collected from below the depth of the bottom of the flat storage building floor, and thus may not accurately reflect the nature and extent of contamination in this location.

Based on the available data, it cannot be determined whether a release of carbon tetrachloride beneath the flat storage building has occurred. A release from the flat storage is less likely,

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because information provided by Garvey Elevator in their 104E response, and the interviews, indicates that carbon tetrachloride was not directly applied in the flat storage building. The liquid fumigant piping system does not extend to this building. The mechanism for such a release would likely be from residual carbon tetrachloride on grain transferred to this building that seeped through the concrete floor or cracks in the floor.

4.1.4 Steel Grain Bins

Three large-capacity, vertical, round, steel grain bins were located at the site. The Garvey Elevator 104E response indicates that two of the large steel bins were constructed in 1959 with the main silos. One steel bin is currently present on site south of the main silos on the west side at the northeast corner of the flat storage (Figure 3.1). Another steel bin was located at the southeast side of the main silos. According to the 104E response, this steel bin collapsed and was removed in 1961. Also, aerial photographs show a third large steel grain bin located at the northwest side of the main silos. It also appears to have been removed in the early 1960s.

The fumigant used in these grain storage structures is not specifically described in the 104E response. However, the document generally refers to liquid 80-20 fumigant, aluminum phosphide pellets, and liquid malathion as having been used to kill and control insect infestations in various grain bins. Therefore, it is likely that the carbon tetrachloride-laden 80-20 fumigant was applied in the steel bin structures.

The interviewed former employees mostly indicated that aluminum phosphide or malathion was used in the steel bin still present on site. One former Garvey employee indicated that the 80-20 fumigant was applied in the grain bin that collapsed in 1963, four years after it was built.

As with the flat storage building, the area of carbon tetrachloride in soil gas extends beneath this grain storage building, but nearby soil samples were nondetect for carbon tetrachloride.

4.1.5 Railroad Spur and Construction Debris Disposal Pit

According to the Garvey Elevator 104E response, aluminum phosphide was used occasionally to fumigant a railcar loaded with grain that required treatment. The pellets were pushed below the surface of the grain with the pellet-loaded applicator probe. The usual dosage was 325 pellets per 1,000 bushels of grain.

The former Garvey Elevator Superintendent and Area Manager stated during his October 2008 interview that 80-20 fumigant also was used to treat grain cars on the rail spur to the north of the elevator if needed. Furthermore, he indicated that carbon tetrachloride may be found along the tracks north of the main elevator structure. Another former employee stated that 5-gallon buckets were used to transport and spread the liquid 80-20 fumigant in the rail cars on the spur. This former employee also said there was a "slush pit" located along the spur which was used as a dumping area for debris and cleaning fluids.

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Aerial photographs available to HGL from select years between 1963 to 1990 were examined for evidence of the debris pit. Based on the aerial photographs and the description from the former employee, the area of the construction debris disposal pit has been plotted on Figure 3.1. No samples for VOCs or pesticides have been collected from the center of this area.

4.1.6 Fumigant Applicator Wash Area

The area consisted of a concrete pad at the rear of the office/shop building (Figure 3.1). According to the Garvey Elevator 104E response, this concrete pad was used as a wash area for fumigant and herbicide applicators and equipment. Items were cleaned by rinsing thoroughly with water. Also, empty containers were rinsed at this location prior to disposal at the sanitary landfill.

It is unknown if containers, nozzles or hoses specific to the application of the liquid 80-20 fumigant, or pesticides, were washed at this location

4.1.7 Chemical Storage Shed

According to the Garvey Elevator 104E response, this structure was constructed in 1990 (Figure 3.1). However, aerial photographs from 1963 onward show a building present in the location of the current structure. Also, many of the chemicals stated to be stored in this building were used since the 1960s. It is likely that a new building was constructed in 1990 to replace an older structure.

The 104E response document described this building as housing chemicals in general, and specifically several pesticides. Table 3.1 lists chemicals, their usage dates, and storage locations that were reported in the 2003 NDEQ PA/SI report based on the Garvey response to the 104E request (TetraTech, 2003; Garvey, 2003). During the October 2008 interviews, former employees stated that malathion, phosphide pellets, and chemicals other than the 80-20 fumigant, were stored in this building. It is also likely that pesticides other than those present in the shed when the 104E response was written have been stored in the shed since the facility began operation.

Based on the previous soil and soil gas sampling conducted around this building, it is not a source area for carbon tetrachloride contamination. However, no samples from around this building have been collected for pesticides.

4.1.8 Transformers

During the 1994 site reconnaissance conducted by Terracon (contracted by AGP) for the Phase I ESA, two transformer stations were observed (Terracon, 1994). Terracon interviewed a former Garvey Elevator Area Manager who indicated that the transformers noted by Terracon were replacements for the original transformers to the facility. This former Area Manager believed the transformers were replaced in the mid-1980s. Because EPA banned polychlorinated biphenyls (PCB)s in 1979, its likely that the original transformers contained

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PCBs at a concentration greater than 500 ppm, but that replacement transformers did not contain PCBs.

The first transformer station was ground-mounted in the same area of current transformers located to the south of the main silos at the east end to the east of the existing steel grain bin (Figure 3.1). Terracon noted that the three transformers at this station had a height of approximately 10 feet and a diameter of 5 feet. An oily stain was observed on the exterior of the easternmost transformer at this station, but ground staining was not noted. No samples were collected for PCBs analysis. The 2003 Garvey Elevator 104E response illustrates these same three ground-mounted transformers. The current transformer station at this location that was observed by HGL in January 2009 is newer and approximately 4 feet in height with a width of about 5 feet, and depth of approximately 3 feet, but is still mounted at ground level on a concrete pad.

The other transformer station noted by Terracon in 1994 consisted of three pole-mounted transformers located near a storage shed situated along the railroad spur south of the elevator. According to the Terracon report, these transformers appeared to be in good shape from the vantage point of the observer (Terracon, 1994). The 2003 Garvey Elevator 104E response illustration does not show the storage shed or the adjacent pole-mounted transformers. Also, HGL did not observe the shed and pole-mounted transformers. Based on the aerial photographs provided to HGL as background documents, this shed was removed from the site sometime after 1990 (the date of the most recent aerial photograph available to HGL). It appears these transformers and the shed were removed sometime between the 1994 Terracon site reconnaissance and the submittal of the 104E response in 2003.

A set of transformers also is present near the northwest corner of the flat storage building. The illustration in the Garvey Elevator 104E response also depicts a set of transformers at this location (Figure 3.1). No other historical information was available regarding this set of transformers.

According to the Garvey Elevator 104E response, the electrical room adjacent to the transformers south of the main silos was built in 1990, while the electrical room northwest of the flat storage was erected in 1989. No discussion of the transformers was present in the 104E response.

No PCB soil samples have been collected at the transformers to evaluate a release from the transformers to the ground surface.

4.1.9 Other Chemical Sources

Other potential historic sources of contamination are depicted on Figure 3.1 and include:

- Diesel Fuel underground storage tanks (USTs)/ASTs
- Drum Storage/Oil Barrels
- Parts Cleaner in quonset building that was constructed in 1988.

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- Oil Barrel Rack
- Mineral Oil Tank – 8,000 gallon, bulk delivery, dust suppression; installed 1988

According to the 104E response, two 1,000-gallon diesel USTs were installed adjacent to the northeast corner of the quonset building in 1985 (Figure 3.1). This document stated that the fuel tanks were removed in 1993, and that a removal permit was obtained. The two USTs were replaced by a 500-gallon AST situated immediately north of the USTs former location to provide fuel for facility vehicles. A Garvey Elevators area site manager, Bill Overy, interviewed by Terracon in 1994, stated that the NDEQ issued a no further action letter regarding the USTs. It does not appear that further investigation is required for these petroleum tanks. The oil barrel rack in the office/shop and the parts cleaner in the maintenance building (Quonset), are not likely sources because they are contained inside buildings, and no evidence of major leaks from either feature was documented in the site file.

The drum storage area may be a source area for a release to soils to the north of the quonset building; although, HGL did not observe any drums or waste oil containers or significant soil staining this area during the January 2009 site visit. According to the 104E response, Safety-Kleen removes all waste liquids from the elevator facility; however, no soil samples have been collected from this area for SVOCs, VOCs or pesticides.

An 8,000-gallon AST was installed in 1988 near the headhouse on the east side of the main silos to hold mineral oil used for grain dust suppression. Oil is delivered to the site in a tanker truck. The oil is sprayed on the grain as it is being discharged to rail cars or trucks. This feature does not appear to be a source area for site-related contamination.

4.2 CONTAMINATED SYSTEM

This section summarizes the regional geologic setting and the site-specific conceptual hydrogeologic model based on data collected during the various site characterization studies conducted at the site. Hydrogeologic characteristics that affect the model are presented, particularly with respect to features that influence groundwater flow and contaminant transport.

The local stratigraphy described is based on the results of and observations recorded during drilling conducted at the site during past investigations. A generalized cross-section is depicted on Figure 2.4. CSM Calculations that will be used for the RI are illustrated in Attachment 6.

4.2.1 Unsaturated Zone Physical Features

The lithology of the unsaturated zone consists of silt, clayey silt, and silty clay in the zone from 0 to 65 feet bgs. Below this is a sand layer that ranges from fine to coarse sand down to a depth of 130 feet bgs; however, the water table begins at about 115 feet bgs which makes this sand a transition zone between the unsaturated zone and the saturated zone.

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4.2.2 Saturated Zone Physical Features

4.2.2.1 Stratigraphy

The Pleistocene aquifer makes up the saturated zone, which is identified by three aquifer zones: the upper, medial, and lower. The upper aquifer zone begins at about 115 feet bgs and consists of a fine to coarse sand with gravel to a depth of 130 feet bgs. It is separated from the medial aquifer zone by a silty clay/clayey silt/clayey sand fine-grained unit that creates a semi-permeable hydraulic barrier. The medial aquifer zone begins below the fine-grained unit at about 135 feet bgs and consists of fine to coarse sand with gravel to a depth of 150 feet bgs. The medial and lower aquifers are separated by another fine-grained unit creates a semi-permeable hydraulic barrier. The lower aquifer consists of fine to coarse sand with gravel.

4.2.2.2 Groundwater Flow

Geologic features within the Pleistocene aquifer that likely affect groundwater flow and contaminant transport include the following:

- Fine to coarse sand in the upper aquifer zone, which allows rapid groundwater movement;
- A clayey silt unit that creates a semipermeable hydraulic barrier between the upper and medial aquifer zones;
- Medium to course sand in the medial aquifer zone, which allows rapid groundwater movement;
- A clayey silt unit that creates a semipermeable hydraulic barrier between the medial and lower aquifer zones. This may not be existent to the east of the site.
- Fine to coarse sand and gravel in the lower aquifer zone, which allows rapid groundwater movement.

Other features that affect the groundwater flow at the site include the municipal well located to the northeast of the site. This well appears to have pulled contaminated water toward it based on samples from the municipal well that are contaminated with carbon tetrachloride. In addition, there was an operating production well located to the northwest of the Garvey Grain Elevator. This well appears to have pulled carbon tetrachloride contamination toward it when it was operating. This well could have cross contaminated the upper and medial aquifers after it was shut down because the well appears to be screened across both aquifers. According to the 104E Response, the well was installed in 1959, and capped in 1996 (Garvey, 2003). No installation or abandonment records are available for this well.

The baseline flow conditions in 1995, before installation of the groundwater extraction system, are represented by Figure 11 of the HWS Site Characterization Report provided in Attachment 7 (HWS, 1995). The baseline flow conditions and the current flow conditions are discussed below by aquifer zone.

Upper Aquifer Zone

The direction of the groundwater flow of the upper aquifer zone is to the east-southeast.

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Slug tests, grain size analysis, and a pump test from the West Highway 6 & Highway 281 Site located to the north of Garvey Elevator indicate an average hydraulic conductivity of 1 x 10^{-2} to 9 x 10^{-2} centimeters per second (cm/s) for the upper aquifer zone.

The recovery wells that have been installed at the site have altered the local groundwater flow at the site causing a cone of depression in the area of the grain silos and the buildings on the north side of the silos. On the basis of downgradient water quality alone, it is not possible to perform an evaluation of the effectiveness of the recovery wells in controlling downgradient migration of contaminants from the source area because the recovery wells have experienced equipment malfunctions that prevented their continuous operation.

Silty Clay, Clayey Silt, and Clayey Sand (fine grain unit)

The silty clay, clayey silt, and clayey sand (fine grain unit) layer between the upper and the medial aquifer zone acts as a semipermeable barrier to hydraulic communication between the two aquifer zones. Geotechnical samples collected this fine-grained unit for the West Highway 6 & Highway 281 Site indicated hydraulic conductivities ranging from 1 x 10^{-09} to 1 x 10^{-04} cm/s. Drilling for previous Garvey site investigations indicates that the fine grained unit is not found east of the site. Drilling directly to the east of the site (east of the railroad tracks) did not show signs of the fine grained unit, though the unit may have been missed because the borings were not continuously logged. However, a similar unit consisting of a silty clay ranged from 5.9 x 10^{-9} to 1.4 x 10^{-10} cm/s with an average value of 9 x 10^{-10} cm/s was encountered north of the Garvey site, during drilling activities conducted at the West Highway 6 & Highway 281 Site.

Medial Aquifer Zone

The direction of the groundwater flow of the medial aquifer zone is to the east-southeast. The hydraulic conductivity estimated using grain size analysis for the medial aquifer zone ranged from 2 x 10^{-3} to 2 x 10^{-2} cm/s at the West Highway 6 & Highway 281 Site located to the north of Garvey Elevator (ERM, 2002). The head in the medial aquifer zone wells is typically lower than that of the upper aquifer zone wells, indicating the semipermeable nature of the clay silt layer.

Silty Clay, Clayey Silt, and Clayey Sand (fine grain unit)

The Silty Clay, Clayey Silt, and Clayey Sand (fine grain unit) layer between the upper and the medial aquifer zone acts as a semipermeable barrier to hydraulic communication between the two aquifer zones. No geotechnical samples have been analyzed from this unit; therefore, the hydraulic conductivity of the unit is unknown. Drilling at the area indicates that the fine grained unit is not found east of the site. However, a similar unit of a silty clay with conductivities ranging from 5.9 x 10^{-9} to 1.4 x 10^{-10} cm/s (average 9 x 10^{-10} cm/s)was encountered north of the site, during drilling activities at the West Highway 6 & Highway 281 Site.

Lower Aquifer Zone

The flow direction of the lower aquifer is to the east/southeast. The fine grained unit above

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the lower aquifer does not exist to the east, so the medial and lower aquifers merge to the east of the site. At the West Highway 6 & Highway 281 Site, hydraulic conductivity values in the lower aquifer ranged from $9.63x10^{-03}$ to $1.47x10^{-01}$ cm/s.

4.3 CONTAMINANT FATE AND TRANSPORT

This section describes the generalized environmental fate and transport of the COCs and chemicals of potential concern (COPCs) in the physical system at the site. The COCs and COPCs identified for the site and the physical and chemical properties for each are listed on Table 4.1. The COCs identified consist of chemicals associated with the 80/20 fumigant – carbon tetrachloride and carbon disulfide. The COPCs identified include EDB, degradation compound of carbon tetrachloride, PCBs, and select pesticides. The site COCs and VOC COPCs at the site are associated with one identified on-site source area: the former liquid fumigant AST and piping. The liquid fumigant compounds also may be associated with the grain elevator silos, and other structures in which they were applied (see Section 4.1 above). Carbon tetrachloride has contaminated groundwater at the site, and has migrated downgradient to the east-southeast in the direction of groundwater flow. The mechanisms by which the liquid fumigant contaminants can potentially migrate from the source area and affect other media are illustrated in Figure 4.1. Figure 4.2 depicts the biodegradation and reaction pathways of carbon tetrachloride and EDB.

PCBs are associated with locations of former or current transformers. The pesticides are associated with the chemical storage shed, fumigant applicator wash area, and the disposal pit. PCBs and pesticides were not evaluated during previous investigations. The primary mechanism for PCBs and pesticides to contaminate other media consists primarily leaching into soils near where they were applied (pesticides), or spill (pesticides and PCBs). These contaminants can also migrate into surface water bodies or drainage ways, and adsorb to sediments, as a result of overland migration from during surface movement of drainage waters. Figures 2.2 and 6.2 illustrate the surface water drainage pathways on site.

4.3.1 General Factors Influencing Fate and Transport

Knowledge of contaminant fate and transport is important in determining how contaminants will be distributed throughout the soil and groundwater at a site. The controlling environmental factors at Garvey Elevator Site include a low-permeability loess layer composed of silts and clays which is underlain by sand. The sand is separated into an upper, medial, and lower aquifer zone by fine-grained units. Groundwater flow is to the east-southeast. The most significant factors that will affect the fate and transport of contaminants at the site are advection, dispersion, and contaminant solubility and sorption.

4.3.1.1 Contaminant Chemical and Physical Properties

Table 4.1 presents some physical and chemical properties of the COPCs identified at the site. These properties typically influence the fate and transport of contaminants. A discussion of the

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general physical and chemical properties affecting fate and transport of these analytes in soil and groundwater follows.

Water Solubility

Water solubility describes the mass of a compound that will dissolve in a measured amount of water at a given temperature and pressure. Water solubility is important in assessing the fate and transport of contaminants in groundwater because it indicates the affinity of the analyte for water. High water solubility means that greater amounts of the analyte will enter the aqueous phase, whereas a low water solubility indicates that a contaminant may be present as a separate phase (USEPA, 1979). The water solubility of an analyte can be used to assess chemical mobility, chemical stability or breakdown, bioaccumulation, and chemical sorption. An analyte with a low water solubility (<10 milligram per liter [mg/L]) will tend to adsorb to soil, be persistent, bioaccumulate, and have negligible mobility in the environment. Conversely, an analyte with a high water solubility (>1,000 mg/L) will adsorb to soil only negligibly and be highly mobile in the environment, but will readily biodegrade and should not bioaccumulate (Ney, 1998).

Vapor Pressure

Vapor pressure indicates whether an analyte will significantly volatilize into the air. Generally, the higher the vapor pressure of a contaminant, the greater its tendency to volatilize. An analyte with a low vapor pressure (<0.000001 [or 10^{-6}] torr) will not volatilize significantly into the air, but will instead be persistent in the environment and have the potential to bioaccumulate. An analyte with a high vapor pressure (>0.01 [or 10^{-2}] torr) is likely to significantly volatilize into the air (Ney, 1998).

Henry's Law Constant

The Henry's Law constant of a constituent is the relative equilibrium ratio of a compound in air and water at a constant temperature. The Henry's Law constant indicates the relative ease with which the constituent may be removed from aqueous solution by volatilization (i.e., whether it is more likely to partition to water or the air) (USEPA, 1979). A low Henry's Law constant ($<10^{-7}$ atmospheres cubic meters per mole [atm-m^3/mole]) indicates that the analyte is less volatile than water and, therefore, as the water evaporates the concentration of the analyte will increase. For analytes with a high Henry's Law constant ($>10^{-3}$ atm-m^3/mole), volatilization from water will be rapid (Howard, 1990).

Octanol Water Partition Coefficient

The octanol water partition coefficient (K_{ow}) is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature. This coefficient serves as an indicator of the bioaccumulation potential of a chemical in the fatty tissue of living organisms and the chemical's ability to adsorb to soil. A low K_{ow} (<500) indicates that the analyte will not significantly adsorb to the soil, making it highly mobile in the environment, as well as having little to no bioaccumulation and a tendency to biodegrade. A high K_{ow} (>1,000) indicates that the analyte will be adsorbed to the soil and have little mobility in the

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environment, that the analyte will not biodegrade significantly, and it will likely bioaccumulate (Ney, 1998).

Organic Carbon Partitioning Coefficient

The organic carbon-water partitioning coefficient (K_{oc}) is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil per the equilibrium chemical concentration in solution. The adsorption coefficient is indicative of the extent to which an analyte will be adsorbed to organic carbon in soil. Analytes with a high K_{oc} ($>10,000$) will readily adsorb to organic carbon and become relatively immobile, but are also persistent and bioaccumulative. Analytes with a low K_{oc} ($<1,000$) will not adsorb to soil organic carbon and will, therefore, be mobile in the environment (Ney, 1998).

Density/Specific Gravity

The density of a substance is its mass per unit volume. The density of a chemical will determine whether it sinks or floats when it encounters groundwater. The specific gravity of a chemical is its density normalized to the density of water. A substance with a specific gravity less than 1 will float in water, while a substance with a specific gravity greater than 1 will sink. Contaminants with a specific gravity greater than 1 generally must also be present as a DNAPL before they will sink through water. This can be useful in determining well screen depths when attempting to monitor for specific analytes in groundwater. In addition, relatively dense compounds will have a tendency to migrate through soil layers more rapidly than relatively less dense compounds (USEPA, 1979).

4.3.1.2 VOCs

This section discusses the VOCs which are considered to be COCs and COPCs at the site. The VOCs that were detected in groundwater at, or downgradient of, the site include carbon tetrachloride, chloroform, and carbon disulfide. The other VOCs listed on Table 4.1 (chloromethane, dichloromethane, and EDB) are COPCs because they are suspected of being present at the site based on historical site activities and potential degradation process.

Halogenated Volatile Organic Compounds

Carbon tetrachloride, chloroform, chloromethane, dichloromethane, and ethylene dibromide are halogenated volatile organic compounds. A halogenated compound is a compound onto which a halogen (e.g. chlorine, fluorine, bromine, or iodine) has attached itself (FRTR, 2009). These compounds evaporate quickly from surface water and soil. They tend to leach into groundwater from soils. These compounds also have a low potential to accumulate in aquatic life (USEPA, 2009a). Chloroform, chloromethane and dichloromethane are biodegradation products of carbon tetrachloride which eventually biodegrade to methane. Ethylene dibromide biodegrades to ethylene and bromide ions (EXTOXNET, 2009a)

Nonhalogenated Volatile Organic Compounds

The only COPC which is a nonhalogenated volatile organic compound is carbon disulfide. A nonhalogenated compound is one which does not have a halogen (e.g. chlorine, fluorine, bromine, or iodine) attached to it (FRTR, 2009). Carbon disulfide evaporates from surface

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water and soil. It is also highly mobile and can be leached from soil by water. Biodegradation is not a significant fate process for carbon disulfide. Bioaccumulation in the food chain is expected to be low (USEPA, 1994).

4.3.1.3 Semivolatile Organic Compounds

Semivolatile organic compounds (SVOCs), including PCBs, are suspected to be present at the site. PCBs are considered a COPC because they have been used at the site in transformers. PCBs are halogenated SVOCs that are persistent in soil and water. PCBs tend to adhere to soils or evaporate. They typically do not leach to groundwater. The only known breakdown process is by slow degradation by microbes (FRTR, 2009 and USEPA, 2009b). PCBs can accumulate in the above-ground parts of plants, including food crops. They are bioaccumulated by aquatic organisms (USEPA, 2009c).

4.3.1.4 Pesticides

The specific pesticides known to have been stored at the site are aluminum phosphate, malathion, glyphosate (i.e. Roundup®), and 2,4-D. In addition, it is likely that other pesticides were stored in the chemical storage shed since the facility opened in 1959. In general, pesticides have a high persistence in the environment. But the degradation, solubility and mobility of pesticides vary depending on the particular pesticide. Aluminum phosphate reacts spontaneously with water to form a gas, and is considered non-persistent and non-mobile in the soil environment, and poses no risk to groundwater (EXTOXNET, 2009b). Malathion and 2,4-D both have low persistence and short half-lives in the environment; however, both are soluble in water and can pose a risk to groundwater if breakdown is inhibited (EXTOXNET, 2009c). Glyphosate is highly adsorbed to most soils and is highly soluble in water. However, it generally is considered non-mobile because of its high soil adsorption, except when attached to eroded soil particles (EXTOXNET, 2009d).

4.3.2 Unsaturated Zone

The unsaturated zone has been described as the subsurface soil layers that have a three phase system consisting of soil, water, and air (Fetter, 1988). This zone is also termed the vadose zone. Water and air exist in the vadose zone in the interstitial spaces between individual soil particles.

Water is present in the vadose zone as both water vapor and liquid water. Larger pore spaces contain a film of liquid water that coats mineral grains and is held in place by molecular attraction. Smaller pore spaces contain water that is held in place by capillary action. Water will percolate downward under the influence of gravity when the volume present exceeds the holding capacity of the capillary forces.

The vadose/unsaturated zone at the site is approximately 115 feet thick and consists of loess and interbedded silt, fine sand, and clay to 65 feet bgs. Below these deposits are sands

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consisting of silty fine sand to coarse sand with gravel (HWS, 1995 and Tetra Tech EM, 2003).

4.3.2.1 Volatile Organic Compound

VOCs are present at the site as both chlorinated and nonchlorinated compounds. In general, the chlorinated VOCs have high vapor pressures, high solubilities in water, high densities, and low organic carbon partitioning coefficients as compared to the non-chlorinated VOCs. The chlorinated VOCs also have higher densities than both the non-chlorinated VOCs and water. Therefore, if chlorinated VOCs are released in sufficient volume, they will tend to migrate through the unsaturated zone and settle to the bottom of the water column forming a separate DNAPL layer. While migrating, the chlorinated VOCs will also tend to volatilize and occupy soil pore space in the vapor phase.
Chlorinated VOCs with relatively high K_{oc} values (such as carbon tetrachloride), or those that are nonpolar molecules (such as carbon tetrachloride, carbon disulfide, and EDB), may also undergo hydrophobic sorption and attach themselves to organic matter in vadose zone soils. However, given the low organic content of the site soils, retardation by adsorption is not likely to be significant.

The non-chlorinated VOCs (carbon disulfide and EDB) detected at the site have relatively low solubilities. They also have relatively low K_{oc} values and densities greater than that of water. If released in sufficient volume, these compounds would tend to migrate through the vadose zone and upon reaching the water table could form a separate, dense nonaqueous phase liquid (DNAPL) layer.

4.3.2.2 PCBs

PCBs have not been sampled for at the site. However, there are transformer and electrical equipment that may be the source of PCB spills. PCBs typically adhere to soil and do not leach to groundwater unless exposed to organic solvents which can cause the PCBs to leach quite rapidly through the soil. Higher chlorinated congeners have a lower tendency to leach the lower chlorinated congeners (USEPA, 2009b).

4.3.2.3 Pesticides

Pesticides have not been sampled for at the site. However, pesticides were stored on site in the chemical storage shed, which may be a source area for pesticide spills. Pesticides typically adhere to soil, and have low leaching potential. Two of the pesticides stored at the site, malathion and 2,4-D, are soluble in water an can migrate into the subsurface; although they have only short to moderate half-lives (EXTOXNET, 2009c).

4.3.2.4 Influence of Existing SVE System

Vapor phase chlorinated VOCs and compounds resulting from environmental degradation are known to be present in the unsaturated zone and groundwater at the site. VOCs have relatively high Henry's Law constants indicating that all compounds will tend to partition to the vapor

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phase provided there is sufficient mixing between the partitioning media. In addition, VOCs have high vapor pressures that can be released through volatilization from either contaminated soil or groundwater. The rate of volatilization depends on the chemical specific vapor pressures, ambient temperature, and unsaturated zone permeability.

The SVE system vacuums vapor phase contaminants from the unsaturated zone via extraction wells connected to extraction blowers. Placing the unsaturated zone under vacuum promotes mixing between the soil and soil gas, thereby promoting the partitioning of contaminants to the vapor phase.

Operation of the SVE system can also increase oxygen levels in the soil pore space and stimulate biodegradation of aerobically biodegradable organics. However, increasing oxygen levels in soil pore space may alter redox conditions within the soil. The SVE system is further detailed in Section 3.3.

4.3.3 Saturated Zone

The saturated zone exists below the water table and is a dual phase system consisting of soil and groundwater. In the saturated zone all pore space is filled with liquid water.

Three aquifer zones, the upper, medial, and lower zones, have been identified within the saturated zone at the site. The upper aquifer zone begins at the water table depth of approximately 115 feet bgs and extends to a depth of approximately 130 feet bgs. It consists of fine to coarse sand with gravel.

The upper aquifer zone is separated from the medial aquifer zone by a discontinuous fine-grained unit that may act locally as a barrier to vertical migration. The medial aquifer zone begins below the silty clay layer at approximately 135 feet bgs and extends to a depth of approximately 150 feet bgs.

The medial aquifer zone also is separated from the lower aquifer zone by a discontinuous fine-grained unit that may act locally as a barrier to vertical migration. The lower aquifer zone consists of fine to coarse sand with gravel, and extends from 155 feet bgs to bedrock at approximately 240 feet bgs.

4.3.3.1 Volatile Organic Contaminants

The nonchlorinated and chlorinated VOCs that are COPCs at the site have specific gravities greater than 1 except for the chlorinated COPC chloromethane. Therefore, upon reaching the saturated zone, these compounds will migrate downward through the water column. These compounds can form a dense non-aqueous phase liquid (DNAPL) layer if concentrations are great enough. Lateral migration in the direction of groundwater flow will take place simultaneously. As the compounds are water soluble, dissolution will also take place.

Vertical migration may continue through the upper aquifer zone until the DNAPL reaches the

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fine-grained unit separating the upper and medial aquifer zones. Upon reaching this fine-grained unit, vertical migration will be impeded; however, lateral migration in the direction of groundwater flow will continue.

Chloromethane has a density less than that of water. Therefore, upon reaching the saturated zone, this compound will float and potentially form a light non-aqueous phase liquid (LNAPL) layer. Lateral migration in the direction of groundwater flow will take place simultaneously. Because chloromethane is water soluble, dissolution will take place.

4.3.3.2 PCBs

Groundwater beneath the site occurs at a depth of approximately 115 feet bgs. Groundwater has not been sampled for PCBs. Because PCBs do not tend to migrate in soils, they are not expected to be found in the groundwater at the site. However, solvents such as carbon tetrachloride can enable PCBs to leach to groundwater (USEPA, 2009b).

4.3.3.3 Pesticides

Pesticides have not been sampled for in groundwater. Because of the thick unsaturated zone, and the low mobility or persistence of the pesticides known to have been stored on site, they are not expected to be observed in groundwater. However, both malathion and 2,4-D are noted to have been detected in groundwater at other sites (EXTOXNET, 2009c).

4.3.3.4 Influence of Existing SVE and GWE System

The existing SVE system was designed and installed to address VOC contamination in the vadose zone. The SVE system enhances partitioning of VOCs to the vapor phase and subsequently vacuums contaminant vapors out of the soil. In the process, the volume of VOCs that partition from soil to groundwater is reduced, and the impact to groundwater is lessened. The GET system captures groundwater via extraction wells; extracted groundwater is treated through an air stripper then discharged to two injection wells located upgradient of the site. The pumping of the extraction wells influences localized groundwater flow. Section 3.3 presents a detailed discussion of the SVE and GET systems.

4.4 CURRENT AND FUTURE LAND USE

The site property is zoned I-1 light industrial and is situated outside the HICA. The site is currently occupied by AGP, which operates the facility as a grain elevator. Future land use is not expected to change. The site is surrounded by agricultural, residential, and light industrial. See Section 2.1 for a detailed discussion of the current zoning and use of surrounding properties.

4.5 EXPOSURE PATHWAY ANALYSIS

Historical releases at the site have contaminated soil and groundwater beneath the main buildings, and contaminated groundwater has migrated off site. The potential for current

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and/or future exposure to human and ecological receptors exists on site, and at locations downgradient of the site. Possible exposure routes and potential receptors are illustrated in Figures 4.3 and 4.4 and discussed in the following subsections.

4.5.1 Potential Human Health Risk Receptors and Exposure Routes

There is insufficient data to determine whether risks posed by site-derived contaminants are above acceptable risk thresholds for CERCLA. Based on available data, the potential exposure pathways for human health risk (groundwater ingestion, incidental soil ingestion, dermal contact, and/or inhalation of particulates re-entrained in air) are incomplete. Previous investigations have identified downgradient wells that are used for drinking water and other domestic purposes with concentrations that exceed EPA maximum contaminant level (MCL) for carbon tetrachloride. A private well survey has been conducted and impacted residents have either been provided municipal water service, whole-house filtration systems, or supplied by another alternative water source such as bottled water. Currently there is only one residential well (located at 2325 S. Showboat Boulevard) which contains carbon tetrachloride over the MCL that is still used for drinking water (Tetra Tech, 2009). Irrigation wells downgradient of the site that may be pose a potential threat by redistributing contaminated groundwater on fields in the area. Contaminants from the irrigation wells could also be distributed to the air.

The potential for dermal contact and/or inhalation may exist due to historic emissions from the distribution of carbon tetrachloride in the elevator and the spills that occurred that may have deposited contaminants on surface soils. An exposure risk may exist for nearby residents, on-site recreational receptors, and on-site industrial and construction workers via direct contact of contaminated surface soils and inhalation of particulates re-entrained in ambient air. Construction workers also may be exposed to subsurface soil contamination should excavation activities occur on site. Again, there is insufficient data to determine whether these potential exposure pathways are complete. No surface soil data has been collected from the site or from nearby residences/businesses.

Another potential pathway of concern for the human health risk involves vapor intrusion. Vapor intrusion is the process by which volatile chemicals migrate as vapors from a subsurface source into the indoor air of buildings. Soil gases (air) are found in the pore spaces between soil particles. Contaminants can volatilize into these spaces and can move with soil pore space within the vadose zone. Vertical migration up towards building foundations may occur, often driven by differences between interior and exterior air pressures. Soil vapor can then enter a building through cracks or perforations in slabs or basement floors and walls and through openings around sump pumps or where pipes and electrical wires pass through the foundation.

Vapor intrusion is possible when contaminated vapors are present in the subsurface zone directly next to or beneath the foundation of a building. Humans can be exposed to contaminated soil vapor when the vapor is drawn into the building and mixed with indoor air. Inhalation is the only significant route of exposure to these vapors. This exposure pathway may be complete for industrial and construction workers on-site, but is not complete for resident or

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recreational receptors (Figure 4.3). No data have been collected to determine whether vapor intrusion is a complete pathway for these receptors.

4.5.2 Potential Ecological Risk Receptors and Exposure Routes

The possible presence of contaminated surface soils at the site also presents a potential concern for both aquatic and terrestrial receptors on site (Figure 4.4). As with the human health risk receptors, available data are insufficient to support a quantitative assessment of ecological risk. Several plants, invertebrates, birds, mammals and aquatic biota and invertebrates may be potential receptors of contamination of surface soil, sediment, and surface water. The two main exposure routes are ingestion and direct contact. No sampling has taken place in surface soils. The wooded areas on and near the site are areas of potential concern for wildlife receptors. The major COPC for any potential ecological receptors, particularly via the aquatic food chain pathway, are PCBs because they are known to bioaccumulate. Pesticides also are of particular concern for any potential ecological receptors because of their toxicity. PCBs and pesticides have not been tested for on-site soils, drainageway sediments, or the on site pond. For a complete list of potential ecological risk receptors and exposure routes see Figure 4.4.

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TABLES

Table 4.1
Physical and Chemical Properties for
Selected Chemicals of Potential Concern
Garvey Elevator Site
Hastings, Nebraska

Contaminants of Potential Concern	Solubility in Water (mg/L)	Vapor Pressure (Torr)	Henry's Law Constant (atm-m^3/mol)	Density (g/mL)	Molecular Weight (g/mol)	K_{ow}	K_{oc} (L/kg)
Carbon Tetrachloride	793	91.3	0.0276	1.59	153.82	2.62-2.83	48.6
Carbon Disulfide	1180	360	0.0144	1.26	76.1	1.84	1.0
Ethylene Dibromide (1,2-Dibromoethane)	3910	11.2	0.000667	2.2	187.86	1.93	43.8
Chloroform	7950	246	0.00367	1.48	119.38	1.70	35
Dichloromethane (Methylene chloride)	13,000	400	0.00325	1.32	84.93	1.25	23.7
Chloromethane (Methyl Chloride)	5320	4028	0.00882	0.92	50.49	0.91	14.3
Polychlorinated Biphenyls[1,2]	0.0034 to 4.38	NA	0.00033 to 0.00005	1.44 @ 30 °C	aroclor specific	NA	3.1×10^5
Malathion	143	4.0×10^{-5}	9.9×10^{-9}	1.23	330.36	2.75	30.5
Glyphosate	12,000	negligible	3.5×10^{-8}	1.7	169.08	-3.2	18.8
2,4-Dichlorophenoxy Acetic Acid (2,4-D)	677	1.4×10^{-7}	4×10^{-19}	1.57	221.04	-0.83	29.4

Notes:
Cmpnd = Compound
mg/L = Milligrams per liter
atm-m^3/mol = atmospheres per cubic meter per mole
g/mL = grams per milliliter
g/mol = grams per mole
K_{ow} = Octanol Water Partition Coefficient
K_{oc} = Organic Carbon Partitioning Coefficient
NA - Not applicable
UA - Unavailable
1 = Chemical Abstract Service number 1336-36-3, K_{oc} value from: Cleanup Levels and Risk Calculations, Model Toxics Control Act Cleanup Regulation, Chapter 173-340 Washington Administrative Code, Washington State Department of Ecology, https://fortress.wa.gov/ecy/clarc/Reporting/ParameterQuery.aspx
2 = http://www.epa.gov/safewater/dwh/t-soc/pcbs.html

Data Sources:
EPA Regional Screening Levels Chemical Parameters, April 2009
Groundwater Chemicals Desk Reference, Third Edition (Lewis Publishers, 2000)
USEPA website, technical factsheet information (http://www.epa.gov/safewater/)
Exotoxnet Pesticide Information Profiles: http://extoxnet.orst.edu
Superfund Chemical Data Matrix (USEPA, 2004a)
Soil Screening Guidance: Technical Background Document (USEPA, 1996)
Issue Paper on the Environmental Chemistry of Metals (ERG, 2004)
Matheson Tri-Gas MSDS (2007)
Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002b)
Office of Pollution Prevention Fact Sheets (USEPA, 1995)
Pesticide Properties Database (PPDB), Agriculture & Environment Research Unit, University of Hertfordshire http://sitem.herts.ac.uk/aeru

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FIGURES

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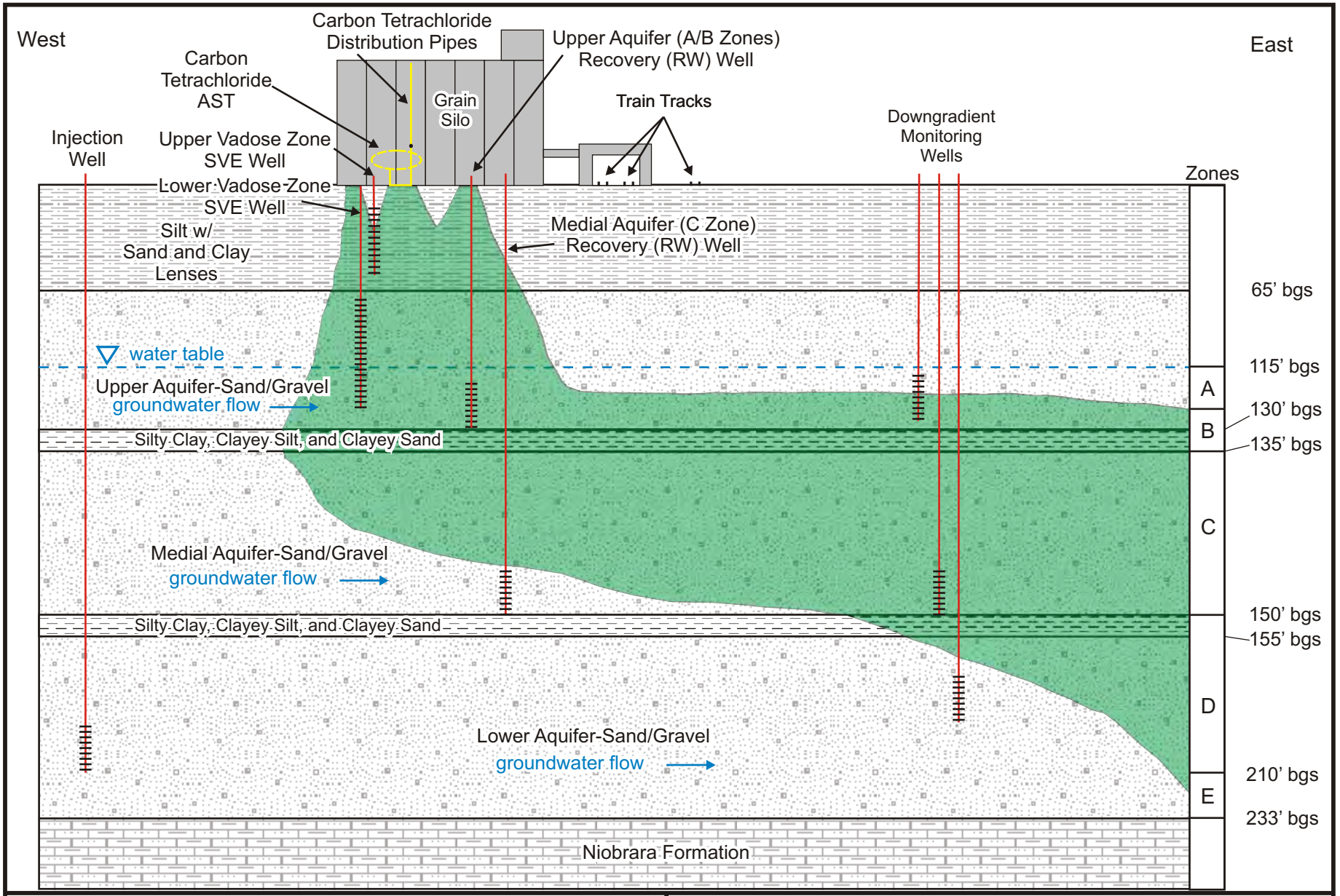
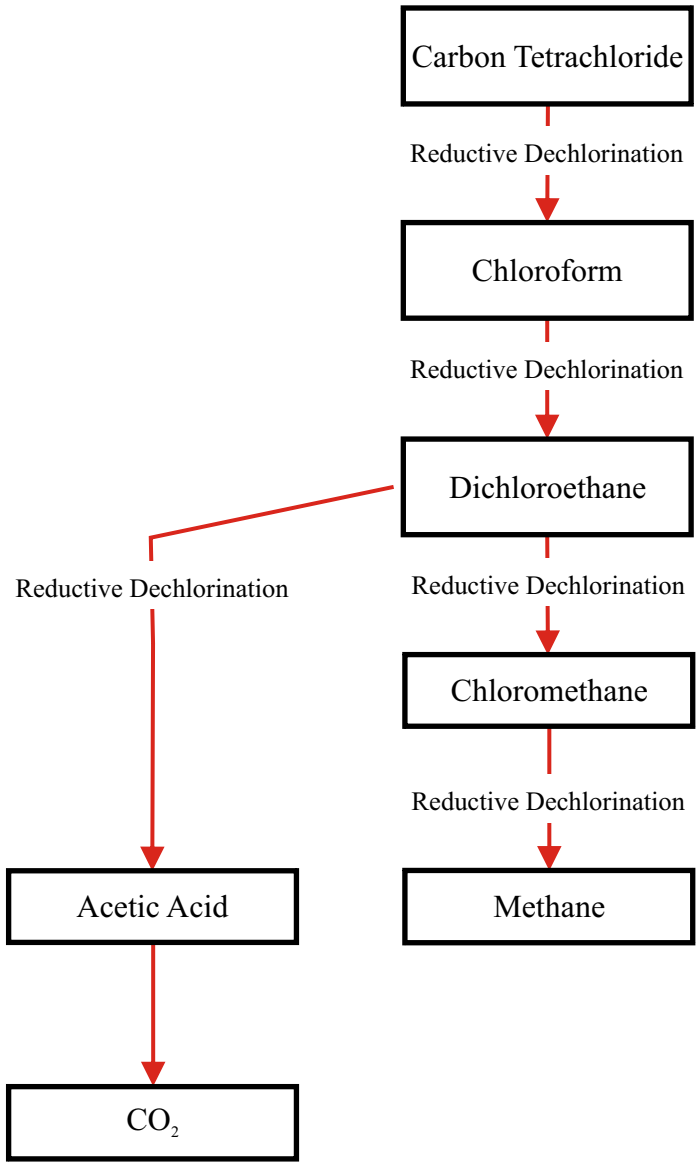


Filename: X:/EPA009/Garvey/RI_FS/ Conceptualized_FateTransport_Liquid_Fumigant.cdr
Project: EP9033.01.46.11
Revised: 05/18/09 CV
Source: Hasting Utility Department, Nebraska DNR, HGL Database

HGL HydroGeoLogic, Inc CDM

Figure 4.1
Conceptualized Physical Fate and Transport
Liquid Fumigant Contamination



Filename: X:/EPA009/Garvey/RI/FS/ Biodegradation_Reaction_Pathways.cdr
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: HGL

HGL HydroGeoLogic, Inc

Figure 4.2
Biodegradation and Reaction Pathways of Carbon Tetrachloride
Garvey Elevator Site—Hastings, NE

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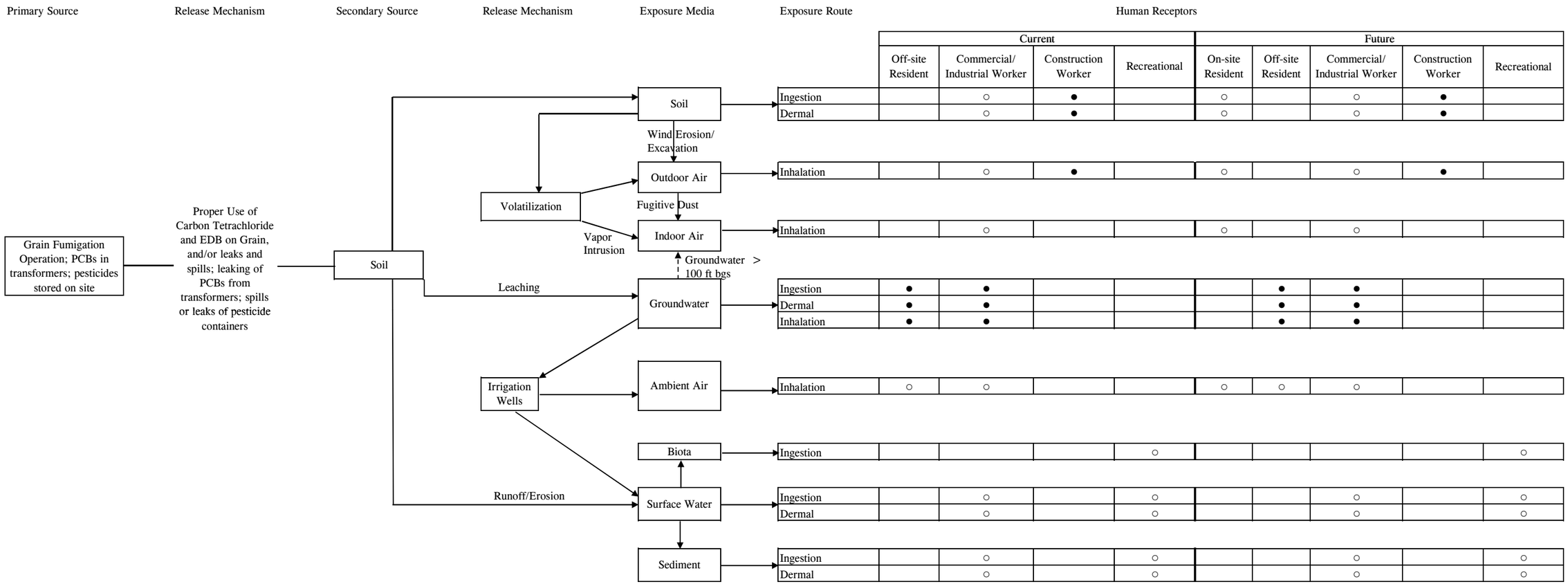
Figure 4.3
Conceptual Site Model for
Human Exposure Pathway
Garvey Elevator Site
Hastings, Nebraska



LEGEND

	Pathway may be complete
○	Pathway is not complete
●	Pathway may be complete, but data are lacking

DEFINITIONS:

Resident: Residents located on or adjacent to contamination.
Commercial/Industrial Worker: Works primarily inside the building and is on site on a daily basis.
Construction: On site for short and/or long durations, and performs light to heavy construction, such as laying pipe and excavation.

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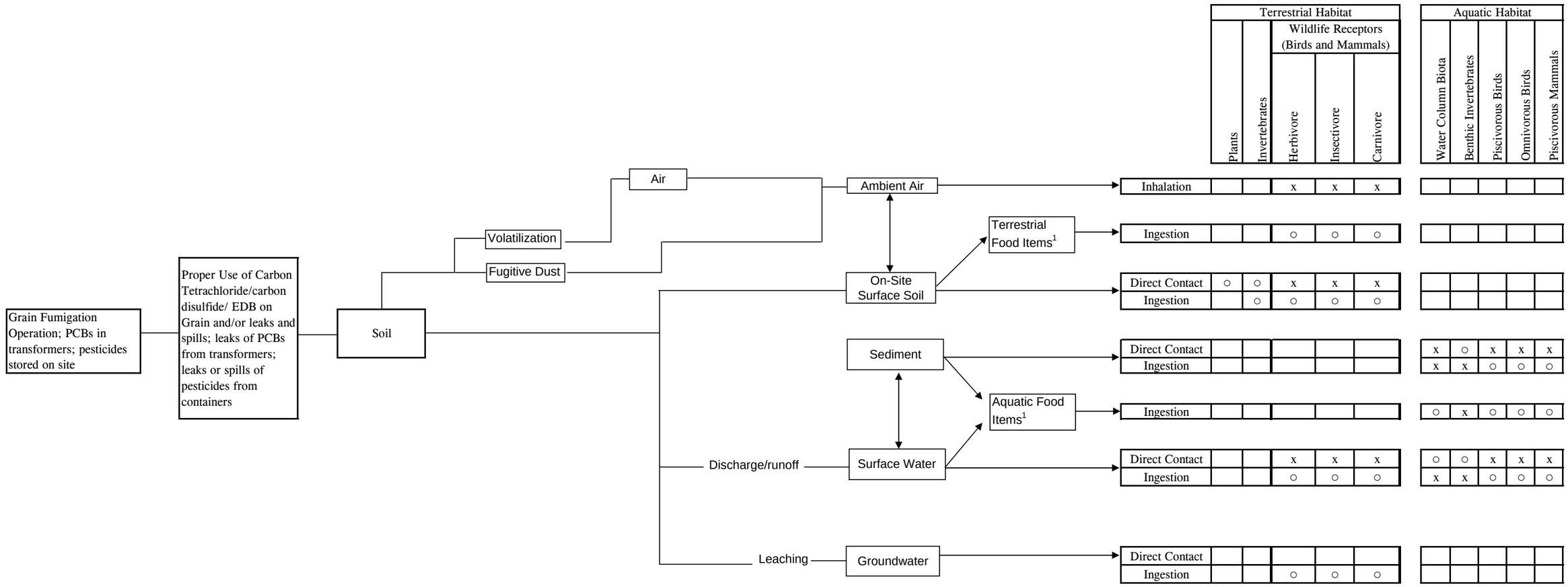
Figure 4.4
Conceptual Site Model
Ecological Exposure Pathway
Garvey Elevator Site
Hastings, Nebraska



Notes:

x	Pathway is not complete
○	Pathway may be complete, but is judged to be minor or methods are not available to perform quantitative assessment
	Pathway may be complete, but data are lacking to perform quantitative assessment

Notes:

Lower trophic level receptors, such as plants and soil invertebrates, will be exposed through direct contact. Wildlife receptors may be exposed to soil contaminants through inhalation and dermal contact as well as ingestion. The data necessary to estimate dermal exposure are generally not available for wildlife, and the data and methods required to estimate inhalation exposure are poorly developed or not available (EPA, 1993). Therefore, for the purposes of this assessment, both dermal and inhalation exposure are assumed to be negligible. For wildlife receptors, only exposure through the ingestion pathway was quantified. Because ecological receptors primarily contact surface soil, the ecological risk assessment considered exposure to chemicals only in the surface soil.

HGL HydroGeoLogic, Inc Exceeding Expectations

5.0 PROJECT GOALS AND APPROACH

This section presents the preliminary identification of the likely RAOs, which describe what a future remedial action should accomplish in order to be protective of human health and the environment. These RAOs are then translated into preliminary remediation goals (PRGs) for each media and contaminant of concern. Potential remedial action alternatives are also identified. Site investigations presented in subsequent sections utilize the PRGs and potential remedial action alternatives to guide the sample collection activities and ensure the additional data collected are of sufficient quality to assess the risk to human health and the environment. At the conclusion of the site characterization field work, the preliminary RAOs and the PRGs will be reviewed during the FS.

5.1 CHEMICALS OF KNOWN AND POTENTIAL CONCERN

Carbon tetrachloride and carbon disulfide are known chemicals of concern at the site. These COCs were determined based on previous studies by PRP-lead removal actions, NDEQ-lead site investigations, and EPA-lead removal actions which have been described previously in Section 3. A primary on-site source area for the carbon tetrachloride has been identified at the Garvey Elevator site from previous investigations. This source area is the location of the former liquid fumigant AST. These COCs and their preliminary remediation goals are listed in Table 5.1.

COPCs include EDB (a component of the liquid fumigant) and the degradation compounds of carbon tetrachloride (chloroform, dichloromethane, and chloromethane). Other COPCs include PCBs, which have been associated with three areas where transformers were, or are currently, situated. Samples for PCBs were not collected during the previous investigations at the site. Also, select pesticides that were stored in the chemical storage shed are considered COPCs. These pesticides include: malathion, 2,4-dichlorophyenoxy acetic acid (2,4-D), and glyphosate (Roundup®). Aluminum phosphate is not considered a COPC because it spontaneously reacts with water to form and gas, and is not considered non-persistent and non-mobile in soil, and poses minimal risk to groundwater (EXTOXNET, 2009b). Sampling for pesticides was not conducted during previous investigations at the site. These COPCs and their PRGs are listed in Table 5.1.

5.1.1 Preliminary Remedial Action Objectives

RAOs are narrative statements that present the intended results of a remedial action. Definition of RAOs is the first step in the development of remedial action alternatives required for the FS. An interim ROD will be conducted which presents RAOs for the OU1 groundwater. The legal documentation of the RAOs will occur subsequent to the RI/FS in a future ROD, which will document the remedial action selected for the site.

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The previous investigations conducted at the site and data generated during the RI will be used to modify the preliminary CSM, which was discussed in Section 4. Based on the CSM, preliminary RAOs for the project will be developed for the FS. Prior to the completion of the RI and FS a focused FS (FFS) will be conducted to evaluate the current on-site remedial system. During the FFS, preliminary RAOs will only be developed for the evaluation of the current on-site remedial system and not for the evaluation of human health.

The preliminary RAOs for protection of human health that will be developed for the FS are to prevent exposure to groundwater and subsurface soil that are contaminated above acceptable risk levels. The preliminary RAOs for protection of the environment are to prevent or minimize further migration of the contaminant plume (source control), prevent or minimize further migration of contaminants from source materials to groundwater (source control), and to return groundwater to its expected beneficial uses wherever practicable (aquifer restoration).

5.1.2 Preliminary Remediation Goals

Remediation goals provide acceptable contaminant concentrations in each medium for remedial actions to be met. Remediation goals are based on concentrations found in Federal and State ARARs or concentrations developed from an assessment of risk. Remediation goals are to be protective of human health and the environment. The legal documentation of the remediation goals occurs in the ROD for the site. However the COPCs identified during the previous investigations allow for identification of PRGs. The PRGs for the site are summarized in Table 5.1 for human health protection for each contaminant of concern and for each medium.

5.1.2.1 State and Federal ARARs

By law, cleanup actions conducted under CERCLA must meet standards, requirements, criteria, or limitations that are commonly referred to as ARARs. ARARs may be either "applicable" requirements or "relevant and appropriate" requirements. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements, on the other hand, are those standards, requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not directly applicable, address problems or situations sufficiently similar to those encountered at the CERCLA site to warrant their required use at the CERCLA site.

Factors to be considered in determining ARARs are:

1) The purpose of the requirements and the purpose of the CERCLA action.
2) The medium and substances regulated by the requirement and the medium and substances at the CERCLA site.
3) The actions or activities regulated by the requirement and the remedial action contemplated at the site.

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4) The potential use of resources affected by the requirement and the use or potential use of the affected resource at the CERCLA site.

ARARs are divided into three types of requirements: chemical-specific, location-specific, and action-specific. Chemical-specific requirements are usually health- or risk-based numerical values or methodologies which, when applied to the site conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a contaminant that may be found in, or discharged to, the environment. Location-specific requirements are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. Action-specific requirements are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances or contaminants. Potential chemical-, location-, and action-specific ARARs that may be applicable at the project site are discussed in the following subsections.

5.1.2.2 Chemical-Specific ARARs

Chemical-specific requirements include laws or requirements that set concentration limits or ranges for specific chemicals in various environmental media. These requirements provide site cleanup levels, or a basis for calculating cleanup levels, for COPCs in the designated media. Chemical-specific ARARs are also used to indicate an acceptable level of discharge, to determine treatment and disposal requirements for a particular remedial activity, and to assess the effectiveness of a remedial alternative. In the event that a chemical has more than one requirement, the most stringent of the requirements is applied.

To be considered (TBC) criteria are used when ARARs do not exist or are not protective. As with ARARs, TBCs may be chemical-specific, location-specific, or action-specific criteria. TBCs are nonpromulgated criteria, advisories, guidelines, and policies issued by Federal or State government agencies.

Potential chemical-specific ARARs include the MCLs established by the federal Safe Drinking Water Act and Nebraska's Safe Drinking Water Act (Neb. Rev. Stat. 81-1501 – 81-1532). Table 5.2 presents a listing of potential contaminant-specific ARARs and TBC criteria that may be applicable to the project site. This list was developed for the site COPCs.

5.1.2.3 Location-Specific ARARs

This subsection provides an overview of potential location-specific ARARs that may need to be considered during the process of performing remedial activities at the project site. This list will be modified throughout the RI/FS process as new information becomes available regarding chemical data, site conditions, and potential remedial actions for the various areas.

Location-specific requirements set restrictions on the types of remedial activities that can be performed based on the location of the site or other site-specific characteristics. Alternative remedial actions may be restricted or precluded based on federal and state siting laws for

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hazardous waste facilities, proximity to wetlands or floodplains, or proximity to man-made features such as existing landfills, disposal areas, or historic buildings. Location-specific ARARs provide a basis for assessing these restrictions during the formulation and evaluation of site-specific remedies.

Potential location-specific ARARs that may limit the types of remedial actions that can be performed at the site include:

- Clean Water Act Section 404.
- Federal and State of Nebraska regulations concerning active fault areas and floodplains; wilderness areas, wildlife refuges, and scenic rivers; historic sites and archaeological findings (National Historic Preservation Act of 1966, as amended 16 USC 461 et seq.); and rare, threatened or endangered species consistent with Section 7 of the Endangered Species Act of 1973 (amended 16 USC 1531).
- The Flood Plain Management Act, Neb. Rev. Stat. §31-1001 to §31-1031, and Title 258 - Rules Governing Flood Plain Management, govern certain activities occurring in floodplains (Department of Natural Resources).

The Nebraska Nongame and Endangered Species Act, Neb. Rev. Stat. §37-801 to §37-811 (re-codified in 1998), and Title 163, Chapter 4, 012, require consultation with the Nebraska Game and Parks Commission regarding actions which may affect threatened or endangered species and their critical habitat (Nebraska Game and Parks Commission).

5.1.2.4 Action-Specific ARARs

Action-specific requirements set controls or restrictions on the design, implementation, and performance of specific remedial activities. After remedial alternatives are developed, action-specific ARARs specify performance levels, actions, or technologies, as well as specific cleanup levels for discharge of residual chemicals, and provide a basis for assessing the feasibility and effectiveness of the remedial alternatives.

The list of potential action-specific ARARs for the project site are shown in Table 5.2. Once the specific remedial alternatives are selected at the feasibility study stage, the appropriate ARARs will be reviewed to assure that all requirements will be met prior to implementing the selected remedial alternatives.

5.1.3 Risk-Based Preliminary Remediation Goals

According to the Risk Assessment Guidance for Superfund (RAGS), in general remediation goals based on risk-based calculations are determined using cancer or non-cancer toxicity values with specific exposure assumptions (EPA, 1998). For chemicals with carcinogenic effects, the National Contingency Plan (NCP) has described the development of remediation goals, as a practical matter, as a two-step process. A concentration equivalent to a lifetime cancer risk of $1x10^{-6}$ is first established as a point of departure. Then, other factors are taken into account to determine where within the acceptable range the remediation goals for a given contaminant at a specific site will be established.

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The NCP discusses a generally acceptable risk range of $1x10^{-4}$ to $1x10^{-6}$. EPA has further clarified the extent of the acceptable risk range by stating that the upper boundary is not a discrete line at $1x10^{-4}$. Risks slightly greater than 1x10-4 may be considered to be acceptable (i.e., protective) if justified based on site-specific conditions, including any uncertainties about the nature and extent of contamination and associated risks.

For non-cancer effects, the NCP states that an acceptable exposure level must be defined (using reliable toxicity information such as EPA's reference dose [RfD]). According to EPA guidance, (RAGS Part A, EPA appropriate National and regional guidance [USEPA, 1989]), generally, if the Hazard Index (HI) (Intake/RfD) is above 1 (i.e., the site exposure is estimated to be above the RfD) there may be a concern for potential non-cancer effects. Therefore, in calculating remediation goals at a site to protect for non-cancer effects, remediation goals are generally set at an HI of 1 or below 1.

Risk-based PRGs (non-ARARs) may be modified within the acceptable risk range during the remedy selection process based on a balancing of the major trade-offs among the alternatives as well as the public and Agency comments on the Proposed Plan. Such balancing among alternatives and consideration of community and State acceptance will establish the specific level of protection the remedy will achieve (i.e., the final remediation levels).

5.1.4 Preliminary Identification of Remedial Action Alternatives

5.1.4.1 Potential Remedial Action Alternatives

The PRP performed removal actions at the site from January 1999 to January 2008 to address groundwater, soil, and soil gas contamination. After Garvey Elevators, Inc. filed for bankruptcy on March 27, 2008, and did not continue work at the site, EPA Region 7 took control of the removal actions. EPA initiated federal-lead removal actions on May 19, 2008. These removal actions have included operating the existing SVE and GET systems, and modifying the SVE treatment system. These removal actions are intended to mitigate the immediate threats posed by the contaminants at the site and to prevent further off-site migration of contaminants.

It is anticipated that any future proposed RA alternatives will include continued operation of the existing SVE and GET systems to address the source area, although these systems will be evaluated for potential optimization and/or expansion. Additional RA alternatives will likely be implemented. These additional remedial actions may include, but are not limited to, the following:

- In-situ biological treatment;
- In-situ chemical treatment;
- In-well air stripping;
- Installation and operation of a new non-aqueous phased liquid (NAPL) recovery system

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5.1.4.2 Additional Data Needs to Evaluate Alternatives

To evaluate the expansion or optimization of the GET system, additional data needs include:

- Aquifer characteristics and groundwater flow directions
- Evaluation of current system components to determine if they are adequately sized
- Current groundwater recovery rates and well drawdown
- Levels of total dissolved solids (TDS), total suspended solids (TSS), total phosphorous, and biofouling bacteria

To evaluate the expansion or optimization of the SVE system, additional data needs include:

- Leak testing of the current system
- Vacuum testing over the depth of the vadose zone

For in-situ biological and chemical treatment, additional data needs include evaluating the following parameters:

- Total organic carbon (TOC) concentrations
- Natural oxidant demand of soils
- Dissolved oxygen levels in groundwater
- Permeability and porosity of the sediments in the vadose zone and saturated zone
- Sulfate concentrations

The additional data needs for in-well stripping include:

- Depth to groundwater
- Evaluation of aquifer characteristics
- Concentrations of biofouling bacteria
- Groundwater pH levels.

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TABLES

Table 5.1
Chemicals of Potential Concern and Preliminary Remediation Goals
Garvey Elevator Site
Hastings, Nebraska

Contaminants of Potential Concern*	Reporting Limits				Surface Water PRGs		Groundwater PRGs (µg/L)	Soil PRGs (1)		Shallow Gas Concentration Corresponding to Indoor Air Concentration (µg/m³)	Target Indoor Air Concentration (µg/m³)
	Hapsite Mobile Lab	EPA Region 7 Lab									
	Water (µg/L)	Soil(4) (µg/kg)	Soil Gas/Air(5) (µg/m³)	Water(6) (µg/L)	Acute (µg/L)	Chronic (µg/L)		Residential (mg/kg)	Migration to Ground water (DAF20) (mg/kg)		
Carbon Tetrachloride	5	5	1.1	1	35,200	44.2	5	0.25(2)	0.066	1.6	0.16
Carbon Disulfide	5	5	1	1	NE	NE	250(3)	230(3)	2.0	7,000	700
Ethylene Dibromide (1,2-Dibromoethane)	5	5	1.6	0.02(8)	NE	NE	0.05	0.0071(3)	0.00026	0.11	0.011
Chloroform	5	5	0.86	1	28,900	1,240	0.19(2)	0.30(2)	0.0012	1.1	0.11
Dichloromethane (Methylene chloride)	5	5	0.72	1	NE	16,000	5	11(2)	0.023	52	5.2
Chloromethane (Methyl Chloride)	5	5	0.36	1	NE	NE	1.8(3)	1.8(3)	0.013	24	2.4
Malathion	N/A	1.1	N/A	0.05	NE	0.1	180(3)	310(3)	0.19(2)	N/A	N/A
Glyphosate	N/A	Na	na	Na	NE	NE	700	1,500(3)	0.87(2)	N/A	N/A
2,4-Dichlorophenoxy Acetic Acid (2,4-D)	N/A	1.1	N/A	1	NE	NE	70	170(3)	0.094(2)	N/A	N/A
PCBs(7)	N/A	10 to 20	NA	0.4 to 1	2	0.0017	0.5	0.22 to 0.98(3)	$1.4x10^{-4}$ to $5.2x10^{-2}$ (2)	N/A	N/A

Notes:
(1) Whenever available, levels associated with carcinogenic risk are listed, otherwise levels associated with non-carcinogenic risks are listed.
(2) EPA RSLs for Chemical Contaminants at Superfund Sites, May 2009
(3) Nebraska VCP RGs, August 2006
(4) EPA Region 7 RLAB Method 3230.16D, GC/MS Analysis of Low Level Volatile Compounds in a Soil Matrix by Closed System Purge and Trap (Base Methods SW846 5035 and 8260C).
(5) EPA Region 7 RLAB Method 3230.4E, Analysis of Ambient Level Whole Air Samples for Volatile Organic Compounds by GC/MS (Base Methods TO-14, TO-14A, TO-15).
(6) EPA Region 7 RLAB Method 3230.13D, GC/MS Analysis of Low Level Volatile Organic Compounds in an Aqueous Matrix (Base Methods: Method 624, SW846 5030B, and SW846 8260C).
(7) PCBs consist of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Quantitation limits and PRGs vary depending on the arochlor.
(8) EPA Method 504.1, EDB and DBCP in Drinking Water by GC/ECD
-Surface Water PRGs are from Nebraska Surface Water Quality Standards, Title 117, March 2009 (NDEQ, 2009).
-Groundwater PRGs are from Nebraska Ground Water Quality and Use Classification, Title 118, March, 2006 (NDEQ, 2006a) unless otherwise noted.
-Residential Soil PRGs are the lowest goals set from either the EPA RSLs, or the NE VCP Remeditioan Goals (NDEQ, 2006b), as noted.
-Soil to Groundwater migration PRGs are Nebraska VCP Remediation Goal (RG) DAF 20 migration to groundwater unless otherwise noted. If from the EPA RSLs, than the Risk-based SSL for protection of groundwater was used (USEPA, 2009d).
-Shallow Gas Concentrations and Target Indoor Air Concentrations are from OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance, November 2002 [USEPA, 2002]), (Table 2c 10^{-6} Risk Level).

RSL = Regional Screening Levels
na = Not analyzed; no EPA Region 7 method available
N/A=Not Applicable
NE= Not Established
NR= Not Reported
PRG=Preliminary Remediation Goal
PCBs = Polychlorinated Biphenyls
RG = Remediation Goal
RL = Reporting Limit
VCP = Voluntary Cleanup Program
µg/L= micrograms per liter
mg/Kg= milligrams per kilograms

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Table 5.2
Preliminary List of Action-Specific ARARs Summary
Garvey Elevator Site
Hastings, Nebraska

Action	Specific Activity	Action-Specific ARAR
Groundwater Monitoring	Well Registration, Permitting	Neb. Rev. Stat. 46-602 et seq; Title 456, Chapter 10, 12, Hastings Ordinance No. 3754, City Code Section 32-616; Title 178 Chapter 12
	Well Driller Licenses	Neb. Rev. Stat. 46-1201 to 46-1241; Title 178, Chapter 10
	Well Spacing	Neb. Rev. Stat. 46-651 to 46-655
	Groundwater Monitoring	40 CFR Part 264, 40 CFR Part 265 Subpart F, 40 CFR Part 270.14(c)
Alternate Water Supply	Well Registration	Neb. Rev. Stat. 46-602 et seq; Title 456, Chapter 10, 12, Hastings Ordinance No. 3754, City Code Section 32-616
	Well Driller Licenses	Neb. Rev. Stat. 46-1201 to 46-1241; Title 178, Chapter 10
	Well Spacing	Neb. Rev. Stat. 46-651 to 46-655
	Permitting of Public Water Supplies	Municipal and Rural Domestic Ground Water Transfer Permit Act, Neb. Rev. Stat. 46-638 to 46-650
	Public Water Supply Systems	The Nebraska Safe Drinking Water Act, Neb. Rev. Stat. 71-5301 to 71-5313, Title 179
Extraction Wells	Well Registration, Permitting	Neb. Rev. Stat. 46-602 et seq; Title 456, Chapter 10, 12, Hastings Ordinance No. 3754, City Code Section 32-616
	Well Driller Licenses	Neb. Rev. Stat. 46-1201 to 46-1241; Title 178, Chapter 10
	Well Spacing	Neb. Rev. Stat. 46-651 to 46-655
	Withdrawal and Transfer of Ground Water	The Industrial Ground Water Regulatory Act, Neb. Stat. 46-675 to 46-690, DNR Regs Title 456, Chs. 4 and 7
Well Abandonment	Well Abandonment	Neb. Rev. Stat. 46-602; Regulations Governing Water Well Construction, Pump Installation and Water Well Abandonment Standards, Title 178; and Title 456, Ch. 9.
Institutional Controls	Deed Restrictions	RCRA 40-CFR 264.119 and 265.119; Nebraska Hazardous Waste Regulations, Title 128, Chapters 21 and 22
Groundwater Treatment	Air Stripping	Air Quality Regulations, Title 129, Ch. 1, 5, 6; Ch. 17, Sec. 001; Ch. 27 Sec. 002 Nebraska Hazardous Waste Regulations, Title 128, Ch. 4, Sec. 002 if active carbon is used
	Carbon Adsorption, Ion-Exchange, and Granular Media Filtration	Nebraska Hazardous Waste Regulations, Transport and Storage, Title 128, Ch. 2; Ch. 4, Sec. 002; Ch. 8, 9, 10, 11, 12-15, 21, and 22. Air Quality Regulations, Title 129. Integrated Solid Waste Management Regulations, Title 132.
	Flocculation/Sedimentation, Reverse Osmosis, Enhanced Oxidation, and Chemical Precipitation	Rules and Regulations for Design, Operation and Maintenance of Wastewater Treatment Works, Title 123. Transport and Storage, Title 128, Ch. 2; Ch. 4, Sec. 002; Ch. 8, 9, 10, 11, 12-15, 21, and 22. Air Quality Regulations, Title 129. Integrated Solid Waste Management Regulations, Title 132.
	Aerobic and/or Anaerobic Biological Treatment	Nebraska Department of Agriculture. Underground Injection and Mineral Prod. Well Regulations, Title 122; Integrated Solid Waste Management Regulations, Title 132, Ch. 13.
	On-Site Treatment	40 CFR Part 264, 40 CFR Part 265 Subparts I and J. LDR Requirements of Title 128, Ch. 20.
	Discharge of Water	Rules and Regulations Pertaining to the Issuance of Discharge Elimination System Permits, Title 119; Effluent Guidelines and Standards, Title 121; Nebraska Surface Water Quality Standards, Title 117.
	Infiltration/Reinjection	Rules and Regulations for Underground Injections and Mineral Production Wells, Title 122; Ground Water Quality and Use Classification, Title 118; Title 119; Rules and Regulations for Wastewater Treatment Works, Title 123.
	Financial Assurance	40 CFR Part 264 or Part 265; Title 123; Title 128, Chapters 21 and 22; Title 132, Chapter 8
Soil	Excavation and Removal	Surface Water Standards, Title 117; Rules and Regulations Pertaining to the Issuance of Discharge Elimination System Permits, Title 119; Title 128, Ch. 2; Ch. 4, Sec. 002; Ch. 8-15, 21, and 22. Air Quality Regulations, Title 129. Integrated Solid Waste Management Regulations, Title 132. UIC Regulations, Title 122. 40 CFR Part 264 or Part 265, Subpart G.;
	Disposal at Commercial Landfill	Nebraska Hazardous Waste Regulations, Ch. 8-11. Integrated Solid Waste Management Regulations, Title 132, Ch. 12.
	Financial Assurance	40 CFR Part 264 or Part 265

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6.0 REMEDIAL INVESTIGATION APPROACH AND ACTIVITIES

The following sections present identified data gaps and activities to resolve those data gaps in order to complete site characterization, the human health and ecological risk assessments, and inform the feasibility study. The field activities to address the data gaps are discussed below as they pertain to OU1 and OU2. There are two phases of work encompassing both OUs. The first phase consists primarily of the source areas investigation and on-site and off-site DPT groundwater sampling. The second phase of work is primarily devoted to on-site and off-site well installation and sampling.

Before initiating the main field activities discussed below for both OUs during each of the two phases of work, a limited field effort will be conducted to gather data for the Focused Feasibility Study and the Interim ROD. This limited field effort includes well surveying and collection of water level data from select wells. Attachment 8 provides the field activities memorandum submitted under separate cover and approved by EPA on May 20, 2009.

6.1 IDENTIFICATION OF DATA GAPS

This section identifies the data gaps in existing data collected at the site and its environs during previous investigations (see Section 3.0) and data needs resulting from construction and evaluation of the CSM (Section 4.0). Known data gaps are identified in the following subsections. The field sampling regime designed to resolve these data gaps is presented in Sections 5.2 and 5.3.

6.1.1 Surface Soil

No surface soil samples (0 to 1-foot depth) have been collected on site. Additional data is needed to evaluate whether contamination exists in exposed surface soils at the site as the result of leaking transformers and spilled or dumped pesticides. In addition, no surface samples have been collected to evaluate whether the known contaminants at the site, carbon tetrachloride and carbon disulfide, are present in exposed surface soils. It is unlikely that carbon tetrachloride, or its degradation compounds, would be present in surface soils, but confirmation samples should be collected for completion of the risk assessment. Because of generally widespread use of pesticides, background soil samples also should be collected for pesticide analysis for comparison to source area pesticide analytical results.

6.1.2 Soil Gas

Additional data is needed to conduct the human health evaluation of workers within the facility building. It is known that carbon tetrachloride is present in soil gas. Soil gas samples should be collected from beneath the office and shop building and maintenance building foundations to provide sufficient data to accurately evaluate the potential VOC exposure of facility employees.

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6.1.3 Indoor Air

Additional data is needed to conduct the human health evaluation of workers within the facility buildings. It is known that carbon tetrachloride is present in soil gas. Indoor air samples from the office and shop building should be collected to provide sufficient data to accurately evaluate the potential VOC exposure of facility employees. Background air samples from outdoors should be collected to evaluate ambient conditions on site at the time of the indoor air sampling.

6.1.4 Subsurface Soil

Previous investigations have shown that carbon tetrachloride is present in subsurface soils in the area of the former fumigant AST. The observed concentrations in soil samples collected in the general area of the AST were not indicative of a significant soil source. However, deep soil sampling (below 10 feet bgs) in the immediate area of the former fumigant AST has been limited. Additional and deeper soil sampling for VOCs analysis should be conducted in this area where historical information indicates a leak(s) did occur. The soil gas data also indicates this is a primary area of carbon tetrachloride contamination.

Also, the soil gas data showed a broad area of carbon tetrachloride contamination at depth beneath or adjacent to the main grain elevator, the smaller elevator east of the main elevator, the flat storage building, and northward in the area of MW-3 (Figure 6.1). Additional subsurface soil samples should be collected immediately adjacent to these features (or in the area of MW-3) to evaluate them as potential source areas for fumigant contamination.

Several current and historical features that could be potential source areas for carbon tetrachloride have not been the focus of previous investigations. These features include the current and former steel grain bins, construction debris disposal pit, railroad siding, and fumigant applicator wash area. Subsurface soil samples should be collected at these areas to evaluate them as potential source areas.

Subsurface soil samples also should be sampled for pesticides and PCBs. This sampling should be limited to those potential source areas were these contaminants were known to be stored, used, or potentially may have been disposed of on site.

6.1.5 Groundwater

Examination of previous groundwater analytical results shows two prominent areas where groundwater detections do not appear to be attributable to the former fumigant AST. The first area is east-southeast of the flat storage building and the existing steel grain bin. Ground water sampling should be conducted adjacent to these structures to determine if one or both of them is a source area for the contamination observed in downgradient wells. The second area is near MW-3 and the Garvey water supply well. Groundwater sampling should be conducted upgradient of this area to determine if the groundwater contamination observed in this area is the result of contamination upgradient to the northwest. In addition, the former construction

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debris disposal pit was situated immediately to the east of the MW-3 and Garvey supply well area (Figure 6.1). Groundwater samples should be collected beneath this potential source area to evaluate elevated carbon tetrachloride levels in this general area, and to evaluate possible pesticides that may have been disposed of in the disposal pit.

A groundwater extraction and treatment system has been installed at the site as a response action by the PRP to inhibit the further migration of contaminants downgradient to the east-southeast of the site. A sufficient amount of groundwater measurement data is needed to determine whether pumping of the on-site extraction wells is exerting hydraulic control of the contaminant plume(s). Also, these data would allow better placement of additional on site monitoring wells.

Additionally, the collection of geochemistry data during groundwater sampling would help determine aquifer groundwater characteristics and their impact on remedial alternatives.

6.1.6 Groundwater Downgradient of Source Area

Data collected downgradient of the source area include sampling of existing monitoring and private wells. However, there are three irrigation wells in the field immediately to the east (downgradient) of the site that have not been sampled. These three irrigation wells should be sampled to support the risk assessment. Previous investigations have indicated the presence of carbon tetrachloride in the groundwater, and additional data is needed to determine the size and configuration of the contaminant plume downgradient of the source area. In addition, permanent monitoring points are needed to further delineate and monitor the existing plume and to provide groundwater gradient and flow direction data for the CSM.

6.1.7 Sediments and Surface Water

Sediment and surface water samples have not been collected at the site from the two drainage ways and the pond on site during previous investigations. Samples should be collected from these drainageways for the COCs and COPCs to evaluate possible migration of contaminants in the surface water pathway. In particular, this data is needed to complete the SLERA.

6.2 SOURCE AREA INVESTIGATION (OU1)

The following section outlines and discusses the field investigation to be conducted for OU1 by media. OU1 consists of contaminated soils and groundwater at the source area. Table 6.3a provides a summary of the RI sampling program and quantities for the source areas portion of the field investigation. Table 6.3b includes a summary of more general aspects of the OU1 field effort that are not focused solely on the source areas. The FSP included as Appendix A details the field methods and procedures to be employed during the field investigation, while the QAPP included in Appendix B provides the analytical QA/QC measures that will be used during the investigation.

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6.2.1 Phase I Activities

6.2.1.1 Groundwater

The Phase I investigation of groundwater at OU1 consists of collecting groundwater samples from five DPT borings (SB-9, -12, -13, -29, and -32) near potential or known source areas, or adjacent to areas where observed groundwater contamination has not been well characterized (Table 6.1). Figure 6.1 illustrates the proposed location of the DPT borings. These data will be used to evaluate potential source areas and to further refine the understanding of the groundwater contamination emanating from these source areas and migrating downgradient to the east.

At four of the locations discrete groundwater samples will be collected approximately every five feet from the water table at approximately 115 feet bgs to the top of the upper fine-grained unit at approximately 130 feet bgs. Four samples will be collected from each of these borings. Prior to the groundwater sampling effort, DPT EC logging will be conducted at each of the borings (Figure 6.1). EC data will be collected to an approximate depth of 130 feet bgs, or refusal of the rods and probe. The EC data will be used to evaluate the lithology, particularly the presence and depth of the upper fine-grained unit. The groundwater sample depths will be adjusted as necessary at each fine-grained unit to accommodate targeted sampling to evaluate contamination potential pooled on the top of this unit. The upper fine grained unit will not be penetrated near potential source areas to prevent the boring from serving as a conduit for contamination to migrate from the upper aquifer to the medial aquifer.

At SB-32 upgradient of the Garvey water supply well, EC logging will be conducted to approximately 150 feet bgs, which is the approximate depth of the lower fine-grained unit observed in other locations on site. The EC data will be used to determine the depth and thickness of both fine-grained units. Then, groundwater samples will be collected at the water table, immediately above and below the fine-grained units, and in middle of the upper and intermediate aquifer, for a total of seven samples. Boring SB-32 is deeper than the other on-site DPT groundwater borings because it is assumed that the Garvey water supply well extends at least into the intermediate aquifer. No records of the depth of water supply well are available. As noted above in Section 4, the only information regarding it is that the well was installed in 1959, and capped in 1996 (Garvey, 2003).

Groundwater sampling procedures are detailed in Section 3.5 of the FSP provided in Appendix A. All groundwater samples will be submitted to the Region 7 EPA laboratory for low detection limit (LDL) VOCs analysis. At select locations, the groundwater samples also will be submitted for one or more of the following analyses: PCBs, SVOCs, and pesticides (Table 6.1). Section 4.0 of the QAPP provided in Appendix B provides detail on the analytical methods, QC requirements and sampling, and sample handling and custody.

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6.2.1.2 Subsurface Soils

VOCs

Evidence of downward migration of carbon tetrachloride through the vadose zone to the saturated zone beneath the former carbon tetrachloride fumigant storage tank has been documented in previous investigations. Further investigation is required to evaluate potential source areas and to further define the horizontal and vertical extent of contamination in the subsurface soil beneath the former fumigant AST source area. The data collected from the subsurface soil investigation will be used to evaluate, optimize and enhance the interim source area corrective action; and for the risk assessment.

Previous investigations included subsurface soil sampling and soil gas sampling in the vicinity of several potential source areas for the carbon tetrachloride contamination detected in the groundwater. A summary of the previous investigation soil boring locations are shown on Figure 6.1 along with the proposed boring locations for the RI Phase I field effort at OU1. A summary of the soil data from the PRP-lead investigation executed by ENSR is included in Attachment 1.

Table 6.1 provides a sample summary and rationale for known and potential source area sampling at the site. Site features that may be potential source areas for the carbon tetrachloride contamination include:

- Fumigant applicator wash area
- Vertical grain elevator silos
- Current and former round steel grain bins
- Flat grain storage building; and
- Railroad siding for loaded grain railcars

Additionally, elevated levels of carbon tetrachloride in groundwater have been detected in the vicinity of nested well cluster MW-3 and the Garvey supply well, and in the construction debris disposal pit (See Figure 3.1).

Based on the previous investigation sample locations, previous analytical data, and site features, 25 DPT borings will be advanced at the site to 20 feet bgs. A photoionization detector (PID) will be utilized to screen the soil cores for organic vapors every foot. A descriptive log of the soil cores will be completed for each soil boring. Grab soil samples will be collected approximately every 5 feet or at locations with high PID readings from 5 feet bgs to 20 feet bgs for a total of 4 soil samples per boring.

To provide a vertical soil profile below the former fumigant AST, continuous soil sampling will be collected at one boring (SB-2) from the ground surface to groundwater table (approximately 115 feet bgs). A PID will be utilized to screen the soil cores for organic vapors every foot, and a descriptive log of the soil column will be completed. From 5 feet bgs, grab soil samples will be collected approximately every 5 feet to a depth of 25 feet bgs

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and then at an interval of 10 feet (or at locations with high PID readings) to the total depth of 115 feet bgs for a total of 14 soil samples per boring location.

The samples will be submitted to the EPA Region 7 laboratory for analysis for VOCs. Soil sampling procedures are detailed in Section 3.0 of the FSP in Appendix A.

PCBs

PCBs have not been sampled for near the two current and one former electrical transformers on site. Five borings will be completed to collect subsurface soil samples for PCBs analysis. Two borings (SB-18 and SB-19) will be completed adjacent to the transformers on the south side of the main grain silos towards the east end. Also, two borings (SB-20 and SB-21) will be completed adjacent to the transformers at the west end of the main silos. One boring (SB-17) will be installed where the former transformer was located along the rail spur south of the silos. The proposed boring locations are illustrated on Figure 6.1. Except for SB-18, the borings will be completed to a depth of 10 feet, with samples collected at 5 feet and 10 feet bgs. Because SB-18 also is to be used for evaluation of the former steel grain bin located at that location, it will be completed to 20 feet bgs. At SB-18, subsurface soil samples will be collected every 5 feet from 5 feet to 20 feet bgs.

A descriptive log of the soil cores will be completed for each soil boring. The analytical samples will be submitted to the EPA Region 7 laboratory for PCBs analysis. Soil sampling procedures are detailed in Section 3.0 of the FSP in Appendix A.

Pesticides and SVOCs

Pesticides have not been sampling for at the chemical storage shed, or the nearby location of the former chemical storage shed, during the investigations at the site. Also, there is a potential for pesticides to have been stored at the drum storage area, disposed of in the construction debris disposal pit, or flushed into the subsurface at the fumigant applicator wash area (Figure 3.1). Therefore, six subsurface soil borings will be sampled for pesticides at these potential source areas, as follows:

- Chemical Storage Shed (SB-24)
- Former Chemical Storage Shed (SB-30)
- Fumigant Applicator Wash Area (SB-4, SB-5)
- Former Drum Storage Area (SB-23)
- Construction Debris Disposal Pit (SB-29)

The proposed boring locations are illustrated on Figure 6.1. Also, one pesticides background location along the truck access road from Marion Drive to the facility will be sampled at all on site depths at which pesticides are sampled. These data are necessary for comparison to the potential source area results because it is expected that some level of pesticides will be present in this mostly rural area of Hastings. This comparison will be useful in evaluating the pesticide data to determine if more than a normal application has occurred in a potential source area scheduled for pesticides sampling. Table 6.1 provides a summary of the borings and sample depths organized by potential source area for the pesticides sampling effort. All

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borings will be completed to 20 feet bgs, and sampled from every 5 feet from 5 feet to 20 feet bgs. Soil sampling procedures are detailed in Section 3.0 of the FSP in Appendix A.

A descriptive log of the soil cores will be completed for each soil boring. The analytical samples will be submitted to the EPA Region 7 laboratory for analysis for organochlorine pesticides, organophosphorus compounds (including malathion), and chlorinated herbicides (including 2,4-D) analysis. The samples also will be analyzed for SVOCs.

It should be noted that an analytical method is not available for the COPC glyphosate in soil at the EPA Region 7 laboratory. They have stated that glyphosate decomposes quickly, and that a reliable method could not be developed.

6.2.1.3 Surface Soils

Surface soils have not been collected at the site during past investigations. To complete the risk assessment, surface soils will be collected at the potential source areas from exposed soils (Table 6.1). To evaluate possible liquid fumigant contamination in surface soils, 25 samples for VOCs analysis will be collected. The sample locations generally correspond to the 20-foot deep subsurface VOC soil boring locations (Figure 6.1). The only exception to this is that instead of collecting a surface soil sample for VOCs at SB-3 in the area of the former fumigant AST piping, the surface soil sample will be collected at deep boring location SB-2 because it is situated at the location of the tank in exposed soil. SB-3 will be completed through the concrete immediately adjacent to the grain silos (Figure 6.1).

Surface soils to be analyzed for pesticides will be collected from the six of the proposed boring locations for evaluation of pesticides in subsurface soil. Also, a surface sample for pesticides analysis will be collected at the background pesticides soil boring location discussed above in Section 6.2.1.2. Surface soils also will be sampled for PCBs analysis at the five borings completed to evaluate PCBs in subsurface soils.

Soil sampling procedures are detailed in Section 3.0 of the FSP in Appendix A. The VOCs, PCBs, and pesticide analyses are the same as those indicated for the subsurface soils in Section 6.2.1.2 above.

6.2.1.4 Sediment and Surface Water

As noted above in Section 6.1, no sediment or surface water samples have been collected from the drainageways on site during past investigations. To complete the risk assessments, and evaluate the potential for off-site surface migration of site-related contaminants, surface water pathways samples will be collected. Five sediment samples will be collected from the intermittent drainage ways on the cropland west of the elevator facility buildings that drain to the south (Figure 6.2) into the on site pond. One sediment and surface water sample will be collected from the on site pond, and a sediment sample will be collected from the drainage outlet on the south end of the pond. Four sediment samples will be collected from the north-flowing drainage ditch between the rail spur and the railroad tracks along the eastern site

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property boundary (Figure 6.2). One background sediment sample will be collected from each of the two drainage systems at a location upgradient of potential influence from site runoff.

Sediment and surface water sampling procedures are detailed in Section 3.0 of the FSP in Appendix A. The analytical samples will be submitted to the EPA Region 7 laboratory for VOCs, PCBs, organochlorine pesticides, organophosphorus compounds (including malathion), and chlorinated herbicides (including 2,4-D) analysis.

6.2.1.5 Subslab Soil Gas/Indoor Air

The purpose of the vapor intrusion/indoor air investigation is to determine whether site-related VOCs (primarily carbon tetrachloride) are present in the air in on-site buildings that employees work in due to possible vapor intrusion. Results of the study will be evaluated using a risk assessment to determine if workers are at risk. The RI report will also be used to determine if additional samples are required during the remediation process. No previous sampling of soil gas beneath the concrete floor has been collected to evaluate the exposure risk to workers at the elevator facility.

Six subslab soil gas samples and six indoor air samples will be collected in the office and shop building, while four soil gas samples and four indoor air samples will be collected in the eastern portion of the maintenance building (quonset). The quonset maintenance building has concrete only in the eastern half of the building; the western half of the building has a dirt and gravel floor. Figures 6.3 and 6.4 illustrate the sample locations in the office and shop, and maintenance building, respectively.

In conjunction with the collection of subslab soil gas samples and air samples, two outdoor "background" air samples will be collected for comparison to the indoor air samples to assist in characterizing the possible contribution of outdoor (ambient) air to results observed for indoor air (USEPA, 2002).

Before sample collection, HGL will check for items in the buildings that may contain COPCs that may affect the sampling results. In the event COPC-containing chemicals are found in the building, those that can be removed prior to the sample collection activities will be removed. Because this is an operating business, it may not be possible to remove all COPC-containing chemicals from the premises. After removal of the items, the building will be ventilated before sample collection activities commence. The ventilation in the building will be returned to normal working conditions during the vapor sample collection. Summa canisters will be used to collect indoor air samples at a height of 3 to 5 feet above the ground (breathing zone). Subslab vapor ports will be installed through the concrete and gravel floors. Indoor air samples and subslab samples will be conducted simultaneously over the same time period. Section 3.0 of the FSP included as Appendix A specifies how the subslab vapor ports will be installed and how both the subslab samples and the indoor air samples will be collected.

The samples will be collected into summa canisters over an 8-hour period because that is general period of time that a worker is expected to be present on site over a 24-hour period.

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Therefore, the samples will be collected over the typical period of exposure. Subslab soil gas and air sampling procedures are detailed in Section 3.0 of the FSP in Appendix A. The analytical samples will be submitted to the EPA Region 7 laboratory for TO-15 VOCs analysis.

6.2.2 Phase II Activities

Phase II activities for OU1 will consist of well installation, aquifer testing, and monitoring well sample collection. The data collected during Phase I will be evaluated to determine if the locations and depths of the proposed monitoring wells discussed below are still appropriate.

6.2.2.1 Well Installation

Hydraulic Conductivity Well

One hydraulic test well (HTW-40) will be installed at an upgradient location in the northwest corner of the site property in the vicinity of monitoring well MW-8A and hydraulic testing well MW-33. Figure 6.5 illustrates the proposed well location. HTW-40 will be installed using the reverse rotary drilling technique to a depth of approximately 233 feet bgs. Well drilling, installation, and development procedures are discussed in Section 3.0 of the FSP provided in Appendix A.

HTW-40 will be installed as a permanent 4-inch monitoring well screened across the medial and lower aquifer from approximately 140 to 233 feet bgs. Based on boring logs from previous drilling activities on site, the unconsolidated deposits to bedrock contact should be encountered about 233 feet bgs. The upper aquifer will not be screened, and will be sealed from communication with the long HTW well screen throughout the medial and lower aquifer because of the potential of the upper aquifer to be impacted by possible groundwater contamination from upgradient sources.

Additional Monitoring Wells

Additional monitoring wells may be installed on site. Tentative well locations are identified on Figure 6.5. The decision to install new on-site monitoring wells, and final locations and depths (i.e. aquifers to be monitored) of the wells, will be determined based on:

- Data collected during the Focused Feasibility Study and the Interim ROD field effort; and
- Data collected during the Phase I activities at the site.

Additional well are thought to be necessary in the following general areas and depths:

- Two well clusters monitoring the upper and medial aquifer in areas that should be affected by the GET system, but have not been confirmed.
- One well cluster to monitor all three aquifers near the location of the former fumigant AST.
- Two well clusters (as needed) installed outside the GET system capture zone to monitor the contaminated system outside the influence of the GET system or contaminant concentrations downgradient of the extraction system.

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The specific depths and locations of the monitoring wells to be installed during Phase II will be informed by data obtained during Phase I field work. Therefore, an addendum to this Work Plan will be submitted once the method of installation, number, locations, depths, and analyses, and for the monitoring wells have been confirmed.

If possible as the drilling progresses, two soil samples will be collected at each of the two fine grained units based on lithology observed during the planned drilling and logs from previous drilling activities on site. These samples will be used to evaluate the ability of the two fine grained units to retard downward migration of contaminants, to evaluate the two fine grained units regarding chemical retardation characteristics, and for other chemical data necessary for the feasibility study. Additionally, one soil sample will be collected from each aquifer zone: the upper aquifer, the intermediate aquifer between the two fine-grained units, and the deep aquifer. The samples will be used to characterize the physical properties of the subsurface materials in each aquifer zone

If possible, the samples from the fine-grained units will be collected with a thin-wall sampler (i.e. Shelby tube) to comply with American Society for Testing and Materials (ASTM) standards for undisturbed samples. Geotechnical sample collection procedures are discussed in Section 3.5.5 of the FSP provided in Appendix A. The fine-grained soil samples will be submitted to a subcontracted laboratory for geotechnical analysis including grain size distribution, moisture content, soil porosity calculations, permeability, and bulk density. Samples also will be collected from each of these two intervals and submitted for TOC, pH, and natural oxidant demand. HGL also will collect one geotechnical soil sample for maximum index density and unit weight using a vibratory table (ASTM D4253) from the saturated sand unit in each aquifer zone (a total of 3 samples). Collection of these samples will require a drilling method that is capable of allowing collection of a large volume of cohesionless soil.

A subcontracted lab will perform the natural oxidant demand analyses. TOC and pH samples will be submitted to the Region 7 EPA laboratory for analysis. Section 4.0 of the QAPP provided in Appendix B provides detail on the analytical methods, QC requirements and sampling, and sample handling and custody.

6.2.2.2 Existing Monitoring Wells

The existing 32 on-site monitoring wells and new monitoring wells will be sampled as part of the RI field program. There will be four rounds of sampling conducted throughout the field program. The purpose of the additional sampling events is to monitor the migration of the contaminated groundwater plume at the site during the period between completion of the RI/FS and the approval of the ROD. The wells will be sampled using low-flow purging and sampling techniques. Purging and sampling procedures are detailed in Section 3.0 of the FSP in Appendix A.

All well samples will be submitted to the EPA Region 7 laboratory for LDL VOCs analysis. On the initial sample round, a subset of eight discrete sampling horizons will be sampled for monitored natural attenuation (MNA) parameters including alkalinity, chloride, sulfate,

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phosphates, iron, manganese, nitrates, TOC, methane, ethane, and ethene. Also on the initial sampling round, test kits for carbon dioxide, ferrous iron, and dissolved oxygen will be run in the field. Additionally, a subset of nine discrete sampling horizons will be sampled for groundwater treatment evaluation parameters including TSS, TDS, and total phosphorous. Test kits for biofouling bacteria will also be run in the field.

The proposed well sampling parameters for the existing wells are summarized in Table 6.3. The EPA Region 7 laboratory will complete the analyses for MNA parameters, TSS, TDS, and total phosphorous. Section 4.2 of the QAPP (Appendix B) further discusses test kit sample requirements and procedures.

6.2.2.3 Aquifer Testing

Dipole flow testing (DFT) method will be performed in the hydraulic test well (HTW-40) across the entire screened interval of the medial and lower aquifers. Multiple tests can be performed in a well with a long screen to obtain a vertical profile of horizontal hydraulic conductivity. Dipole flow testing procedures are discussed in detail in Section 3.0 of the FSP included as Appendix A.

Slug testing will be conducted on up to six selected on-site monitoring wells to provide aquifer characteristics of the groundwater beneath the source areas. The locations for slug testing will be determined when the locations for additional on-site monitoring wells are finalized. The data will be used during the evaluation of the remedial alternatives during the FS. The slug testing procedures are discussed in detail Section 3.0 of the FSP in Appendix A.

The results of the hydraulic tests will be used with other hydrogeologic data collected during RI activities to evaluate aquifer conditions to support completion of the FS.

6.2.2.4 Remediation System Evaluation

HGL prepared a Proposed Field Activity Memorandum dated April 22, 2009 detailing for EPA the proposed initial data collection activities planned to support an interim ROD for the OU1 groundwater. This memorandum is included in Attachment 8. This work was intended to be executed in conjunction with the on-site monitoring well surveying. However, due to repairs and upgrades now underway to the GET system, the planned system evaluation activities outlined in the memorandum will not be conducted with on-site monitoring well surveying as initially scheduled. Instead, only an initial round of manual water level measurements will be taken during the surveying. The proposed remediation system evaluation activities will be conducted during the main RI/FS activities.

The proposed remediation system evaluation activities include recording water levels in select monitoring wells and GET system readings to document the influence of the GET system on the groundwater flow regime beneath the site. To date, no evaluation of the GET system on groundwater beneath the site has been conducted. These data are necessary to determine whether additional monitoring wells are required at the site, and to assess whether the current

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GET system is capturing contaminated groundwater migrating east-southeastward from the site.

Water levels will be collected while the GET system is running; during the recovery phase after the system is turned off and water levels are allowed to return to "normal"; and then after the system is re-started. The total depths of the monitoring wells also will be measured to reconcile the inconsistency between the depths noted by HWS during installation and the depths recorded by ENSR. Table 1 in Attachment 8 indicates the wells from which water levels will be collected to evaluate the GET system influence, and shows the well depth data collected to date.

The proposed sequence of events is as follows:

1) With the GET system operating, water level measurements will be collected manually from all on-site monitoring wells, and recorded for the extraction wells (dedicated transducers). Monitoring well total depth measurements also will be collected at this time. Next, data logging transducers will be inserted in MW-3A, MW-3B, MW-4A, MW-4B, and MW-13C. In addition, a data logger will be connected to the dedicated transducers installed in the four screened zones of multilevel well MW-30A/C/D/E.
2) Operation of the GET system will be continued for two days, and then the system will be turned off. The system will remain off for five days as the aquifers at the site recover to pre-pumping conditions. During these five days, and the preceding two days of system operation, the temporary and dedicated transducers will collect recovery water level readings approximately once every hour.
3) After five days with the system off, water levels will be collected manually from those monitoring wells without transducers, and from the system readout for the transducers in the pumping wells. Then, the GET system will be re-started.
4) After five days of continuous system operation, water levels will be collected manually from those monitoring wells without transducers, and from the system readout for the transducers in the pumping wells. This marks the end of the study. The temporary transducers and data logger will be recovered, data downloaded, and then returned to the vendors.

During the time period that the water levels readings are recorded, the local computer connected to the GET system will be programmed to record the extraction well pumping levels, the flow meter readings for the extraction wells, the total combined flow meter readings, and local barometric pressure readings. The results of the remediation system evaluation will be used with other hydrogeologic data collected during RI activities to evaluate aquifer conditions to support completion of the FS.

6.3 DOWNGRADIENT INVESTIGATION (OU2)

In Phase I, off-site groundwater (OU2) will be sampled to delineate the horizontal and vertical extent of the off-site groundwater contaminant plume originating from the site. Off-site groundwater will be characterized using DPT techniques along three transects downgradient of the Garvey Elevator. Subsequently, in Phase II, permanent monitoring wells will be installed at

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five locations to monitor the groundwater plume in select areas after the horizontal and vertical extent of the contamination has been delineated. Table 6.2 provides a sample summary and rationale for the OU2 field activities. DPT sampling, and purging and sampling procedures for the permanent monitoring wells are detailed in Section 3.0 of the FSP in Appendix A.

Depending on availability, the EPA mobile laboratory may be used to analyze select groundwater samples in the field to obtain real-time analytical data. Samples proposed for analysis in the EPA mobile lab consist of select samples from the northernmost and southernmost borings along each transect. Also, samples from one or more borings at the most downgradient transect will be analyzed to confirm that the transect is beyond the leading edge of the plume. These field data will be used to determine the approximate northern and southern margins, and leading edge of the plume.

6.3.1 Phase I Activities

6.3.1.1 Transect 1

Transect 1 is proposed to extend along Wabash Avenue south of W. Highway 6 (J Street) approximately 1.7 miles east of Garvey Elevator. Previous site investigation work indicated that residential wells along Wabash Avenue have been impacted, with carbon tetrachloride and chloroform concentrations exceeding their respective PRGs. In addition, the RI/FS activities performed for the former Dana facility (West Highway 6 & Highway 281 Site) detected elevated carbon tetrachloride and chloroform concentrations in DPT borings located along Wabash Avenue. Utilizing data from the West Highway 6 & Highway 281 RI/FS investigation, the Transect 1 borings will extend south from the last of those borings to provide coverage across the carbon tetrachloride and chloroform contaminant plume. Six grid locations along Transect 1 will be completed to bedrock (approximately 240 feet bgs) using a DPT rig. EC downhole logging will be completed at 3 selected borings in the transect from ground surface to approximately 170 feet bgs to provide information on the subsurface materials. The goal is to identify the two silty clay layers (approximately 130 and 150 feet bgs) identified in previous investigations that separate the upper, medial, and lower aquifers. One select boring (collocated with an EC boring) will be continuously soil sampled and visually described to confirm the results of the EC logging at the transect. Figure 6.6 illustrates the proposed off-site DPT groundwater sample locations along Transect 1 with the W. Highway 6 & Highway 281 boring locations, and monitoring well locations. A spacing of approximately 500 feet was used to provide coverage across the anticipated width of the contaminant plume at Transect 1. The intent is to define the boundaries of the carbon tetrachloride and chloroform contaminant plume at Wabash Avenue.

At each transect boring location, groundwater samples will be collected from the top of the water table (estimated at 115 feet bgs) and at 10-foot intervals to the base of the aquifer (estimated to be approximately 240 foot bgs). The sample interval will be adjusted to collect samples at the upper aquifer/silty clay interface and the medial aquifer/silty clay interface identified by the EC logging. A total of 14 groundwater samples will be collected at each boring location. These samples will be submitted to the EPA Region 7 laboratory for LDL

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VOCs analysis. The transect groundwater samples will require a quick turnaround of an initial screening of VOC results. This screening will provide data to adjust the boring locations while still mobilized in the field. The final analytical results will be completed with a two-week turnaround time.

6.3.1.2 Transects 2 and 3

The proposed locations for Transects 2 and 3 are downgradient from Transect 1. Transect 2 is proposed along Showboat Boulevard, approximately 3.25 miles east of Garvey Elevator. Transect 3 is proposed along an access road approximately 1 mile east of Showboat Boulevard (4.25 miles east of Garvey Elevator). The boring locations along each transect will be installed using standard DPT drilling rig techniques. A spacing of approximately 1,000 feet was used to provide coverage across the anticipated width of the contaminant plumes at Transects 2 and 3. EC downhole logging will be completed at selected borings in each transect (from ground surface to approximately 170 feet bgs to provide information on the subsurface materials. The goal is to identify the two silty clay layers (approximately 120 and 150 feet bgs) identified in previous investigations that separate the upper, medial, and lower aquifers. One select boring (collocated with an EC boring) will be continuously soil sampled and visually described to confirm the results of the EC logging at the transect. Figure 6.3 illustrates the proposed DPT groundwater sample locations along Transects 2 and 3. The intent is to define the boundaries of the contaminant plume at each transect. The transect locations may be adjusted to locate the leading edge of the groundwater contaminant plume based on investigation results. After completing Transect 1, sampling will proceed along Transect 3 approximately 1,500 feet downgradient of the perceived leading edge of groundwater contamination. If site-related groundwater contamination is detected along Transect 3, then Transect 2 may be relocated farther downgradient in an attempt to delineate the true leading edge of groundwater contamination. Likewise, the grid spacing may be adjusted during the field investigation based on sampling results.

At each transect boring location, groundwater samples will be collected from the top of the water table (estimated at 115 feet bgs) and at 10-foot intervals to the base of the aquifer (estimated to be approximately 240 foot bgs). The sample interval will be adjusted to collect samples at the upper aquifer/silty clay interface and the medial aquifer/silty clay interface identified by the EC logging. A total of 14 groundwater samples will be collected at each boring location. These samples will be will be submitted to the EPA Region 7 laboratory for LDL VOC analysis. The transect groundwater samples will require a quick turnaround of an initial screening of VOC results. This screening will provide data to adjust the boring and transect locations while still mobilized in the field. The final analytical results will be completed with a two-week turnaround time.

6.3.2 Phase II Activities

6.3.2.1 Additional Monitoring Wells

Based on the DPT groundwater sample results from along the off-site transects, nested

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monitoring well clusters will be installed at five locations to a depth of 240 feet bgs. Nested monitoring wells installed as part of the W. Highway 6 & Highway 281 RI/FS investigation will also be utilized to monitor the Garvey Elevator contaminant plume since the two plumes comingle. The rationale for the new monitoring well cluster placement (including an optional well) is as follows.

- MW-41 - Located south of the contaminant plume boundary at Wabash Avenue to supplement West Highway 6 & Highway 281 wells MW-104 (north plume boundary) and MW-105 (middle of contaminant plume at Wabash Avenue).
- MW-42 - Located in middle of the contaminant plume at Showboat Boulevard to supplement West Highway 6 & Highway 281 well MW-106 (north plume boundary).
- MW-43 - Located south of the contaminant plume boundary at Showboat Boulevard.
- MW-44 - Located at furthest downgradient position from estimated plume leading edge (approximately 1 mile east of Showboat Boulevard).
- MW-45 - Located at furthest downgradient position from estimated plume leading edge (approximately 1 mile east of Showboat Boulevard).
- MW-12D – An optional well to add to the existing MW-12 well cluster to monitor the lower aquifer.

The tentative monitoring well locations are shown on Figure 6.6. These locations will likely be revised as actual data collected from the DPT transect borings is evaluated.

Each groundwater monitoring well cluster will be consist of two 4-inch monitoring wells installed to two discrete depth horizons. The tentative well construction nomenclature will be as follows.

- Upper aquifer (A/B-well) – 110 feet to 130 feet below ground surface (bgs); 10-foot screen
- Medial aquifer (C-well) – 135 feet to 150 feet bgs, 10-foot screen
- Lower aquifer (D/E-well)– 160 feet to 240 feet bgs, 20-foot screen

The two depth horizons for the proposed nested monitoring wells will tentatively be C and D well depths. The actual well construction will be adjusted based on the vertical distribution of contaminants detected in the DPT transect borings.

An addendum to this work plan will be submitted once the number, locations, depths, and method of installation for the monitoring wells have been confirmed.

6.3.2.2 Well Sampling

Once the new nested monitoring well clusters have been installed, they will be sampled in conjunction with the existing monitoring wells as part of the RI field program. The new and existing on-site monitoring wells (OU1) will have four rounds of sampling conducted, while the existing and new off-site monitoring wells (OU2) will only have two sample rounds. Also, the three irrigation wells in the field immediately east (downgradient) of the site will be sampled during the initial sampling round. The purpose of the additional sampling events is to monitor the migration of the contaminated groundwater plume downgradient of the site during

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the period between completion of the RI/FS and approval of the ROD. The irrigation wells also are being sampled to support the HHRA. The monitoring wells will be sampled using low-flow purging and sampling techniques. Purging and sampling procedures are detailed in Section 3.0 of the FSP in Appendix A. The samples from the irrigation wells will be collected from a spigot at the wellhead, if possible.

All well samples will be submitted to the EPA Region 7 laboratory for LDL VOCs analysis. On the initial sample round, a subset of 11 discrete off-site sampling horizons will be sampled for MNA parameters including alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, methane, ethane, and ethene. Also on the initial sampling round, test kits for carbon dioxide, ferrous iron, and dissolved oxygen will be run in the field. Additionally, a subset of four discrete off-site sampling horizons will be sampled for groundwater treatment evaluation parameters including TSS, TDS, total phosphorous. The EPA Region 7 laboratory will complete the analyses for MNA parameters, TSS, TDS, and total phosphorous.

Test kits for biofouling bacteria also will be run in the field. Section 4.2 of the QAPP (Appendix B) further discusses test kit sample requirements and procedures. Well locations and sample depths for these analyses will be determined in the field based on the DPT groundwater sample results and field observations made during the drilling operation. The proposed well sampling parameters are summarized in Table 6.4.

6.3.2.3 Aquifer Testing

Slug testing will be conducted on up to six selected off-site monitoring wells to provide aquifer characteristics of the downgradient, off-site areas affected by the contaminant plume. The locations for slug testing will be determined when the locations for additional off-site monitoring wells are finalized. The data will be used during the evaluation of select remedial options during the FS. The slug testing procedures are discussed in detail in Section 3.0 of the FSP (Appendix A).

6.4 ECOLOGICAL INVESTIGATION

A screening level Ecological Investigation will be conducted to determine whether sensitive environments or endangered species are present at the site to support the ecological risk assessment and FS. No samples will be collected in association with this effort. The Ecological Investigation will consist of:

- Wetland and Habitat Delineation
- Wildlife Observations
- Community Characterization
- Identification of Endangered Species

6.5 MANAGEMENT AND DISPOSAL OF IDW

The investigation-derived waste (IDW) that will be generated during the RI field activities will consist of soil cuttings, well purge water, decontamination water, and general municipal refuse. Contaminated or potentially contaminated IDW will be segregated from uncontaminated

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IDW. Water and soil IDW will be containerized in appropriate containers such as 20 yd^3 roll-off containers and closed-top 55-gallon drums and held at a secure location on site awaiting disposal. Samples will be collected for waste characterization to determine proper disposal methods. All IDW will be managed and disposed in accordance with all applicable local, State, and Federal regulations. IDW management and disposal requirements will be detailed in the FSP.

6.6 SURVEYING

A licensed land surveyor in the State of Nebraska will be subcontracted to provide locational survey data (location and elevation) for all sampling points and monitoring wells. The survey work will be performed in two mobilizations. An initial mobilization will be required to survey existing monitoring wells and provide general reference points for building corners, etc. All on-site soil boring locations and off-site sampling locations (DPT and monitoring wells) will be surveyed during a second mobilization.

6.7 RISK ASSESSMENT

An HHRA and SLERA will be prepared using previous and new data for the Garvey Elevator Site.

6.7.1 Human Health Risk Assessment Approach

The objective of the HHRA is to present an estimation of potential excess lifetime cancer risks and non-cancer health hazards associated with exposure to environmental media of concern at the site under current and future land use conditions. These estimates of potential cancer risk and non-cancer health hazards, along with the uncertainties associated with the data sets used for the calculations and the exposure assumptions in the HHRA will be presented in an appendix to the RI Report. Risks will be calculated and presented by media, receptor and by chemical, as well as for the site.

The methods to conduct the HHRA will be consistent with the USEPA risk assessment guidance as documented in *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)* (USEPA, 1989). Other pertinent guidance documents will be used as appropriate.

Data sets will be compiled for use in the HHRAs for the following environmental media of concern: indoor air (soil gas), soil, surface water, sediment and groundwater.

During the initial investigations, only subsurface soil, groundwater, and soil-gas samples were collected. As described in previous sections, HGL will collect additional samples from the same environmental media, and surface soils, and sediment as part of the RI. The data used in the HHRA and ERA will be obtained from the previous studies and RI data sets in the following manner:

- Surface soil data – the results of all sampling events will be pooled;

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- Shallow subsurface soil data – the results of all sampling events will be pooled;
- Sediment - sediment samples collected during the RI investigation;
- Surface water –surface water samples collected during the RI investigation;
- Groundwater – the most current data will be used (i.e., the results of the RI; and
- Indoor air – the most current soil-gas data will be used.

Only validated data will be used in the HHRA and the ERA. Data that are rejected during the validation process will not be included. J-qualified data will be used as if they were not qualified.

6.7.2 Ecological Risk Assessment Approach

A screening level ERA will be prepared using previous and new data for the Garvey Elevator Site. The screening level ERA will be performed in accordance with USEPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997). The ERA will consist of Steps 1, 2 and 3a of the ERA process. Step 1 will be the problem formulation, Step 2 will be an initial screening, and Step 3a will be a modified screening.

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TABLES

Table 6.1
Potential Source Areas Sample Summary
Phase 1 Activities
Garvey Elevator Site, Hastings Nebraska

Potential Source Area	Sampling Rationale	Sample Type	Number of Locations	Samples Per Location	Boring Depth (ft bgs)	Sample Depth (ft bgs)	Sample Locations	Laboratory		
								Analysis	Sample Count	QC***
Former Liquid Fumigant AST and Piping	Further investigation of impact of CCl4 at the former AST and piping locations.	Surface Soil	2	1	N/A	0 – 1	SB-1, SB-2	LDL VOCs	2	
		Subsurface Soil	2 1	4 14	20 115	5 - 20 5 - 115	SB-1, SB-3 SB-2	LDL VOCs	23	3 FD
Main Grain Elevator Silos	Investigate potential impact of CCl4 in the grain storage area.	Surface Soil	3	1	N/A	0 – 1	SB-6 to SB-8	LDL VOCs	3	
		Subsurface Soil	3	4	20	5 – 20	SB-6 to SB-8	LDL VOCs	12	1 FD
Small Grain Elevator Silos	Investigate potential impact of CCl4 in the grain storage area.	Surface Soil	2	1	N/A	0 – 1	SB-14, SB-15	LDL VOCs	2	
		Subsurface Soil	2	4	20	5 – 20	SB-14, SB-15	LDL VOCs	8	1 FD
Flat Grain Storage Bldg.	Investigate potential impact of CCl4 in the grain storage area and elevated groundwater detection.	Surface Soil	3	1	N/A	0 – 1	SB-11 to SB-13	LDL VOCs	3	
		Subsurface Soil	3	4	20	5 – 20	SB-11 to SB-13	LDL VOCs	12	1 FD
		Groundwater/EC Logging	2	4	130	115 - 130	SB-12, SB-13	LDL VOCs	8	1 FD
Round Steel Grain Bin	Investigate potential impact of CCl4 in the grain storage area and elevated groundwater detection.	Surface Soil	2	1	N/A	0 – 1	SB-9, SB-10	LDL VOCs	2	
		Subsurface Soil	2	4	20	5 – 20	SB-9, SB-10	LDL VOCs	8	1 FD
		Groundwater/EC Logging	1	4	130	115 - 130	SB-9	LDL VOCs	4	
Former Steel Grain Bin Location #1	Investigate potential impact of CCl4 in the former grain storage area on south side of main silos.	Surface Soil	1	1	N/A	0 – 1	SB-16	LDL VOCs	1	
		Subsurface Soil	1	4	20	5 – 20	SB-16	LDL VOCs	4	1 FD
Former Steel Grain Bin Location #2	Investigate potential impact of CCl4 in the former grain storage area on north side of main silos.	Surface Soil	1	1	N/A	0 – 1	SB-22	LDL VOCs	1	
		Subsurface Soil	1	4	20	5 – 20	SB-22	LDL VOCs	4	
MW-3 Area	Investigate the source of groundwater detections in the area of MW-3 and Garvey water well	Surface Soil	1	1	N/A	0 – 1	SB-31	LDL VOCs	1	1 FD
		Subsurface Soil	1	4	20	5 – 20	SB-31	LDL VOCs	4	
		Groundwater/EC Logging	1	7	155	115-155	SB-32	LDL VOCs	6	1 FD
Railroad Siding	Investigate potential impact of CCl4 used in railcars on the railroad siding north of the elevator.	Surface Soil	4	1	N/A	0 – 1	SB-25 to SB-28	LDL VOCs	4	
		Subsurface Soil	4	4	20	5 – 20	SB-25 to SB-28	LDL VOCs	16	2 FD
Construction Debris Disposal Pit	Investigate the potential disposal pit area and the elevated CCl4 in groundwater	Surface Soil	1	1	N/A	0 – 1	SB-29	VOCs, SVOCs, Pesticides	1	
		Subsurface Soil	1	4	20	5 – 20	SB-29	VOCs, SVOCs, Pesticides	4	1 FD
		Groundwater/EC logging	1	4	130	115 - 130	SB-29	VOCs, SVOCs, Pesticides	4	1 FD
Fumigant Applicator Wash Area	Investigate potential impact of activities in the fumigant wash area.	Surface Soil	2	1	N/A	0 – 1	SB-4, SB-5	VOCs, SVOCs, Pesticides	2	
		Subsurface Soil	2	4	20	5 – 20	SB-4, SB-5	VOCs, SVOCs, Pesticides	8	1 FD
Chemical Storage Shed	Investigate potential impacts from fumigant chemicals stored at this location.	Surface Soil	1	1	N/A	0 – 1	SB-24	VOCs, SVOCs, Pesticides	1	
		Subsurface Soil	1	4	20	5 – 20	SB-24	VOCs, SVOCs, Pesticides	4	
Former Storage Shed Location	Investigate potential impacts from fumigant chemicals stored at this location.	Surface Soil	1	1	N/A	0 – 1	SB-30	VOCs, SVOCs, Pesticides	1	
		Subsurface Soil	1	4	20	5 – 20	SB-30	VOCs, SVOCs, Pesticides	2	
Former Drum Storage Area	Investigate potential impacts from chemical drums stored at this location.	Surface Soil	1	1	N/A	0 – 1	SB-23**	VOCs, SVOCs, Pesticides	1	1 FD
		Subsurface Soil	1	4	20	5 – 20	SB-23**	VOCs, SVOCs, Pesticides	4	
Electrical Transformers	Investigate potential impact of PCBs from electrical transformers at the site.	Surface Soil	5	1	N/A	0 – 1	SB-17 to SB-21*	PCBs	5	1 FD
		Subsurface Soil	4	2	10	5 - 10	SB-17, SB-19 to SB-21	PCBs	8	1 FD
			1	4	20	5 – 20	SB-18*	PCBs and VOCs	4	
Drainage Areas	Investigate potential impacts of site contaminants to drainage pathways extending west and south of the site and the railroad siding.	Sediment/Surface Soil	11	1	N/A	0 – 1	SD-1 to SD-11	VOCs, SVOCs, Pesticides, PCBs	11	1 FD
		Surface Water	1	1	N/A	0-1	SW-1	VOCs, SVOCs, Pesticides, PCBs	1	1 FD
N/A	Investigate potential impact of contaminants to indoor air quality in source area buildings occupied by office and shop workers, 1 sample / 1,000 sq. ft.	Subslab Soil Gas	6 4	1 1	N/A	N/A	Office / Shop Bldg. Maint. Shop Bldg.	VOCs VOCs	10	N/A
		Indoor Air	6 4	1 1	N/A	N/A	Office / Shop Bldg. Maint. Shop Bldg.	VOCs VOCs	10	N/A
Background Sampling	Subsurface soil sampling to determine background pesticide levels	Subsurface Soil	1	4	20	5-20	Samples to be collected along truck access road from Marion Drive	Pesticides	4	
	Surface soil sampling to determine background pesticide levels	Surface Soil	1	1	N/A	0-1		Pesticides	1	
	Outdoor locations to determine background (ambient air) levels.	Outdoor Air	2	1	N/A	N/A	Background locations	VOCs	2	N/A

* SB-18 will also be used to characterize the Former Steel Grain Bin Location #1
**SB-23 will also be used to characterize the Former Steel Grain Bin Location #2
***Quality Control Samples will include trip blanks for VOCs, 10% field duplicates, and one rinsate blank for each type of sampling equipment; trip blanks will be submitted with VOC samples

BGS = Below ground surface
VOC = Volatile organic compound
PCB = Polychlorinated biphenols
FD = Field Duplicate
FS = Feasibility Study
TB = Trip Blank
N/A = Not applicable
LDL = Lower Detection Limit
RB = Rinsate Blank

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Table 6.2
OU1/OU2 Sample Summary
Garvey Elevator Site
Hastings, Nebraska

Data Use	Phase of Work	Sample Matrix	Laboratory			Rationale/Notes
			Analysis	Sample Count	QC*	
OU1 Geologic/Geochemical Characterization	Subsurface Soil Physical and Chemical Characterization/ Phase 2	Subsurface Soil	grain size, moisture content, soil porosity, permeability, bulk density, TOC, pH, natural oxidant demand	2 – new monitoring well	0	Two samples will be collected from each of the fined-grained units to provide quantitative lithologic data of geological units that may potentially retard contamination. One sample will be collected from the cohesionless soils in each of the three aquifer zones (3 samples total).
			maximum index density and unit weight using a vibratory table	3 – new monitoring well		
OU1 On-Site Groundwater Characterization	Existing and New Monitoring Well Sampling/Phase 2	Groundwater	TSS, TDS, total phosphorus, PCR, BART	5	0	Select wells will be sampled for groundwater treatment evaluation parameters to support completion of the FS. Wells will be selected based on location and historical data.
			VOCs	32 x 4	13 FD	Samples will be collected from the 32 on site monitoring wells each of 4 sampling events. These data will be used to characterize the on site groundwater contamination along with the DPT groundwater samples.
			MNA (alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, methane, ethane, and ethene)	8	0	Select wells will be sampled for groundwater monitored natural attenuation parameters to support completion of the FS. Wells will be selected based on location and historical data.
OU2 Off-Site Groundwater Characterization	Transect 1 Groundwater/ Phase 1	Groundwater	LDL VOCs	84	8 FD	Six borings with 14 samples per boring; Data will used to further define the off-site contaminated groundwater plume.
	Transect 2 Groundwater/ Phase 1		LDL VOCs	98	10 FD	Seven borings with 14 samples per boring; Data will used to further define the off-site contaminated groundwater plume.
	Transect 3 Groundwater/ Phase 1		LDL VOCs	56	6 FD	Four borings with 14 samples per boring; Data will used to further define the off-site contaminated groundwater plume.
	Subsurface Soil Physical and Chemical Characterization/ Phase 2	Subsurface Soil	grain size, moisture content, soil porosity, permeability, TOC, pH, natural oxidant demand	3 – new monitoring wells	0	Samples will be collected from the fined-grained unit off site to provide quantitative lithologic data of geological units that may potentially retard contamination and to supplement evaluation of these data from the on-site samples.
	Existing and New Monitoring Well Sampling/Phase 2	Groundwater	LDL VOCs	33 x 2	6 FD	Samples will be collected from 23 existing and 10 newly installed off-site monitoring wells to further characterize the extent of off site groundwater contamination. There will be two rounds of sampling.
			TSS, TDS, total phosphorus, PCR, BART	4	0	Select wells will be sampled for groundwater treatment evaluation parameters to support completion of the FS. Wells will be selected based on location and historical data.
			MNA (alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, methane, ethane, ethene)	11	0	Select wells will be sampled for groundwater monitored natural attenuation parameters to support completion of the FS. Wells will be selected based on location and historical data.
OU2 Off-Site Groundwater Risk Assessment	Irrigation Wells	Groundwater	LDL VOCs	3	1 FD	

NOTES:

*QC - Quality Control Samples will include trip blanks for VOCs, 10% field duplicates, and one rinsate blank for each type of sampling equipment; trip blanks will be submitted with VOC samples.
VOC = Volatile Organic Compounds
OU1= Operable Unit 1
OU2 = Operable Unit 2
HTW = Hydraulic Testing Well
BART = Biological Activity Reaction Test
DPT = Direct Push Technology
FD = Field Duplicate
TOC = Total Organic Carbon
FS = Feasibility Study
TB = Trip Blank
LDL = Lower Detection Limit
RB = Rinsate Blank
MNA = Monitored Natural Attenuation

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Table 6.3
Monitoring Well Sampling Summary
Garvey Elevator Site
Hastings, NE

					EPA Region 7 Laboratory										Field Test Kits							
Sample Location	Operable Unit	Depth	Water Level	GW parameters (T, pH, SC, DO, ORP, turbidity)	VOCs	Alkalinity	Chloride	Methane/Ethane/Ethene	Nitrogen (Nitrate+Nitrite)	Sulfate	Total Organic Carbon	Total Suspended Solids	Total Dissolved Solids	Total Phosporus	Ferrous Iron	Carbon Dioxide	Dissolved Oxygen	BART - Iron Related Bacteria	BART - Sulfate Reducing Bacteria	BART - Slime Forming Bacteria	BART - Denitrifying Bacteria	BART - Nitrifying Bacteria
MW-01A	OU1	102-117	X	X	X																	
MW-02A	OU1	103-118	X	X	X																	
MW-03A	OU1	108-123	X	X	X	X	X	X	X	X					X	X	X					
MW-03B	OU1	130.6-133.5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-03D	OU1	171-176	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-03E	OU1	230-235	X	X	X	X	X	X	X	X					X	X	X					
MW-04A	OU1	108.5-123.5	X	X	X																	
MW-04B	OU1	127-132	X	X	X																	
MW-05A	OU1	107.5-122.5	X	X	X																	
MW-05B	OU1	129-132	X	X	X																	
MW-05D	OU1	162-167	X	X	X																	
MW-06A	OU1	107.5-122.5	X	X	X																	
MW-06D	OU1	163.5-173.5	X	X	X																	
MW-06E	OU1	217.6-227.6	X	X	X																	
MW-07A	OU1	98-113	X	X	X																	
MW-07B	OU1	130-135	X	X	X																	
MW-08A	OU1	114.5-129.5	X	X	X	X	X	X	X	X					X	X	X					
MW-09A	OU1	101.3-116.3	X	X	X																	
MW-13C	OU1	133-135.5	X	X	X																	
MW-13E	OU1	230.8-235.8	X	X	X																	
MW-19A	OU1	127-132	X	X	X																	
MW-19C	OU1	152-162	X	X	X																	
MW-20A	OU1	127-132	X	X	X																	

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Table 6.3
Monitoring Well Sampling Summary
Garvey Elevator Site
Hastings, NE

					EPA Region 7 Laboratory										Field Test Kits							
Sample Location	Operable Unit	Depth	Water Level	GW parameters (T, pH, SC, DO, ORP, turbidity)	VOCs	Alkalinity	Chloride	Methane/Ethane/Ethene	Nitrogen (Nitrate+Nitrite)	Sulfate	Total Organic Carbon	Total Suspended Solids	Total Dissolved Solids	Total Phosporus	Ferrous Iron	Carbon Dioxide	Dissolved Oxygen	BART - Iron Related Bacteria	BART - Sulfate Reducing Bacteria	BART - Slime Forming Bacteria	BART - Denitrifying Bacteria	BART - Nitrifying Bacteria
MW-20C	OU1	152-162	X	X	X																	
MW-20D	OU1	182-192	X	X	X																	
MW-20E	OU1	222-232	X	X	X																	
MW-30A	OU1	127-132	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-30C	OU1	152-162	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-30D	OU1	182-192	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-30E	OU1	222-232	X	X	X																	
MW-31A	OU1	127-132	X	X	X																	
MW-31C	OU1	152-162	X	X	X																	
MW-10A	OU2	101.8-116.8	X	X	X																	
MW-10B	OU2	120-130	X	X	X																	
MW-11A	OU2	91-106	X	X	X																	
MW-12A	OU2	102.4-117.4	X	X	X																	
MW-12C	OU2	150-160	X	X	X																	
MW-14A	OU2	91-106	X	X	X																	
MW-17A	OU2	84.5-104.5	X	X	X																	
MW-17C	OU2	130-140	X	X	X																	
MW-17D	OU2	190-192.5	X	X	X	X	X	X	X	X	X					X	X	X					
MW-18A	OU2	97-112	X	X	X	X	X	X	X	X	X					X	X	X					
MW-18C	OU2	135-140	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-18D	OU2	188-193	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-41C	OU2	new well	X	X	X																	
MW-41D	OU2	new well	X	X	X																	

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Table 6.3
Monitoring Well Sampling Summary
Garvey Elevator Site
Hastings, NE

					EPA Region 7 Laboratory										Field Test Kits							
Sample Location	Operable Unit	Depth	Water Level	GW parameters (T, pH, SC, DO, ORP, turbidity)	VOCs	Alkalinity	Chloride	Methane/Ethane/Ethene	Nitrogen (Nitrate+Nitrite)	Sulfate	Total Organic Carbon	Total Suspended Solids	Total Dissolved Solids	Total Phosporus	Ferrous Iron	Carbon Dioxide	Dissolved Oxygen	BART - Iron Related Bacteria	BART - Sulfate Reducing Bacteria	BART - Slime Forming Bacteria	BART - Denitrifying Bacteria	BART - Nitrifying Bacteria
MW-42C	OU2	new well	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-42D	OU2	new well	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-43C	OU2	new well	X	X	X																	
MW-43D	OU2	new well	X	X	X																	
MW-44C	OU2	new well	X	X	X	X	X	X	X	X					X	X	X					
MW-44D	OU2	new well	X	X	X	X	X	X	X	X					X	X	X					
MW-45C	OU2	new well	X	X	X																	
MW-45D	OU2	new well	X	X	X																	
*MW-104A	OU2	100-115	X	X	X																	
*MW-104C	OU2	160-180	X	X	X																	
*MW-104D	OU2	192-212	X	X	X																	
*MW-105A	OU2	108-123	X	X	X	X	X	X	X	X					X	X	X					
*MW-105C	OU2	159.5-179.5	X	X	X	X	X	X	X	X					X	X	X					
*MW-105D	OU2	192-212	X	X	X	X	X	X	X	X					X	X	X					
*MW-106A	OU2	114-129	X	X	X																	
*MW-106C	OU2	161-181	X	X	X																	
*MW-106D	OU2	192-212	X	X	X																	
Total			65	65	65	19	19	19	19	19	9	9	9	9	19	19	19	9	9	9	9	7

* indicates W. Highway 6 and 281 Site monitoring wells

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FIGURES

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Figure 6.1
Proposed On-Site DPT Boring Locations

Legend

- Site Boundary
- Former Steel Grain Bin
- Railroad
- HWS DPT Soil Boring Location
- ENSR DPT Soil Boring Location
- Proposed Soil Boring Location
- Proposed Soil and Groundwater Boring Location
- Monitoring Well
- Former Garvey Water Well
- SB-13 Electrical Conductivity Logging Location

Note:
All HWS and ENSR sample locations were non-detect for carbon tetrachloride, unless otherwise noted.

A surface sample will be collected at each soil boring location.

N

0 100 200 400
Feet

Filename: X:/EPA009/Garvey/RI_FS/Proposed_OnSite_DPT_Boring_Loc.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

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Figure 6.2
Proposed Sediment/Surface Water Sample Locations

Legend

- Site Boundary
- Culverts
- Buildings
- Former Steel Grain Bin
- Concrete Paved Area
- Gravel Road
- Railroad
- Drainageways
- Proposed Sediment Sample Location
- Proposed Surface Water and Sediment Sample Location

0 125 250 500
Feet

N

Filename: X:/EPA009/Garvey/RI_FS/Proposed_Sed_SurfaceWater_Sample_Loc.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

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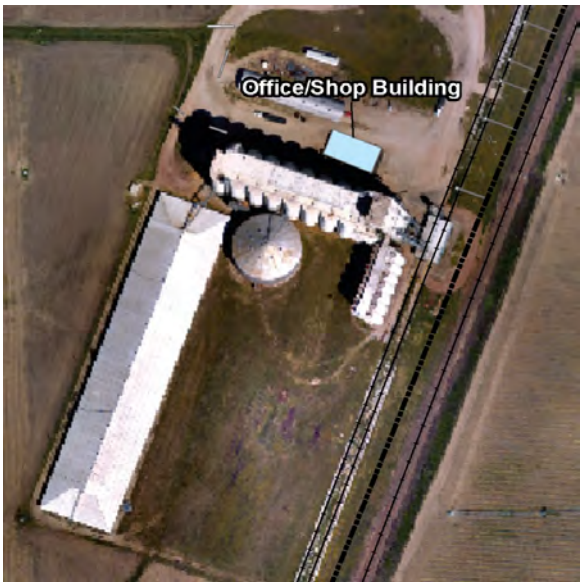

IA-6
SG-6
Maintenance/Storage Room
SG-5
IA-5
SG-4
IA-4
IA-3
SG-3
Bathrooms
Vending Machines
Office
IA-2
SG-2
Lockers
IA-1
AGP Manager Office
HGL Field Office
Break Area
SG-1
Not to Scale
OA-1

Filename: X:\EPA009\Garvey\RI-FS\ Proposed_OfficeShop_SubSlab_SoilGas_ IndoorAir_Samples.cdr
Project: EP9033.01.46.11
Revised: 05/18/09 CV
Source: HGL Database

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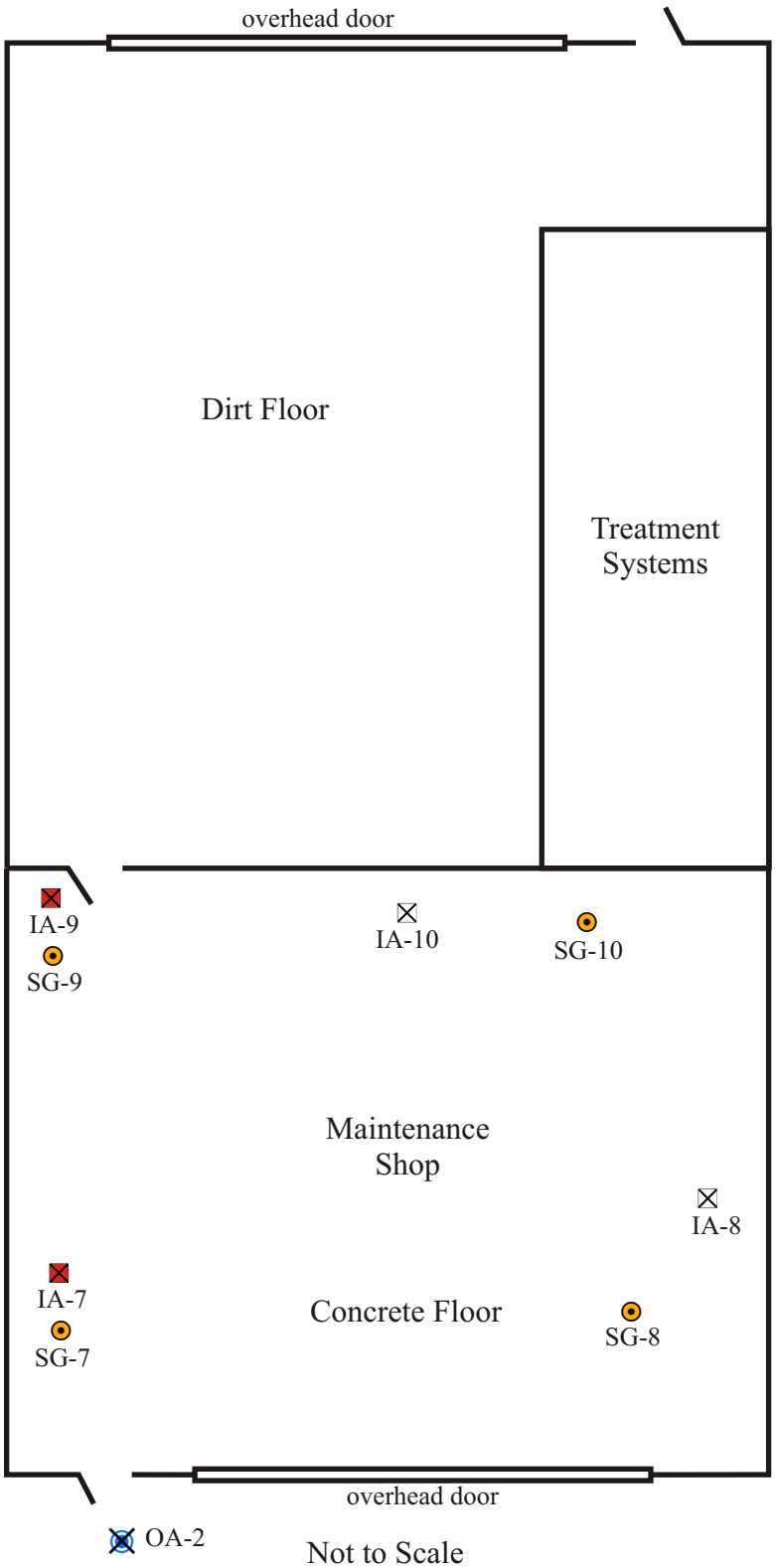
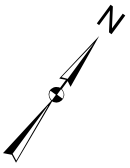
Legend

- Proposed Sub-Slab Soil-Gas Sample Location
- Proposed Indoor Air Sample Location
- Background Air Sample Location

Figure 6.3
Proposed Office/Shop Building Sub-Slab Soil Gas and Indoor Air Sample Locations





Filename: X:\EPA009\Garvey\RI-FS\Proposed_MaintenanceShop_SubSlab_SoilGas_IndoorAir_Samples.cdr
Project: EP9033.01.46.11
Revised: 05/18/09 CV
Source: HGL Database

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Legend

- Proposed Sub-Slab Soil-Gas Sample Location
- Proposed Indoor Air Sample Location
- Background Air Sample Location

Figure 6.4
Proposed Maintenance Building Sub-Slab Soil Gas and Indoor Air Sample Locations

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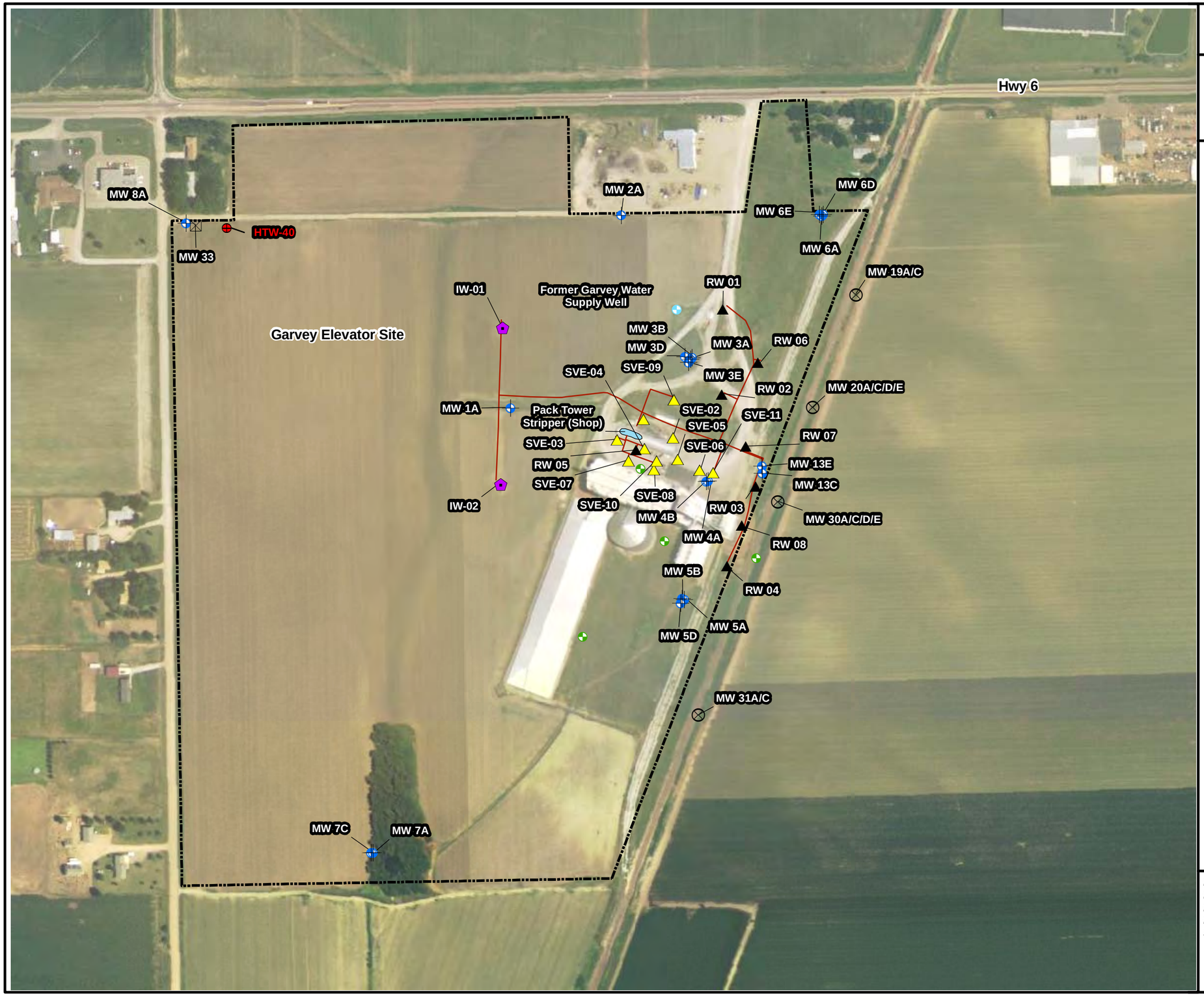
Figure 6.5
Proposed On-Site Well Locations



Legend

- Site Boundary
- Pack Tower Stripper
- GET and SVE System Piping
- Recovery Wells
- Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Assumed Location of Multi-Level Well Installed by ENSR
- Injection Well
- Soil Vapor Extraction Well
- Monitoring Well
- Potential Monitoring Well Location
- Proposed Hydraulic Test Well Location
- Former Garvey Water Well

0 180 360 720
Feet

N

Filename: X:/EPA009/Garvey/RI_FS/Proposed_OnSite_Well_Locations.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

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Figure 6.6
Existing On-Site Monitoring Wells

Legend

- Site Boundary
- Pack Tower Stripper
- ▲ Recovery Wells
- ☒ Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- ⊗ Assumed Location of Multi-Level Well Installed by ENSR
- Monitoring Well
- Former Garvey Water Well

Note:
Well locations based on survey data from the site background files.

N

0 180 360 720
Feet

Filename: X:/EPA009/Garvey/RI_FS/OnSite_MW_Locations.mxd
Project: EP9033.01.46.11
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

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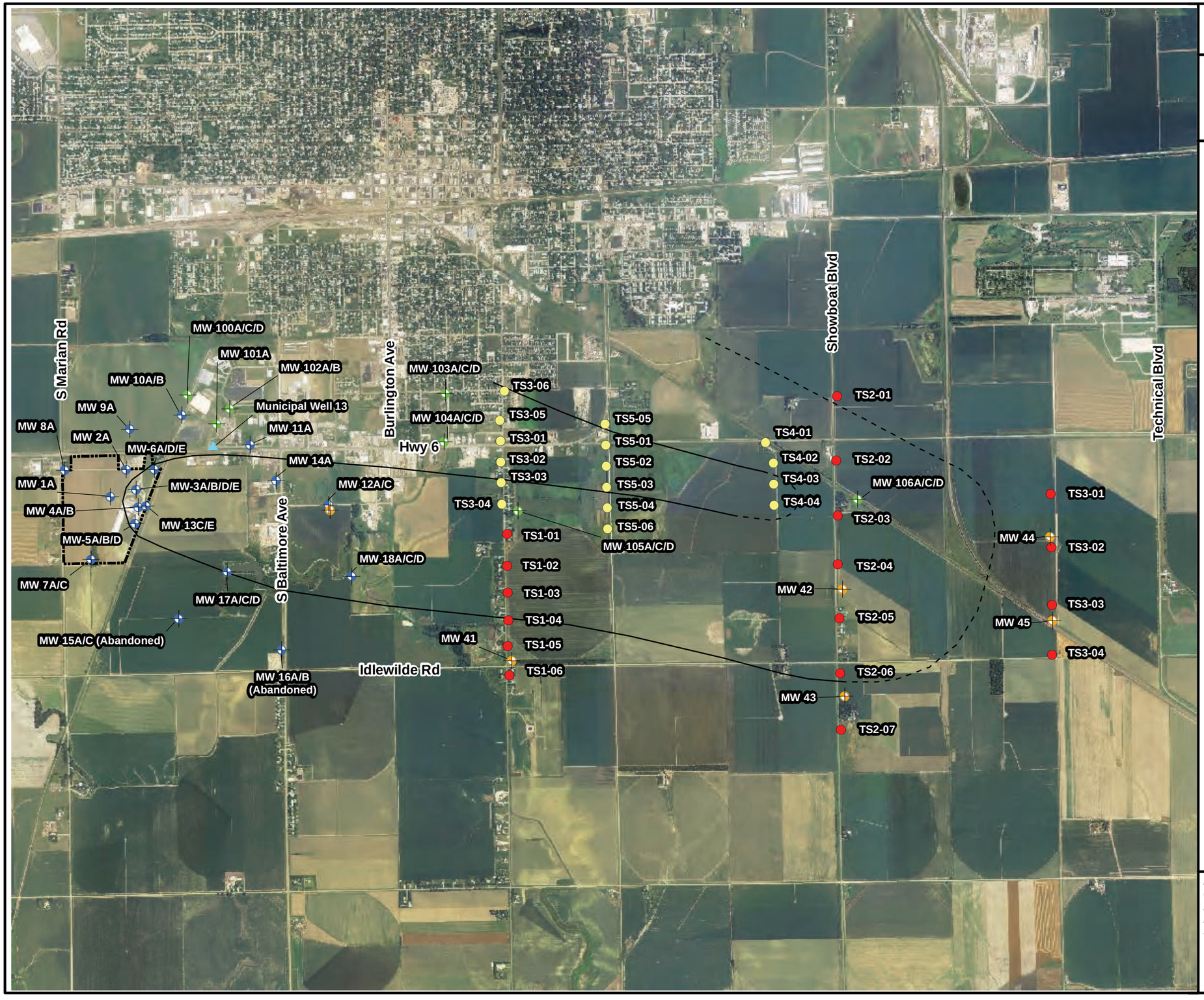
Figure 6.7
Proposed Off-Site Groundwater Transect and Monitoring Well Locations



Legend

- Site Boundary
- Proposed Monitoring Well Location
- Hwy 6 & 281 DPT Transect Boring
- Proposed DPT Transect Boring
- Monitoring Well
- Hwy 6 & 281 Site Monitoring Well
- Municipal Well
- Approximate Boundary of Carbon Tetrachloride MCL (5 µg/L)

N

0 1,200 2,400 4,800
Feet

Filename: X:/EPA009/Garvey/RI_FS/Offsite_Groundwater_Transect_MW_Loc.mxd
Project: EP9033.01.46.11
Revised: 05/15/09 CV
Source: ENSR GDB 2008, DNR

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7.0 COMMUNICATION, DATA MANAGEMENT, AND REPORTING

This section describes the important project elements of communications between team members and the flow and management of data that have been collected.

7.1 COMMUNICATION STRATEGY

Because there are multiple stake holders associated with this project (USEPA Region 7, NDEQ, AGP, HGL, and CDM) a communication strategy is necessary. To obtain the information required for the CERCLA process, frequent interaction among project stakeholders to reach consensus on project goals, develop and refine the CSM, track progress and data/information obtained in the field, and collaborate on project decision making will be necessary. Maintaining clear lines of communication assures that project information is routed to and/or through the appropriate personnel and is a key component of the project approach. Contact information for all parties involved is presented in the Site Management Plan (HGL, 2008c).

7.1.1 Project Team Level Communication

The project team provides the overall communication framework for the sampling and analysis approach by defining project objectives and data quality requirements, and ensuring that both the objectives and data quality requirements are met. The project team consists of representatives from EPA Region 7, NDEQ, and HGL.

Dr. Zurbuchen, the EPA TOPO, will be the key point of contact and center of communications for EPA personnel, HGL, as well as NDEQ. He will coordinate discussion and collaboration among all project stakeholders to establish clear agendas and focus group discussion.

Communications with HGL will be directed through the TOM, Alan Rittgers. Mr. Rittgers and Dr. Zurbuchen will maintain close communication during the course of the RI to track progress in the field, jointly review field data, and bring in other project decision makers when needed. HGL will assign a Field Supervisor that will lead field efforts during the RI. All on-site communications with HGL or its subcontractors regarding field activities will be directed through the Field Supervisor.

A periodic meeting/conference call will be held during field activities to obtain an update on laboratory results and formulate the plan for activities to be conducted for the remainder of the field work. Graphics generated using GIS will be reviewed during these calls.

7.1.2 Technical Team Level Communications

Within the project team are individuals having expertise in geologic, hydrologic, and chemical analytical methods appropriate for the site. These individuals will have the additional responsibility of serving as a technical team to provide a continual, integrated, and multidisciplinary presence throughout the RI process. The technical team will include the

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Field Supervisor. Each member of the technical team is involved in all steps of the RI process and may be present in the field when data collection related to their area of expertise is taking place. The optimization of the field investigation activities and the quality of the evolving and final CSM depends on the interaction between the members of the project and technical teams and field personnel. At least one member of the technical team will be on site during all field activities. This individual will be the site point of contact and will be responsible for daily field decisions.

The technical team will use quick-turnaround time data to generate information that will be evaluated and integrated into the CSM in the field. This requires a dynamic management plan that facilitates rapid decision making by the technical and project teams. The technical and project teams will be in communication with on site field personnel via cell phone and/or e-mail. The on-site technical team representative has the final authority on field operations and will be in regular contact with project and technical team members, via telephone consultation, concerning the present and next day's activities.

Technical team members not in the field will be available for telephone consultation. The technical team will be responsible for ensuring that (1) data collection is relevant to the objectives of the project (that is, able to satisfy data quality requirements), (2) QA/QC procedures for data collection and processing are strictly followed, and (3) field data reduction and processing do not introduce errors into the data and evolving CSM.

7.1.3 Project Support Team

The project support team includes technical and support personnel and equipment operators directly involved in data collection and sampling activities. The project support team is made up of HGL and CDM field personnel, drilling subcontractors, data validators, data managers, and analytical subcontractors. The project support team will be in daily communication with the project and technical teams during field activities. Project support team members may be asked to attend technical team meetings to present results or address other technical issues, as necessary.

7.2 DATA MANAGEMENT

Field and fixed analytical laboratory data will be generated for this project. The data management procedures to be used for each type of data are described below.

7.2.1 Field Data

Field measurements/observations will be recorded in a bound field notebook with numbered pages and also on paper forms appropriate for the task at hand (e.g., soil boring logs, well construction diagrams, sample chains-of-custody). Field data will be scanned and e-mailed or sent via facsimile to the HGL project manager on a periodic basis as needed for distribution to other project/technical team decision makers. A temporary field file established by on-site staff will be maintained by the Field Supervisor or his/her designee to ensure proper hardcopy

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storage of field data. Copies of hardcopy field data will be included in the final project report. Original field notebooks, field forms, and other field documentation will be transferred to EPA at the conclusion of the project for incorporation into EPA's permanent project file.

Several computer-based tools will be used to store and track data as it is collected in the field and to create two dimensional views (2D) to illustrate site conditions and help project decision makers in visualizing the CSM. The following applications will be used during the RI and FS:

- Data management and report generation using Earthsoft's Environmental Quality Information System (EQuIS) Version 5 software
- Visual sample tracking and 2D results viewing using ESRI ArcGIS software

Use of the EQuIS database is discussed below. The data presentation tools (ArcGIS) is discussed in Section 5.3.1.

7.2.2 EQuIS Database

HGL will use an EQuIS relational environmental database (Version 5) and standard industry spreadsheet software programs for managing relevant sampling, geologic, geophysical, and engineering data related to the project. The EQuIS project database will provide data storage, analysis, query, and reporting capabilities, and be able to interface with a variety of spreadsheet, word processing, statistical, geographic information system (GIS), and graphics software packages to meet the full range of task order requirements.

Data collected during the RI will be organized, formatted, and input into the project database for use in applicable phases of the project. Sample information collected by the field team will be recorded and then input directly into the EQuIS database. Laboratory sample analytical data received from the EPA Region 7 laboratory in an electronic data deliverable (EDD) format will either be loaded directly into the EQuIS or electronically converted to an EDD format conducive to the EQuIS data deliverable format and then uploaded into the database. All data entry will be checked for quality control throughout the project.

7.2.3 Fixed Laboratory Data

Fixed laboratory data will be transferred from the EPA Region 7 laboratory (and other laboratories to be determined) to HGL initially in electronic format to be followed by final, signed, hard copies of laboratory deliverables. Hard copies will be used to verify the accuracy of the electronic data. Copies of hardcopy laboratory data will be included in the final project report. Original laboratory reports will be transferred to EPA at the conclusion of the project for incorporation into EPA's permanent project file.

The fixed laboratories will maintain and follow their own detailed procedures for laboratory recordkeeping in order to support the validity of all analytical work. Each data package submitted will contain the laboratories written certification that the requested analytical method was run and that all QA/QC checks were within established control limits on all samples, with exceptions noted.

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7.3 DATA PRESENTATION, INTERPRETATION, AND REVIEW

7.3.1 Data Presentation

Site characterization results will be presented in text, tables, and graphics. As data become available, draft and final results will be distributed to project and technical team members. Text, tables, and databases will be created using Microsoft Word and Excel and Earthsoft EQuIS. Data stored in the EQuIS database will be visualized using plan-view GIS mapping during the RI field program. GIS updates will be available for access by site decision makers. These data presentation tools are discussed below.

A GIS will be developed for the site and study area using ESRI ArcGIS software to facilitate spatial analysis of the data and to generate figures for reports and presentations. The GIS will have geographic base layers consisting of available maps that depict local physiographic features such as roads, buildings, surface water features, railroads, and topography. Site-specific features derived from the site and study area survey results will be added to complete the base layers. Ortho-rectified aerial photography used to conduct the site survey will be obtained from local, county, state, or federal authorities, if available, and used as a photographic base layer. Then, as environmental investigation activities are conducted, the locations, types, and other relevant feature attribute information will be registered in the GIS for use in constructing maps. Analytical results and other characteristic data for samples and measurements will be queried from the project database within the GIS environment or added to the GIS to facilitate spatial queries of map-feature data such as where given chemical parameters of interest are sampled, detected, or exceeding regulatory standards or criteria, by date and depth. This functionality will be used to support data interpretation for preparation of maps and figures for remedial investigation, risk assessment, feasibility study technical memorandums and reports, proposed remedial action plans, and record of decision documents.

Plan view maps and figures will be generated using GIS to facilitate plan-view spatial data analysis. Figures will be generated to illustrate site features, sample locations and results, and locations where media sample quality exceeds regulatory standards and criteria. Figures will be generated in plan view and cross section where applicable, to show the extent of media contamination. Graphic illustrations will include geological profiles, cross-sections, water table maps, contaminant isoconcentration maps, and longitudinal and cross-sectional profiles of media contamination as applicable. GIS will be used in the field to generate 2D plume maps for real-time decision making.

7.3.2 DATA INTERPRETATION

Types of data that will be collected to meet project objectives include:

- Soil and groundwater analytical data for VOCs
- Geotechnical analytical data for subsurface soil
- Site geology and stratigraphy determined from drill cuttings/logging
- Quick-turnaround groundwater VOC data
- Direct field readings for groundwater using field meters

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- MNA data for groundwater
- Field test kit data for groundwater
- Groundwater elevations
- Hydrogeologic data from flowmeter testing
- Hydrogeologic data from slug testing

Geotechnical, hydrogeologic, and groundwater elevation data will all be used to identify groundwater flow directions, determine specific permeability zones within the aquifer, and evaluate the characteristics of the silty clay layer in affecting contaminant migration within the aquifer. Results of the field work will be used to refine the stratigraphic map of the subsurface that may help explain the distribution of contaminants present within the vadose and saturated zones.

Chemical data from a mobile field laboratory (if employed) will be used concurrently to determine the current extent of carbon tetrachloride and related contaminants on site and off site in groundwater. Field analysis will be used to generate VOC data that will be used to guide the field investigation in real-time and determine subsequent sample locations and depths.

Any data that indicates potential DNAPL within the vadose zone or saturated zone will be used in conjunction with the site subsurface stratigraphy to evaluate the feasibility of various treatment technologies in the subsequent feasibility study. Soil and groundwater results, hydrogeologic and stratigraphic data will be used to evaluate potential remedial systems and evaluate alternative options.

7.3.3 QUALITY ASSURANCE

QA protocols including record checking, field audits, and data review will be implemented during the RI to ensure that the field program meets project data quality objectives. The field team leader will be responsible for checking field notes, field forms, and logs on a daily basis for completeness and accuracy.

Field audits will be conducted by an independent QA auditor not associated with performance of the field work to verify procedures are in accordance with applicable field planning documents (this work plan, FSP, QAPP, and HSP).

Data review to verify the quality of data that are generated during the RI is another important component of the QA program. The types of samples that will be collected during the RI field program were discussed previously in Section 4.0, as well as the designated laboratory where sample analyses will be performed. Laboratories include an off-site EPA Region 7 laboratory and an off-site geotechnical laboratory. In addition, several types of qualitative data will also be produced in the field including results from direct reading instruments and field test kits. Various levels of data quality will be achieved by each, and various levels of data review will be required.

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7.3.3.1 Field Measurement Quality Assurance

QA in the field will be maintained by following the procedures specified in the FSP and QAPP including standard operating procedures. Adherence to these procedures will be verified using field audits.

A number of quality control samples will be collected including field duplicates collected for replicate analysis at a 10 percent frequency, field blanks, and equipment rinsate blanks. Details regarding QC samples and equipment decontamination procedures will be included in the FSP and QAPP.

7.3.3.2 Field Measurements and Test Kits

Field measurements will include real-time air monitoring equipment for health and safety, multi-parameter water quality meters, turbidity meters, and water level meters. All equipment will be rented from a reputable equipment vendor. Equipment will be checked for working order upon receipt in the field and will be calibrated daily following manufacturer instructions. Test kits manufactured by BART™, Hach™, and Chemetrics™ will be used in the field following manufacturer instructions.

7.4 FIXED LABORATORY QUALITY ASSURANCE

7.4.1 EPA Region 7 Laboratory

The EPA Region 7 laboratory will produce definitive-level data for the both quick-turnaround and standard turnaround data that will be undergo quality assurance by EPA data quality reviewers. HGL will perform data verification as the data are incorporated into the EQuIS database. Laboratory QC that will be performed will be in accordance with EPA Standard Operating Procedures (SOPs). EPA data packages will be reviewed before being transmitted to HGL project personnel and will contain data qualifiers, as appropriate. Trip blanks will be submitted with coolers containing VOC samples.

HGL will perform a limited review of these data packages to examine the narrative and data qualifiers added by EPA to determine data usability, perform a cross check of sample numbering on the COCs with the numbers in the EPA laboratory package to ensure there were no transcription errors, and review results of field QC samples (trip blanks, equipment rinsate blanks, field duplicates).

7.4.2 Geotechnical Laboratory

The geotechnical laboratory will follow ASTM standards appropriate to each requested analysis. Associated QC will be as specified in the method and the laboratory QA plan.

7.4.3 Vendor Analysis

Analysis of soil samples for natural oxidant demand will be conducted by a chemical supply

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vendor such as Carus Chemical Company following in-house SOPs. The SOPs are provided in the project QAPP.

7.5 REPORTING

7.5.1 Data Summary Report

HGL will prepare a Data Summary Report which will incorporate analytical data from historical investigations and the initial OU1 groundwater investigation. This Data Summary Report will include the results of the recent EPA Removal Section groundwater sampling, survey data, and water level measurements. The Data Summary Report will be used to support the interim ROD that will be produced.

7.5.2 Focused Feasibility Study

HGL will prepare a FFS which will incorporate historical analytical data, existing system information, and limited data from the initial OU1 groundwater investigation. This FFS will include the results of the Data Summary Report and an EPA-prepared groundwater model of the site, which will be used to evaluate the operating recovery well system. The FFS will be used to support the interim ROD that will be produced.

7.5.3 RI Report

HGL will prepare a comprehensive report documenting the results of the RI effort. This report will include a full discussion of the previous sampling events and the RI events conducted by HGL including interpretation of the results. Sections will include but are not limited to:

Introduction - Including the purpose and authority, history, hydrogeological setting, scope of work, and objectives.

Field Activities - Including a discussion of all work performed for the project.

Hydrogeologic Results - Including a discussion of groundwater levels and gradients, tables summarizing elevations, purging and water quality parameters, and figures depicting potentiometric surfaces.

Chemical Investigation Results - Including a discussion of analytical results and summary tables, and data quality review/validation.

Nature and Extent of Contamination - Including a detailed discussion of the horizontal and vertical extent of contamination with an interpretation and trending analysis. It will also include figures depicting the current and historical (if available) extent of groundwater contamination in both horizontal and vertical cross section formats.

Fate and Transport of Contamination - Including a complete discussion of natural attenuation (methodology, water quality parameter results, degradation processes identification,

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degradation rates, and conclusions) as well as typical fate and transport topics.

Risk Assessment - HHRA and a SLERA.

Conclusions and Recommendations - Summary and conclusions of results and recommendations for future work.

7.5.4 Full Feasibility Study

Using the findings of the RI the full FS will be completed. The purpose of the FS is to develop a set of RAs that will mitigate hazards to public health and the environment. The FS will follow "*Guidance for conducting Remedial Investigations and Feasibility Studies Under CERCLA*" (USEPA, 1988). The FS will include RAOs for each medium, presentation of remedial alternatives, evaluation of remedial alternatives, and selection of a remedial alternative. Applicable technologies will be based on specific site conditions and contaminants. RAs selected will be in compliance with the Site RAOs and ARARs.

The FS process includes the following steps.

- Development and Screening of Alternatives
  - Identify potential treatment technologies
  - Identify Action-Specific ARARs
  - Assemble alternative into alternative categories
  - Screen alternatives against short-term and-long term criteria of effectiveness, implementability and cost
- Detailed analysis of alternatives against threshold criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Detailed analysis of alternatives against balancing criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility and volume
  - Short-term effectiveness
  - Implementability
  - Cost
- Detailed analysis of alternatives against modifying criteria
  - Regulatory acceptance
  - Community acceptance

An FS report will be prepared documenting the evaluation of alternatives for the Site. This report will be submitted to USEPA Region 7 and NDEQ for review and comment.

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8.0 SCHEDULE

Upon approval of the RI/FS Work Plan the proposed project schedule for the RI will be implemented for the Garvey Elevator Site. The project schedule is included as Figure 8.1.

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FIGURES

Figure 8.1
RI/FS Project Schedule
Garvey Elevator Site
Hastings, Nebraska

ID	Task Name	Start	Finish
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6	EPA Review	Tue 12/30/08	Thu 4/2/09
7	Final Documents	Fri 4/3/09	Mon 5/25/09
8	EPA Approval	Tue 5/26/09	Mon 6/1/09
9	**Subcontracting**	Mon 5/18/09	Thu 7/2/09
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11	**Field Preparation**	Mon 6/1/09	Thu 6/25/09
12	**OU1 - Groundwater**	**Mon 7/6/09**	**Fri 11/6/09**
13	Mobilization	Mon 7/6/09	Fri 7/10/09
14	DPT Groundwater	Mon 7/13/09	Wed 7/22/09
15	Monitoring Well Installation	Mon 9/21/09	Fri 9/25/09
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25	**EPA Risk Assessment Memo**	Mon 6/22/09	Fri 7/3/09
26	**Focused Feasibility Study**	**Mon 6/15/09**	**Fri 8/7/09**
27	Draft Report	Mon 6/15/09	Fri 7/10/09
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32	**Interim OU1 Proposed Plan**	Mon 7/27/09	Fri 8/7/09
33	**Public Review**	Mon 8/10/09	Wed 9/9/09
34	**Finalize Interim OU1 ROD**	Thu 9/10/09	Wed 9/23/09
35	**Interim OU1 ROD approval**	Wed 9/23/09	Wed 9/23/09
36	**OU1 - Soil**	**Mon 7/13/09**	**Thu 8/6/09**
37	DPT source investigation	Mon 7/13/09	Fri 7/24/09
38	Ecological Investigation	Mon 8/3/09	Thu 8/6/09
39	**OU2 - Groundwater**	**Mon 7/27/09**	**Fri 12/11/09**
40	Transects 1-3	Mon 7/27/09	Fri 8/21/09
41	Monitoring Well Installation	Mon 9/21/09	Fri 10/16/09
42	Monitoring Well Sampling	Mon 11/2/09	Fri 11/13/09
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51	EPA Approval	Mon 3/8/10	Fri 3/19/10
52	**Remedial Alt Screening Memo**	**Mon 1/25/10**	**Fri 2/26/10**
53	Draft Memo	Mon 1/25/10	Fri 2/12/10
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55	**Remedial Alt Evaluation Memo**	**Mon 3/1/10**	**Fri 4/2/10**
56	Draft Memo	Mon 3/1/10	Fri 3/19/10
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58	**Full Feasibility Study**	**Mon 4/5/10**	**Fri 6/25/10**
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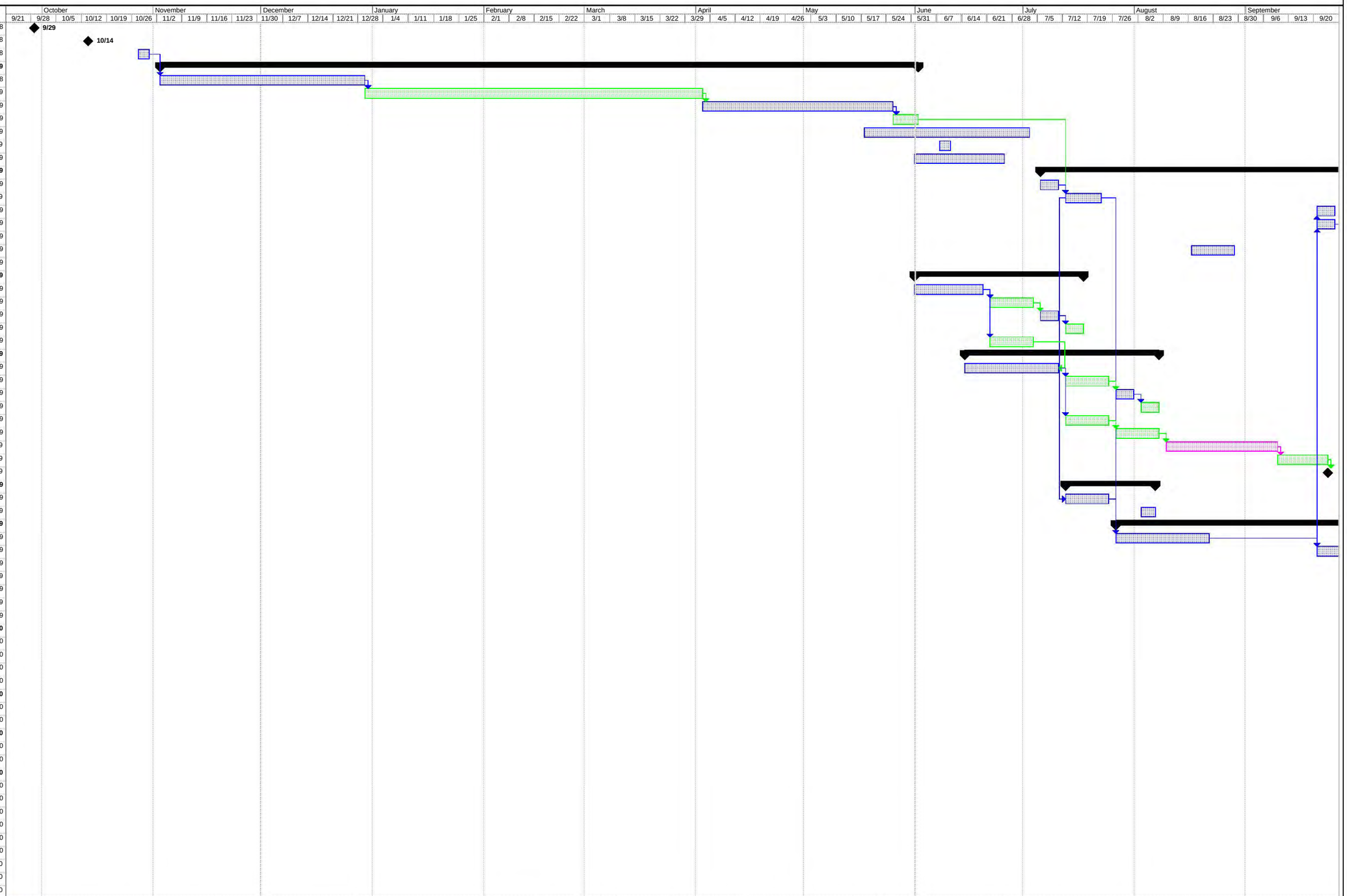
66	**Finalize OU1 and OU2 ROD**	Thu 9/9/10	Wed 9/22/10
67	**ROD approval**	Wed 9/22/10	Wed 9/22/10



Project: Garvey RI-FS Project Schedul
Date: May 29, 2009

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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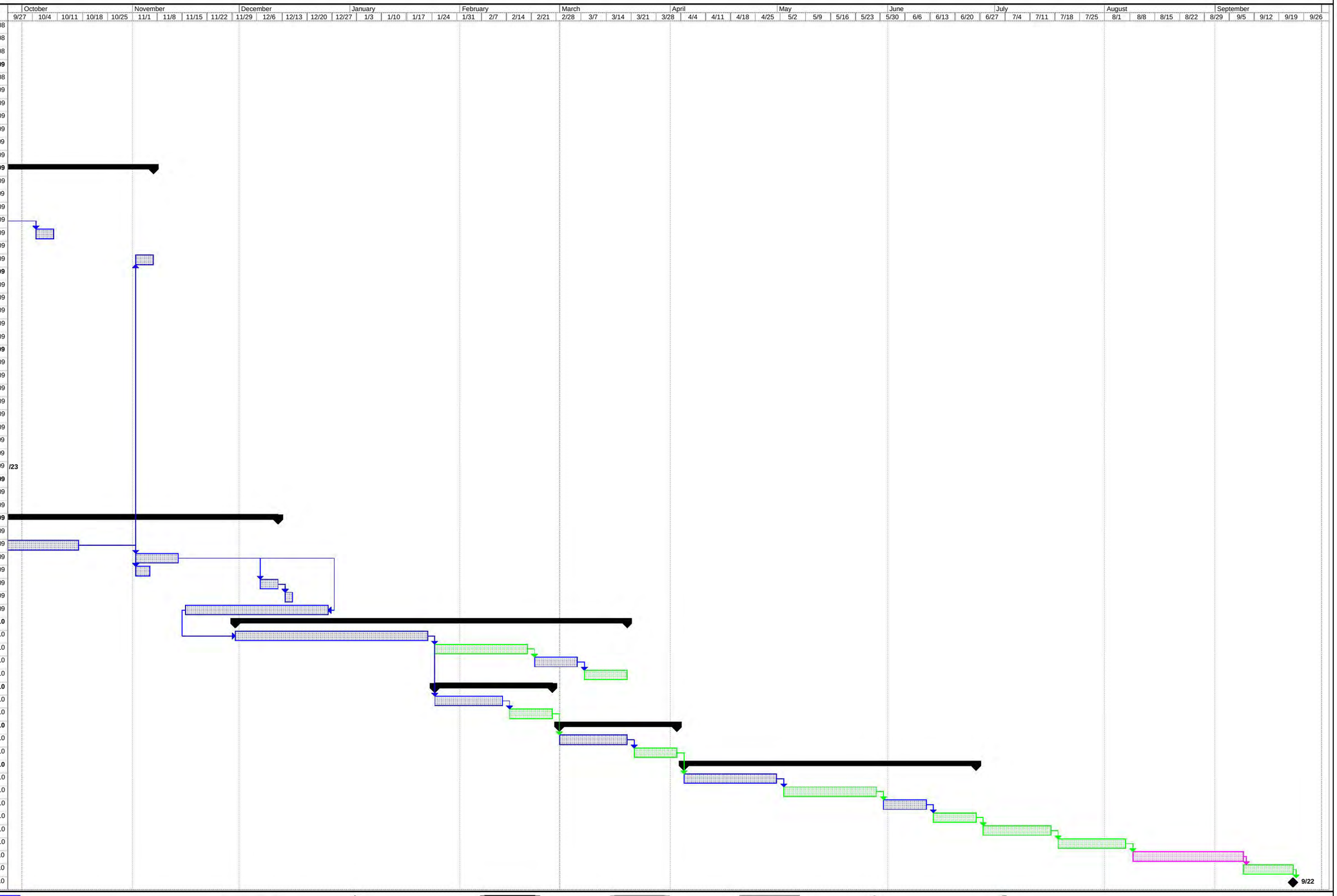

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ATTACHMENT 1

HWS SOIL AND SOIL-GAS SAMPLE MAPS AND DATA

Garvey Elevator Facility
Hastings, Nebraska

Table 6: Summary of Carbon Tetrachloride in Soils

Location	Depth Interval (ft.)	Date Sampled	Carbon Tetrachloride Concentration
Soil Vapor Extraction Well Construction (Reporting limit ranges from 0.1 to 5.0 ug/kg)			
SVE-D	10-11.5	12/06/94	Not Detected
SVE-D	20-21.5	12/06/94	Not Detected
SVE-D	40-41.5	12/06/94	Not Detected
SVE-D	50-51.5	12/06/94	Not Detected
SVE-D	60-61.5	12/06/94	Not Detected
SVE-D	70-71.5	12/06/94	Not Detected
SVE-D	80-81.5	12/06/94	Not Detected
SVE-D	90-91.5	12/06/94	Not Detected
SVE-D	100-101.5	12/06/94	440 ug/kg
SVE-D	109-110.5	12/06/94	Not Detected
SVM-7	17.5-18	12/19/94	535 ug/kg
SVM-7	36-36.5	12/19/94	2 ug/kg
SVM-14	18-18.5	12/19/94	235 ug/kg
SVM-14	36-36.5	12/19/94	13 ug/kg
SVM-28	36.5-37	12/19/94	71 ug/kg
SVM-35	75-77	12/21/94	Not Detected
SVM-35	98-100	12/21/94	5 ug/kg
SVM-70	76-76.5	12/19/94	6 ug/kg
SVM-140	75-77	12/21/94	Not Detected
SVM-140	100-102	12/21/94	Not Detected
Soil Probe Survey (Reporting limit is 7.0 ug/kg)			
P1	8.0-10.0	06/17/94	Not Detected
P2	8.0-10.0	06/17/94	Not Detected
P3	8.0-10.0	06/17/94	Not Detected
P4	8.0-10.0	06/17/94	Not Detected
P5	8.0-10.0	06/17/94	Not Detected
P6	8.0-10.0	06/17/94	Not Detected
P7	8.0-10.0	06/17/94	Not Detected
P8	8.0-10.0	06/17/94	Not Detected
P9	8.0-10.0	06/17/94	Not Detected
P10	8.0-10.0	06/17/94	Not Detected
P11	8.0-10.0	06/17/94	Not Detected
P12	8.0-10.0	06/17/94	Not Detected
P13	8.0-10.0	06/17/94	Not Detected
P14	8.0-10.0	06/17/94	Not Detected
P15	8.0-10.0	06/17/94	Not Detected
P16	8.0-10.0	06/17/94	Not Detected
P17	8.0-10.0	06/17/94	Not Detected
P18	8.0-10.0	06/17/94	Not Detected
P19	8.0-10.0	06/17/94	Not Detected
P20	8.0-10.0	06/17/94	Not Detected
P21	8.0-10.0	06/17/94	Not Detected
P22	8.0-10.0	06/17/94	Not Detected
P23	8.0-10.0	06/17/94	Not Detected
P24	8.0-10.0	06/17/94	8 ug/kg

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Garvey Elevator Facility
Hastings, Nebraska

Table 6: Summary of Carbon Tetrachloride in Soils (continued)

Location	Depth Interval (ft.)	Date Sampled	Carbon Tetrachloride Concentration
Monitoring Well Construction (Reporting limit is 5.0 ug/kg)			
MW-3	110'	06/15/94	Not Detected
Soil Gas Survey (Reporting Limit is 1.0 ug/L)			
SG-1	9.0-18.0	11/30/94	1.5 ug/L
SG-2	9.0-18.0	11/30/94	0.1 ug/L
SG-3	9.0-18.0	11/30/94	1.1 ug/L
SG-4	9.0-18.0	11/30/94	0.1 ug/L
SG-5	9.0-18.0	11/29/94	0.5 ug/L
SG-6	9.0-18.0	11/29/94	Not Detected
SG-7	9.0-18.0	11/29/94	0.3 ug/L
SG-8	9.0-18.0	11/29/94	Not Detected
SG-9	9.0-18.0	11/29/94	0.9 ug/L
SG-10	9.0-18.0	11/29/94	>10 ug/L
SG-11	9.0-18.0	11/29/94	Not Detected
SG-12	9.0-18.0	11/29/94	Not Detected
SG-13	9.0-18.0	11/29/94	Not Detected
SG-14	9.0-18.0	11/29/94	>7 ug/L
SG-15	9.0-18.0	11/29/94	>11 ug/L
SG-16	9.0-18.0	11/29/94	>4 ug/L
SG-17	9.0-18.0	11/29/94	>28 ug/L
SG-18	9.0-18.0	11/29/94	>15 ug/L
SG-19	9.0-18.0	11/29/94	>21 ug/L
SG-20	9.0-18.0	11/29/94	>20 ug/L
SG-21	9.0-18.0	11/29/94	>15 ug/L
SG-22	9.0-18.0	11/29/94	>9 ug/L
SG-23	9.0-18.0	11/29/94	0.5 ug/L
SG-24	9.0-18.0	11/30/94	0.6 ug/L
SG-25	9.0-18.0	11/30/94	>10 ug/L
SG-26	9.0-18.0	11/30/94	>12 ug/L
SG-27	9.0-18.0	11/30/94	1.4 ug/L
SG-28	9.0-18.0	11/30/94	2.4 ug/L
SG-29	9.0-18.0	11/30/94	>10 ug/L
SG-30	9.0-18.0	12/1/94	>13 ug/L
SG-31	9.0-18.0	12/1/94	Not Detected
SG-32	9.0-18.0	12/1/94	Not Detected
Soil Gas Vertical Profiles (Reporting limit is 1.0 ug/L)			
SP-1-1	8.0-10.0	11/30/94	>24 ug/L
SP-1-2	18.0-20.0	11/30/94	1.8 ug/L
SP-1-3	28.0-30.0	11/30/94	>29 ug/L
SP-2-1	8.0-10.0	11/30/94	2.6 ug/L
SP-2-2	18.0-20.0	11/30/94	0.6 ug/L
SP-2-3	28.0-30.0	11/30/94	Not Detected
SP-3-1	8.0-10.0	12/1/94	1.6 ug/L
SP-3-2	18.0-20.0	12/1/94	1.0 ug/L
SP-3-3	28.0-30.0	12/1/94	1.5 ug/L

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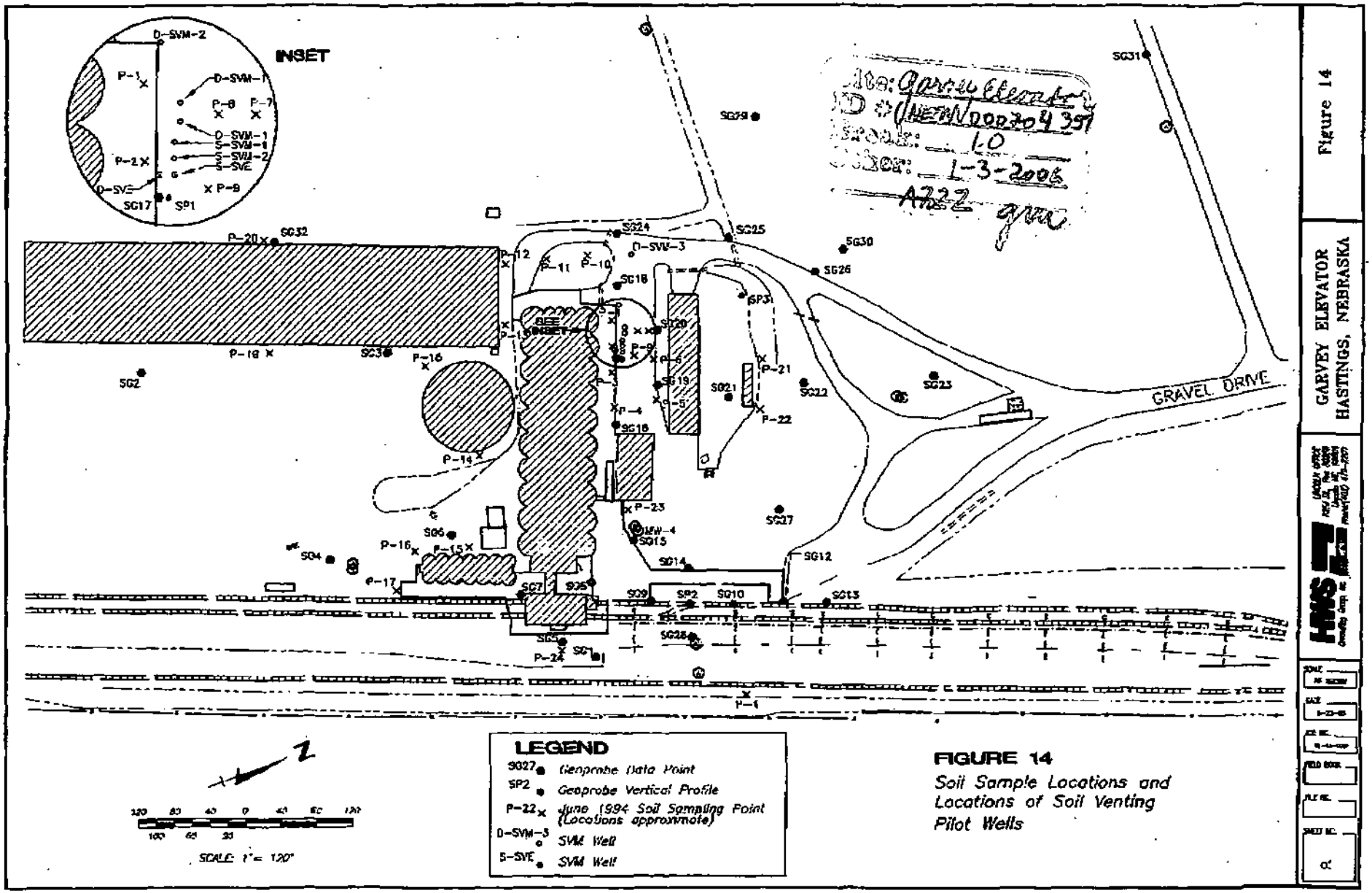


Re: Garvey Elevator
D # (NEN)000704391
Sites: 10
Date: 1-3-2006
A222 gmc

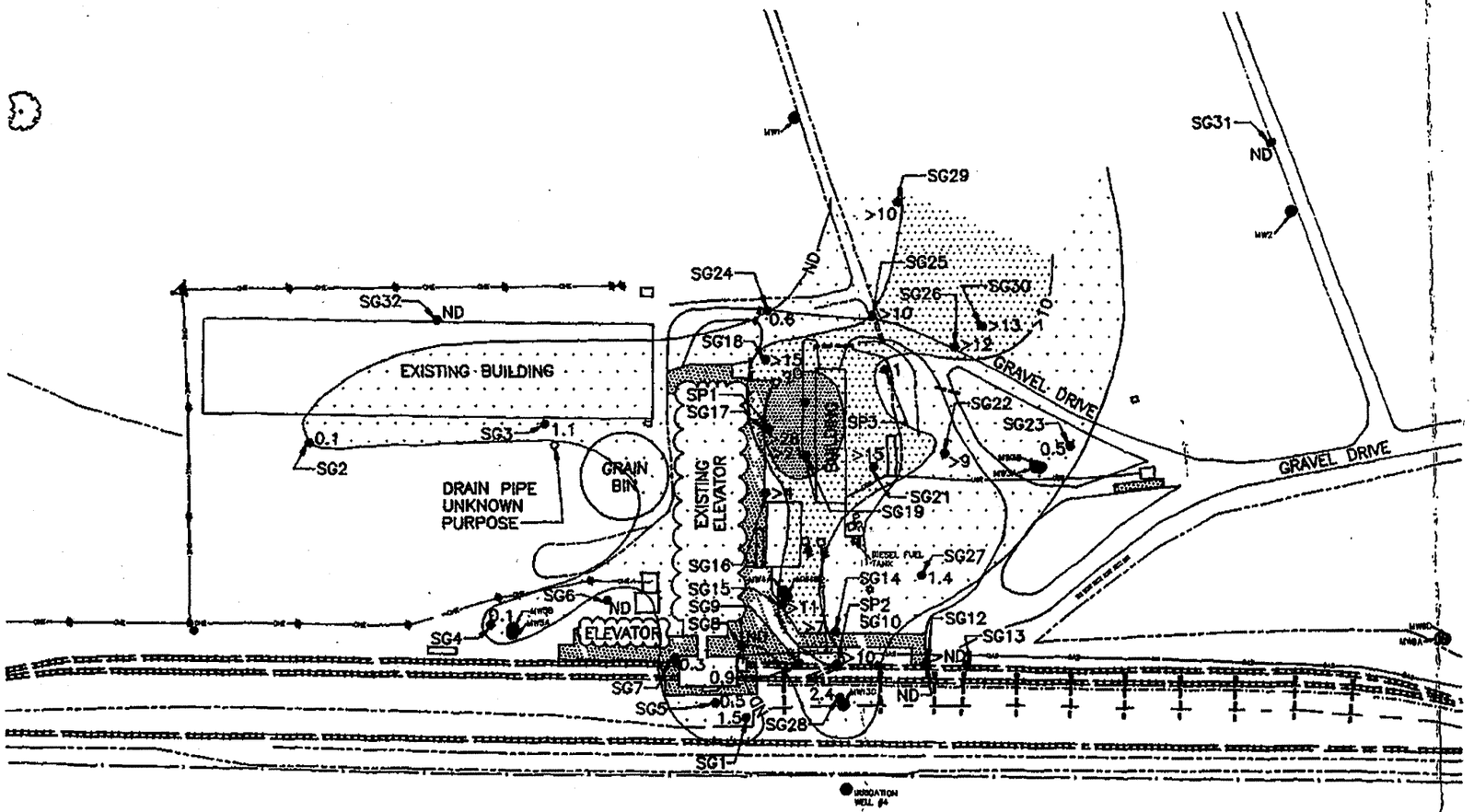
Figure 14 (Site Characterization Report for Garvey Elevator, HWS Consulting, October 1995)

40230587
SUPERFUND RECORDS

US EPA ARCHIVE DOCUMENT

Figure 16: CARBON TETRACHLORIDE IN SOILS

GARVEY ELEVATOR
HASTINGS, NEBRASKA



LEGEND

SG2 ● 0.1	*Geoprobe Data Point Showing Carbon Tetrachloride Concentration in Soil Gas*
>20	*Contour Line of Carbon Tetrachloride Concentrations (Units are ug/L in Air)*
ND	*None Detected*

N

200 0 100 200
100 50 150

SCALE: 1"= 200'

LINCOLN OFFICE
8551 S. 27th, Box 80330
Lincoln, NE. 68501
Phone:(402) 479-2200

HWS Consulting Group, Inc.

SCALE: AS SHOWN
DATE: 10-10-95
JOB NO.: 73-44-0025
FIELD BOOK:
FILE NO.:
SHEET NO.: of

F:\HWS\73-0025T\OCT95\CT_SOIL

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ATTACHMENT 2

ENSR SOIL SAMPLE MAP AND DATA

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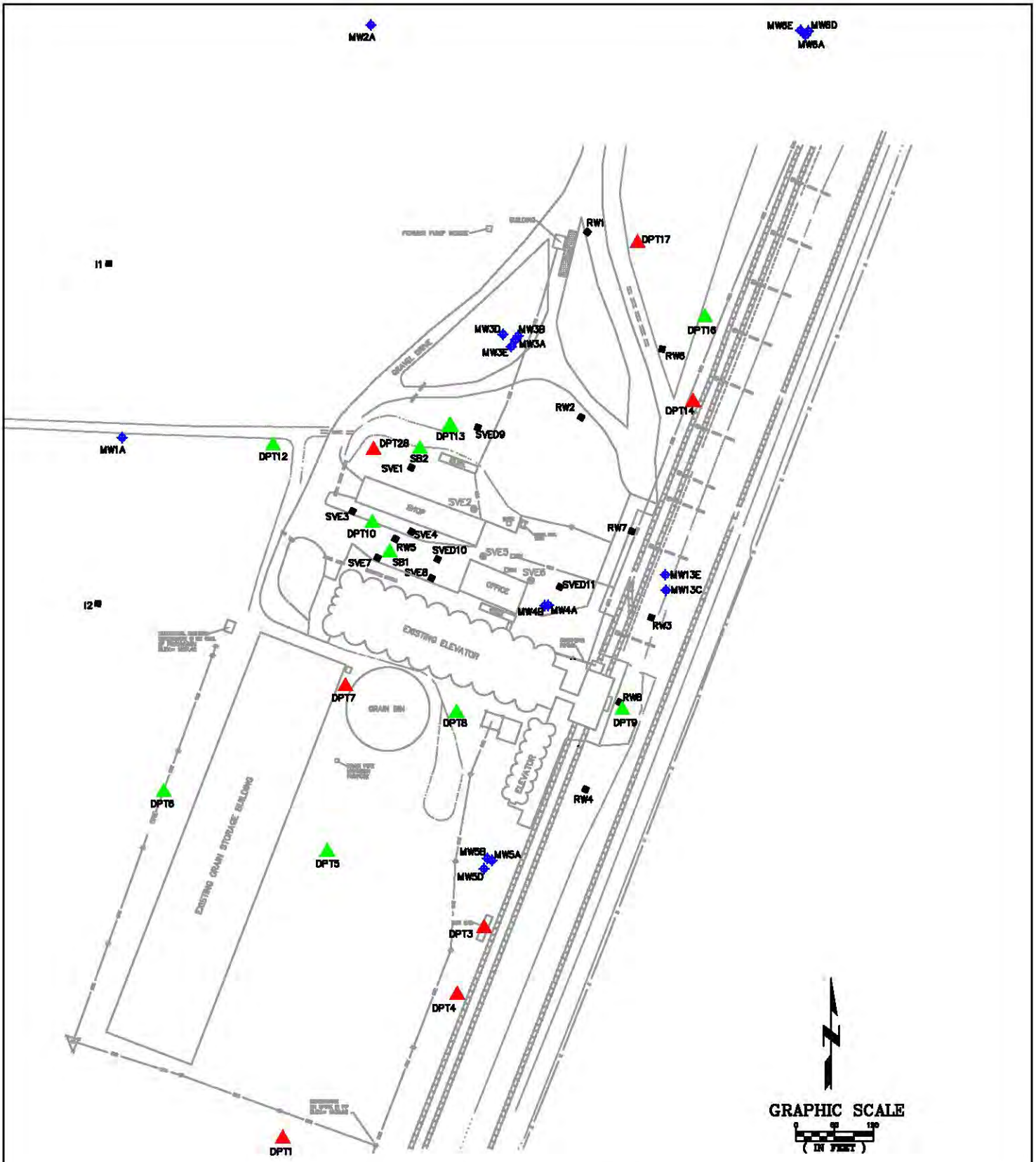

- Proposed Soil Sampling Locations
- Soil Sampling Locations

Figure 1: SEWP (Rev 2.) DPT Soil Sample Locations

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility
2315 W. Highway 6, Hastings, NE

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S-1		S-2		S-3		S-4		S-5		S-6		S-7		S-8		S-9		S-10	
Sample Description	SO07D001SA		SO07D003SA		SO07D005SA		SO07D010SA		SO07D020SA		SO07D030SA		SO07D040SA		SO07D050SA		SO07D060SA		3565-14-01	
Boring Location	DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7			
Sample Depth (feet bgs)	1		3		5		10		20		30		40		50		60			
Date Collected	8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		NA	
Date Analyzed	8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/10/2007		8/9/2007	
ug/kg																				
Chloromethane	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	17	U
Carbon Disulfide	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	17	U
Methylene Chloride	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	17	U
Chloroform	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	17	U
Carbon Tetrachloride	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	17	U
1,2-Dibromoethane	29	U	30	U	30	U	29	U	30	U	29	U	29	U	28	U	26	U	130	
Surrogate (Dibromofluoromethane)	100		96.7		96.9		96.2		95.2		96.8		97.7		93.9		87.3		99.8	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

bgs-below ground surface

L- Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S-11		S-12		S-13		S-14		S-15		S-16		S-17		S-18		S-19		S-20	
Sample Description	SO07D070SA DPT7 70		SO07D080SA DPT7 80		SO07D090SA DPT7 90		SO07D100SA DPT7 100		SO07D100SB		SO07D110SA DPT7 110		SO07D115SA DPT7 115		SO04D010SA DPT4 10		SO04D020SA DPT4 20		SO04D030SA DPT4 30	
Date Collected	8/8/2007		8/8/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007	
Date Analyzed	8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007	
ug/kg																				
Chloromethane	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
Carbon Disulfide	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
Methylene Chloride	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
Chloroform	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
Carbon Tetrachloride	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
1,2-Dibromoethane	26	U	26	U	25	U	26	U	26	U	27	U	27	U	27	U	29	U	26	U
Surrogate (Dibromofluoromethane)	102		90.4		87		92.1		90.1		104		100		105		101		88.7	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

L- Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S-21		S-22		S-23		S-24		S-25		S-26		S-27		S-28		S-29		S-30	
Sample Description	SO04D040SA DPT4 40		SO04D050SA DPT4 50		SO04D060SA DPT4 60		SO04D070SA DPT4 70		SO04D080SA DPT4 80		SO04D080SB		SO04D090SA DPT4 90		SO04D100SA DPT4 100		SO04D107.5SA DPT4 107.5		SO04D115SA DPT4 115	
Date Collected	8/9/2007		8/9/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007	
Date Analyzed	8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/11/2007		8/10/2007	
ug/kg																				
Chloromethane	29	U	30	U	28	U	26	U	26	U	25	U	28	U	26	U	26	U	26	U
Carbon Disulfide	29	U,L	30	U,L	28	U	26	U	26	U	25	U	28	U	26	U	26	U	26	U,L
Methylene Chloride	29	U	30	U	28	U	26	U	26	U	25	U	28	U	26	U	26	U	26	U
Chloroform	29	U	30	U	28	U	26	U	26	U	25	U	28	U	26	U	26	U,L	26	U
Carbon Tetrachloride	29	U	30	U	28	U	26	U	26	U	25	U	28	U	26	U	26	U	26	U
1,2-Dibromoethane	29	U	30	U	28	U	26	U	26	U	25	U	28	U	26	U	26	U	26	U
Surrogate (Dibromofluoromethane)	98.5		97.7		97.4		98.5		100		100		99.9		100		82.44		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

L- Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S-31		S-32		S-33		S-34		S-35		S-36		S-37		S38		S39		S40	
Sample Description	SO03D010SA DPT3 10		SO03D020SA DPT3 20		SO03D030SA DPT3 30		SO03D040SA DPT3 40		SO03D050SA DPT3 50		SO03D060SA DPT3 60		SO03D070SA DPT3 70		SO03D080SA DPT3 80		SO03D090SA DPT3 90		SO03D090SB	
Date Collected	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007	
Date Analyzed	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007	
ug/kg																				
Chloromethane	29	U	30	U	27	U	28	U	30	U	26	U	26	U	25	U	26	U	26	U
Carbon Disulfide	29	U,L	30	U	27	U,L	28	U	30	U	26	U	26	U,L	25	U	26	U	26	U
Methylene Chloride	29	U	30	U	27	U	28	U	30	U	26	U	26	U	25	U	26	U	26	U
Chloroform	29	U	30	U,L	27	U	28	U,L	30	U,L	26	U,L	26	U	25	U,L	26	U	26	U
Carbon Tetrachloride	29	U	30	U	27	U	28	U	30	U	26	U	26	U	25	U	26	U	26	U
1,2-Dibromoethane	29	U	30	U	27	U	28	U	30	U	26	U	26	U	25	U	26	U	26	U
Surrogate (Dibromofluoromethane)	98.4		97		99.2		104		111		104		99.2		112		99.9		102	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

L=Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S41		S42		S43		S44		S45		S46		S47		S48		S49		S50	
Sample Description	SO03D104SA DPT3 104		SO03D104SC MS		SO03D104SC MSD		SO03D117SA DPT3 117		SO01D010SA DPT1 10		SO01D020SA DPT1 20		SO01D030SA DPT1 30		SO01D040SA DPT1 40		SO01D050SA DPT1 50		SO01D060SA DPT1 60	
Date Collected	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
Date Analyzed	8/11/2007		8/11/2007		8/11/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
ug/kg																				
Chloromethane	27	U	480		520		26	U	27	U	27	U	27	U	26	U	29	U	27	U
Carbon Disulfide	27	U	500		500		26	U,L	27	U	27	U,L	27	U	26	U	29	U	27	U
Methylene Chloride	27	U	500		510		26	U	27	U	27	U	27	U	26	U	29	U	27	U
Chloroform	27	U	520		540		26	U	27	U	27	U	27	U	26	U	29	U	27	U
Carbon Tetrachloride	27	U	500		520		26	U	27	U	27	U	27	U	26	U	29	U	27	U
1,2-Dibromoethane	27	U	570		590		26	U	27	U	27	U	27	U	26	U	29	U	27	U
Surrogate (Dibromofluoromethane)	100		95.9		101		97.4		85.4		98.5		104		101		102		102	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

L- Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Wet Weight

ECCS Number	S51		S52		S53		S54		S55		S56		S57		S58		S59		S60	
Sample Description	SO01D062.5SA DPT1 62.5		SO01D068SA DPT1 68		SO01D070SA DPT1 70		SO01D080SA DPT1 80		SO01D090SA DPT1 90		SO01D093SA DPT1 93		SO01D100SA DPT1 100		SO01D109.5SA DPT1 109.5		SO01D109.5SB		SO01D111SA DPT1 111	
Date Collected	8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
Date Analyzed	8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/13/2007	
ug/kg																				
Chloromethane	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
Carbon Disulfide	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
Methylene Chloride	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
Chloroform	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
Carbon Tetrachloride	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
1,2-Dibromoethane	27	U	26	U	26	U	25	U	25	U	26	U	27	U	26	U	26	U	27	U
Surrogate (Dibromofluoromethane)	101		99.3		98.7		99.8		102		103		102		103		101		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

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Soil Wet Weight

ECCS Number	S61		S62		S63		S64		S65		S66		S67		S68		S69		S70	
Sample Description	SO01D114SA DPT1 114		SO17D010SA DPT17 10		SO17D020SA DPT17 20		SO17D030SA DPT17 30		SO17D040SA DPT17 40		SO17D050SA DPT17 50		SO17D060SA DPT17 60		SO17D070SA DPT17 70		SO17D080SA DPT17 80		SO17D090SA DPT17 90	
Date Collected	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007	
Date Analyzed	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007	
ug/kg																				
Chloromethane	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
Carbon Disulfide	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
Methylene Chloride	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
Chloroform	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
Carbon Tetrachloride	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
1,2-Dibromoethane	27	U	30	U	29	U	27	U	29	U	28	U	28	U	30	U	26	U	26	U
Surrogate (Dibromofluoromethane)	103		102		103		104		102		103		105		102		104		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

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Soil Wet Weight

ECCS Number	S71		S72		S73		S74		S75		S76		S77		S78		S79		S80	
Sample Description	SO17D090SB		SO17D100SA DPT17 100		SO17D100SB		SO17D110SA DPT17 110		SO17D112SA DPT17 112		SO17D113SA DPT17 113		SO14D010SA DPT14 10		SO14D020SA DPT14 20		SO14D030SA DPT14 30		SO14D033SA DPT14 33	
Date Collected	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
Date Analyzed	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
ug/kg																				
Chloromethane	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
Carbon Disulfide	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
Methylene Chloride	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
Chloroform	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
Carbon Tetrachloride	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
1,2-Dibromoethane	26	U	26	U	26	U	26	U	26	U	26	U	30	U	29	U	27	U	30	U
Surrogate (Dibromofluoromethane)	102		103		103		104		101		101		101		103		102		104	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

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Soil Wet Weight

ECCS Number	S81		S82		S83		S84		S85		S86		S87		S88		S89	
Sample Description	SO14D040SA DPT14 40		SO14D050SA DPT14 50		SO14D053SA DPT14 53		SO14D060SA DPT14 60		SO14D070SA DPT14 70		SO14D072.5SA DPT14 72.5		SO14D085SA DPT14 85		SO14D090SA DPT14 90		SO14D094SA DPT14 94	
Date Collected	8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
Date Analyzed	8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
ug/kg																		
Chloromethane	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
Carbon Disulfide	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
Methylene Chloride	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
Chloroform	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
Carbon Tetrachloride	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
1,2-Dibromoethane	29	U	30	U	29	U	27	U	29	U	28	U	26	U	26	U	26	U
Surrogate (Dibromofluoromethane)	103		104		102		102		103		105		102		106		105	
Dilution Factor	1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S-1		S-2		S-3		S-4		S-5		S-6		S-7		S-8		S-9		S-10	
Sample Description	SO07D001SA		SO07D003SA		SO07D005SA		SO07D010SA		SO07D020SA		SO07D030SA		SO07D040SA		SO07D050SA		SO07D060SA		3565-14-01	
Boring Location	DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7		DPT7			
Sample Depth (feet bgs)	1		3		5		10		20		30		40		50		60			
Date Collected	8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		NA	
Date Analyzed	8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/8/2007		8/10/2007		NA	
ug/kg																				
Chloromethane	34	U	38	U	37	U	35	U	37	U	35	U	33	U	30	U	27	U	7.8	U
Carbon Disulfide	34	U,L	38	U,L	37	U,L	35	U,L	37	U,L	35	U,L	33	U,L	30	U,L	27	U	7.8	U,L
Methylene Chloride	34	U	38	U	37	U	35	U	37	U	35	U	33	U	30	U	27	U	7.8	U
Chloroform	34	U	38	U	37	U	35	U	37	U	35	U	33	U	30	U	27	U	7.8	U
Carbon Tetrachloride	34	U	38	U	37	U	35	U	37	U	35	U	33	U	30	U	27	U	7.8	U
1,2-Dibromoethane	34	U	38	U	37	U	35	U	37	U	35	U	33	U	30	U	27	U	130	
Surrogate (Dibromofluoromethane)	100		96.7		96.9		96.2		95.2		96.8		97.7		93.9		87.3		99.8	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	84.8		80.3		80.5		82.8		80		83.5		85.3		90.7		96.3		98.8	

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US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S-11		S-12		S-13		S-14		S-15		S-16		S-17		S-18		S-19		S-20	
Sample Description	SO07D070SA DPT7 70		SO07D080SA DPT7 80		SO07D090SA DPT7 90		SO07D100SA DPT7 100		SO07D100SB		SO07D110SA DPT7 110		SO07D115SA DPT7 115		SO04D010SA DPT4 10		SO04D020SA DPT4 20		SO04D030SA DPT4 30	
Date Collected	8/8/2007		8/8/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007		8/9/2007	
Date Analyzed	8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007	
ug/kg																				
Chloromethane	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
Carbon Disulfide	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
Methylene Chloride	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
Chloroform	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
Carbon Tetrachloride	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
1,2-Dibromoethane	27	U	26	U	26	U	27	U	27	U	29	U	30	U	31	U	35	U	28	U
Surrogate (Dibromofluoromethane)	102		90.4		87		92.1		90.1		104		100		105		101		88.7	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	96		97.4		98.1		96.6		96.8		93.4		91.3		88.5		83		94.9	

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US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S-21		S-22		S-23		S-24		S-25		S-26		S-27		S-28		S-29		S-30	
Sample Description	SO04D040SA DPT4 40		SO04D050SA DPT4 50		SO04D060SA DPT4 60		SO04D070SA DPT4 70		SO04D080SA DPT4 80		SO04D080SB		SO04D090SA DPT4 90		SO04D100SA DPT4 100		SO04D107.5SA DPT4 107.5		SO04D115SA DPT4 115	
Date Collected	8/9/2007		8/9/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007	
Date Analyzed	8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/10/2007		8/11/2007		8/10/2007	
ug/kg																				
Chloromethane	33	U	39	U	31	U	27	U	26	U	26	U	32	U	26	U	26	U	27	U
Carbon Disulfide	33	U,L	39	U,L	31	U	27	U	26	U	26	U	32	U	26	U	26	U	27	U,L
Methylene Chloride	33	U	39	U	31	U	27	U	26	U	26	U	32	U	26	U	26	U	27	U
Chloroform	33	U	39	U	31	U	27	U	26	U	26	U	32	U	26	U	26	U,L	27	U
Carbon Tetrachloride	33	U	39	U	31	U	27	U	26	U	26	U	32	U	26	U	26	U	27	U
1,2-Dibromoethane	33	U	39	U	31	U	27	U	26	U	26	U	32	U	26	U	26	U	27	U
Surrogate (Dibromofluoromethane)	98.5		97.7		97.4		98.5		100		100		99.9		100		82.4		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	85.4		78.6		90.1		97		97		97.5		87.6		97.5		97.3		96.3	

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Soil Dry Weight

ECCS Number	S-31		S-32		S-33		S-34		S-35		S-36		S-37		S38		S39		S40	
Sample Description	SO03D010SA DPT3 10		SO03D020SA DPT3 20		SO03D030SA DPT3 30		SO03D040SA DPT3 40		SO03D050SA DPT3 50		SO03D060SA DPT3 60		SO03D070SA DPT3 70		SO03D080SA DPT3 80		SO03D090SA DPT3 90		SO03D090SB	
Date Collected	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007	
Date Analyzed	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/11/2007	
ug/kg																				
Chloromethane	35	U	37	U	30	U	33	U	35	U	27	U	27	U	26	U	26	U	26	U
Carbon Disulfide	35	U,L	37	U	30	U,L	33	U	35	U	27	U	27	U,L	26	U	26	U	26	U
Methylene Chloride	35	U	37	U	30	U	33	U	35	U	27	U	27	U	26	U	26	U	26	U
Chloroform	35	U	37	U,L	30	U	33	U,L	35	U,L	27	U,L	27	U	26	U,L	26	U	26	U
Carbon Tetrachloride	35	U	37	U	30	U	33	U	35	U	27	U	27	U	26	U	26	U	26	U
1,2-Dibromoethane	35	U	37	U	30	U	33	U	35	U	27	U	27	U	26	U	26	U	26	U
Surrogate (Dibromofluoromethane)	98.4		97		99.2		104		111		104		99.2		112		99.9		102	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	82.6		80		91.5		85.7		83.6		96.5		96.3		97.7		97.2		97.3	

L=Low Calibration Check Standard Recovery

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Soil Dry Weight

ECCS Number	S41		S42		S43		S44		S45		S46		S47		S48		S49		S50	
Sample Description	SO03D104SA DPT3 104		SO03D104SC MS		SO03D104SC MSD		SO03D117SA DPT3 117		SO01D010SA DPT1 10		SO01D020SA DPT1 20		SO01D030SA DPT1 30		SO01D040SA DPT1 40		SO01D050SA DPT1 50		SO01D060SA DPT1 60	
Date Collected	8/11/2007		8/11/2007		8/11/2007		8/11/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
Date Analyzed	8/11/2007		8/11/2007		8/11/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
ug/kg																				
Chloromethane	31	U	530		580		27	U	29	U	30	U	30	U	28	U	34	U	30	U
Carbon Disulfide	31	U	550		560		27	U,L	29	U	30	U,L	30	U	28	U	34	U	30	U
Methylene Chloride	31	U	550		570		27	U	29	U	30	U	30	U	28	U	34	U	30	U
Chloroform	31	U	580		600		27	U	29	U	30	U	30	U	28	U	34	U	30	U
Carbon Tetrachloride	31	U	550		580		27	U	29	U	30	U	30	U	28	U	34	U	30	U
1,2-Dibromoethane	31	U	630		660		27	U	29	U	30	U	30	U	28	U	34	U	30	U
Surrogate (Dibromofluoromethane)	100		95.9		101		97.4		85.4		98.5		104		101		102		102	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	88.9		89.9		89.5		95.4		92.2		90.3		91.7		94.3		84.8		92	

L=Low Calibration Check Standard Recovery

US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S51		S52		S53		S54		S55		S56		S57		S58		S59		S60	
Sample Description	SO01D062.5SA DPT1 62.5		SO01D068SA DPT1 68		SO01D070SA DPT1 70		SO01D080SA DPT1 80		SO01D090SA DPT1 90		SO01D093SA DPT1 93		SO01D100SA DPT1 100		SO01D109.5SA DPT1 109.5		SO01D109.5SB		SO01D111SA DPT1 111	
Date Collected	8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007	
Date Analyzed	8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/12/2007		8/13/2007	
ug/kg																				
Chloromethane	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
Carbon Disulfide	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
Methylene Chloride	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
Chloroform	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
Carbon Tetrachloride	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
1,2-Dibromoethane	29	U	26	U	27	U	26	U	26	U	26	U	29	U	27	U	27	U	29	U
Surrogate (Dibromofluoromethane)	101		99.3		98.7		99.8		102		103		102		103		101		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	93		97.3		96.5		98.4		98.4		97.8		92.8		96.6		96.8		93	

US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S61		S62		S63		S64		S65		S66		S67		S68		S69		S70	
Sample Description	SO01D114SA DPT1 114		SO17D010SA DPT17 10		SO17D020SA DPT17 20		SO17D030SA DPT17 30		SO17D040SA DPT17 40		SO17D050SA DPT17 50		SO17D060SA DPT17 60		SO17D070SA DPT17 70		SO17D080SA DPT17 80		SO17D090SA DPT17 90	
Date Collected	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007	
Date Analyzed	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007	
ug/kg																				
Chloromethane	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
Carbon Disulfide	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
Methylene Chloride	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
Chloroform	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
Carbon Tetrachloride	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
1,2-Dibromoethane	29	U	37	U	35	U	29	U	34	U	30	U	31	U	36	U	27	U	27	U
Surrogate (Dibromofluoromethane)	103		102		103		104		102		103		105		102		104		103	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	92.5		80.8		83.4		92.3		84.6		90.5		89.4		82.9		96.2		95.3	

US EPA ARCHIVE DOCUMENT

Soil Dry Weight

ECCS Number	S71		S72		S73		S74		S75		S76		S77		S78		S79		S80	
Sample Description	SO17D090SB		SO17D100SA DPT17 100		SO17D100SB		SO17D110SA DPT17 110		SO17D112SA DPT17 112		SO17D113SA DPT17 113		SO14D010SA DPT14 10		SO14D020SA DPT14 20		SO14D030SA DPT14 30		SO14D033SA DPT14 33	
Date Collected	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
Date Analyzed	8/13/2007		8/13/2007		8/13/2007		8/13/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
ug/kg																				
Chloromethane	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
Carbon Disulfide	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
Methylene Chloride	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
Chloroform	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
Carbon Tetrachloride	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
1,2-Dibromoethane	27	U	28	U	28	U	27	U	27	U	27	U	39	U	36	U	29	U	36	U
Surrogate (Dibromofluoromethane)	102		103		103		104		101		101		101		103		102		104	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	
% Solids	95.2		94.8		94.8		96		95.8		95.7		78.2		82.8		91.6		82.7	

US EPA ARCHIVE DOCUMENT

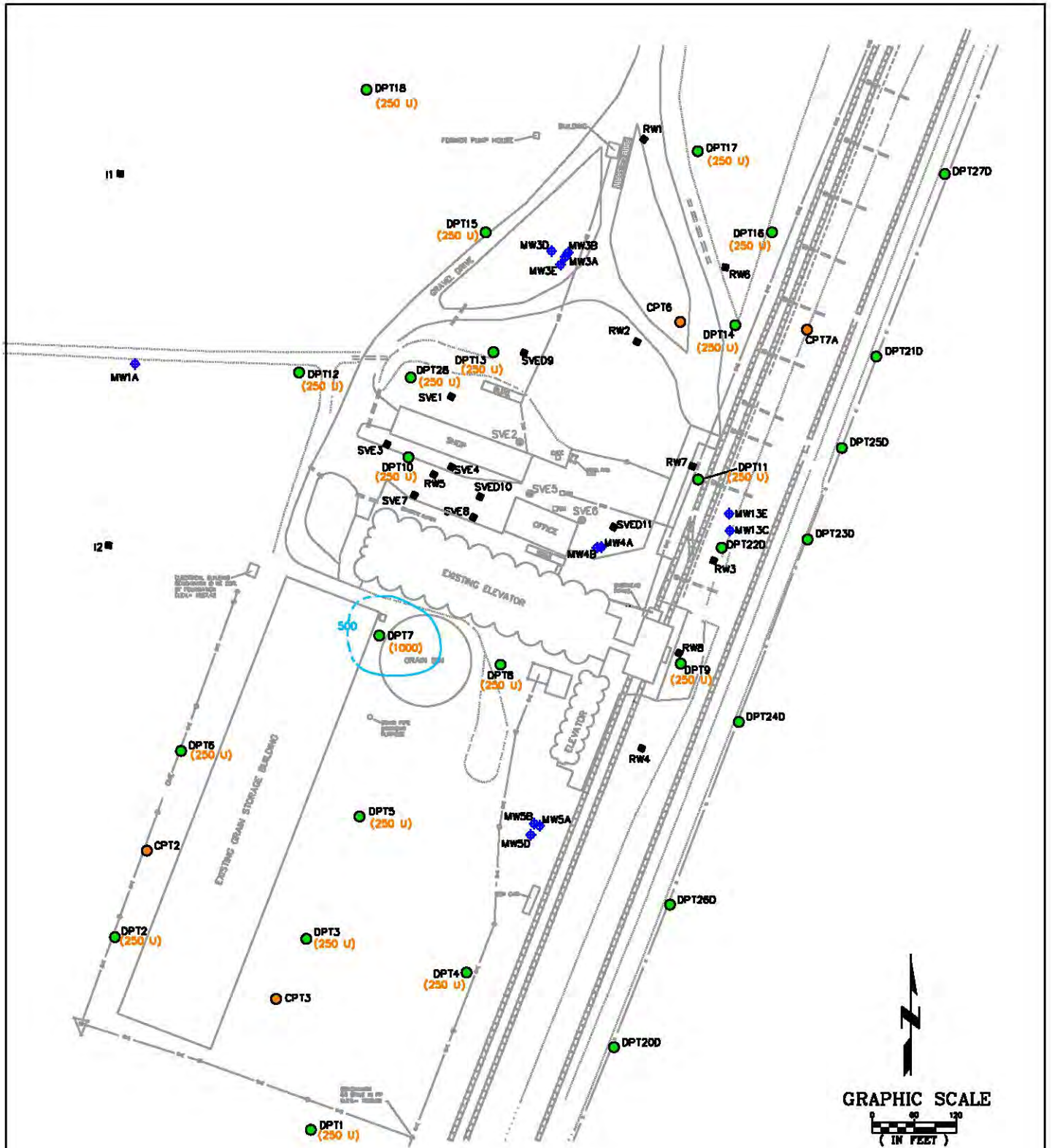
Soil Dry Weight

ECCS Number	S81		S82		S83		S84		S85		S86		S87		S88		S89	
Sample Description	SO14D040SA DPT14 40		SO14D050SA DPT14 50		SO14D053SA DPT14 53		SO14D060SA DPT14 60		SO14D070SA DPT14 70		SO14D072.5SA DPT14 72.5		SO14D085SA DPT14 85		SO14D090SA DPT14 90		SO14D094SA DPT14 94	
Date Collected	8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
Date Analyzed	8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007		8/14/2007	
ug/kg																		
Chloromethane	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
Carbon Disulfide	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
Methylene Chloride	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
Chloroform	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
Carbon Tetrachloride	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
1,2-Dibromoethane	35	U	36	U	35	U	28	U	36	U	30	U	26	U	27	U	26	U
Surrogate (Dibromofluoromethane)	103		104		102		102		103		105		102		106		105	
Dilution Factor	1		1		1		1		1		1		1		1		1	
% Solids	84.1		81.6		82.4		93.7		82.7		90.7		97.3		95.2		97.7	

US EPA ARCHIVE DOCUMENT

ATTACHMENT 3

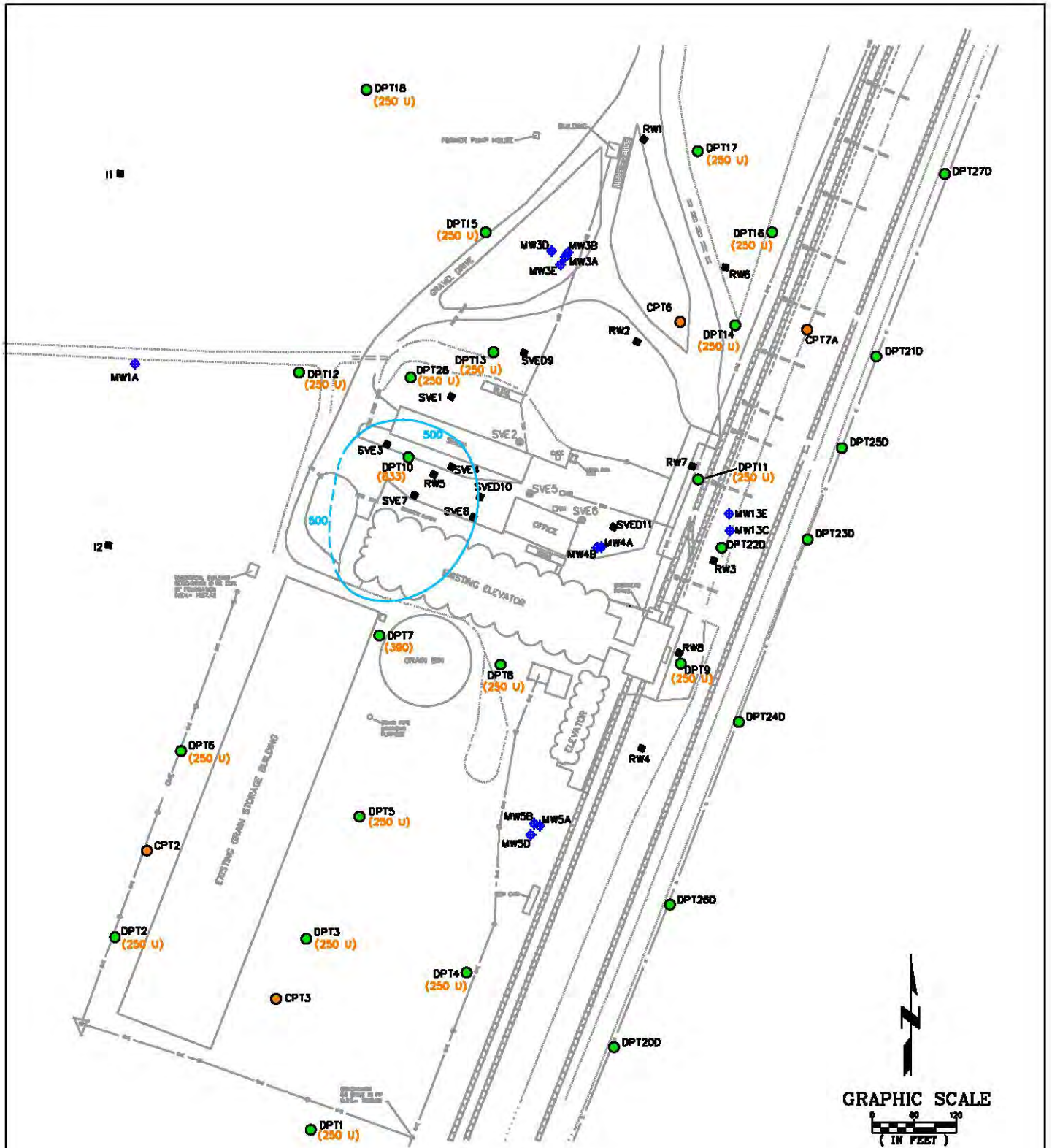
ENSR SOIL-GAS MAPS AND DATA



All Concentrations Shown in ug/m3

DRAFT

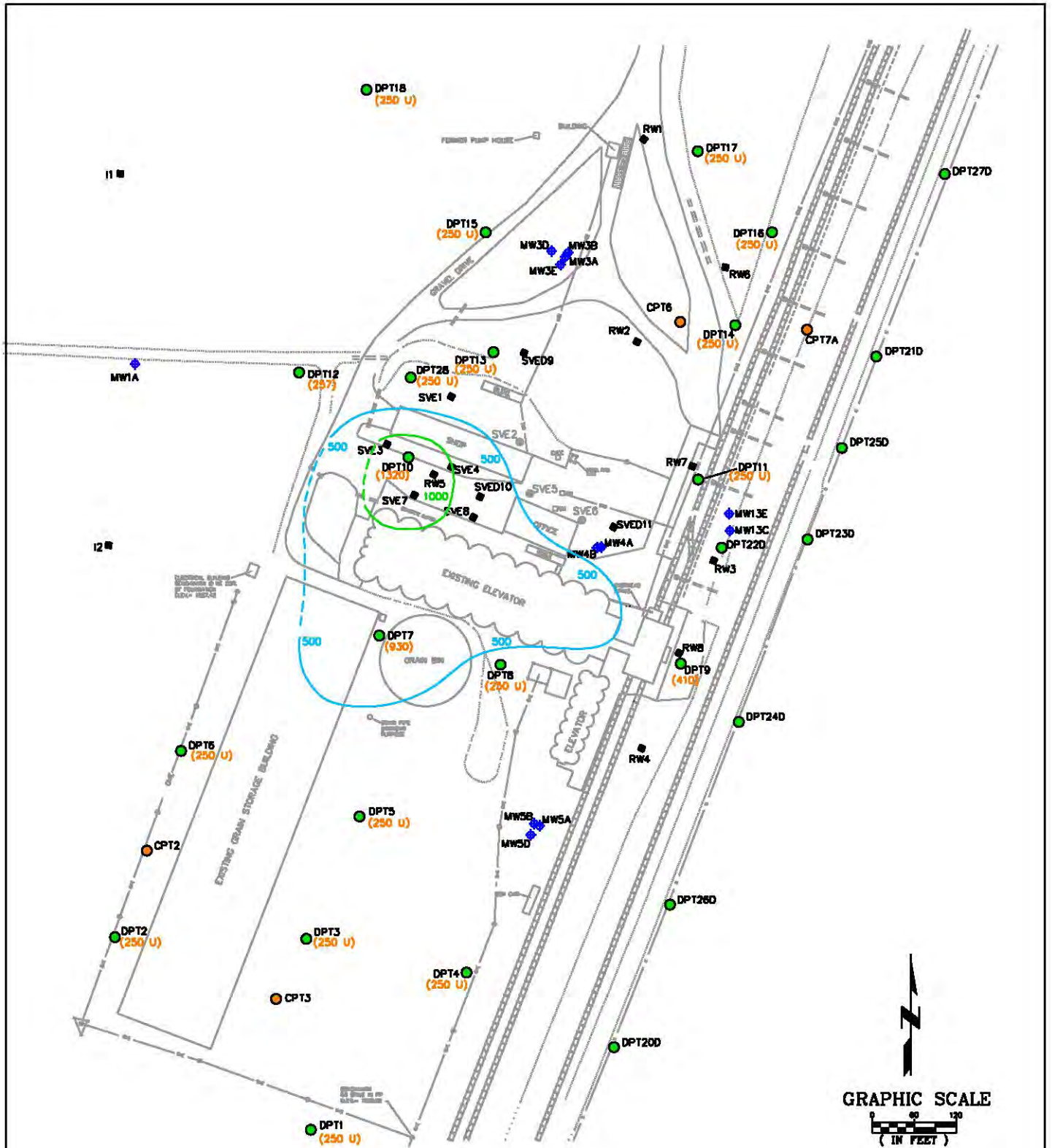
Carbon Tetrachloride in Soil Gas - 10 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 20 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



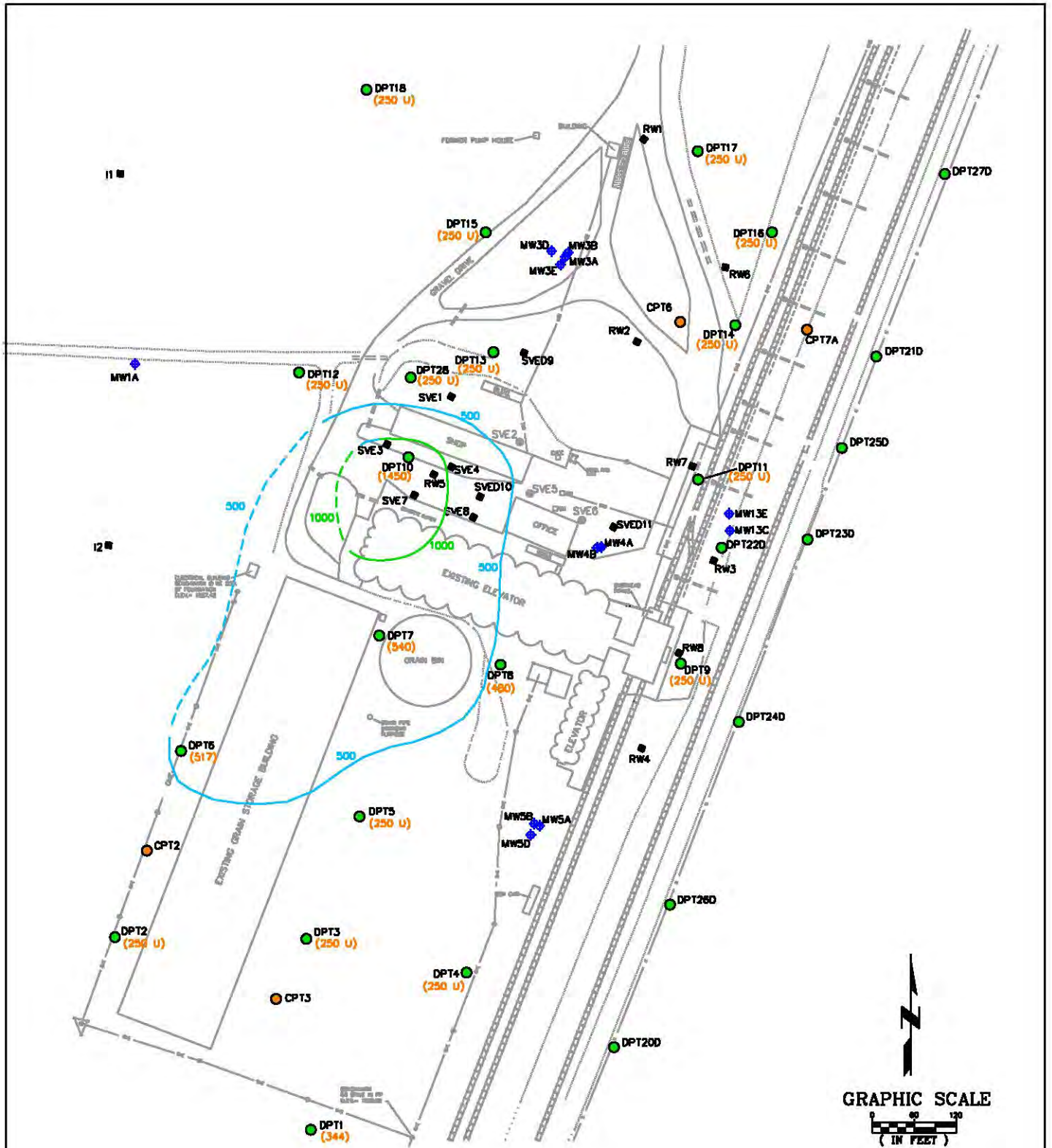
All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 30 ft BGS

SEWP Phase 1 DPT Investigation

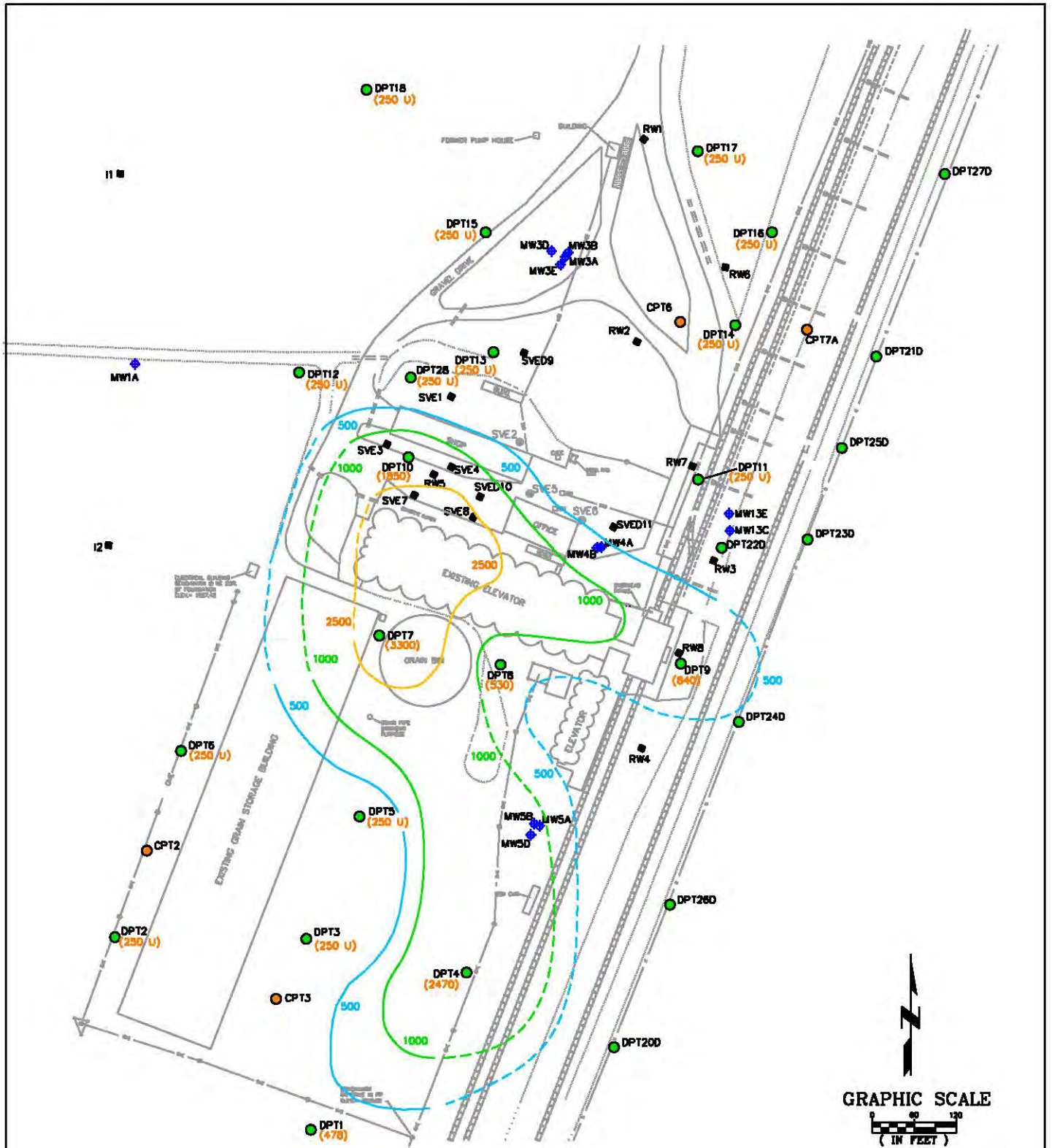
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

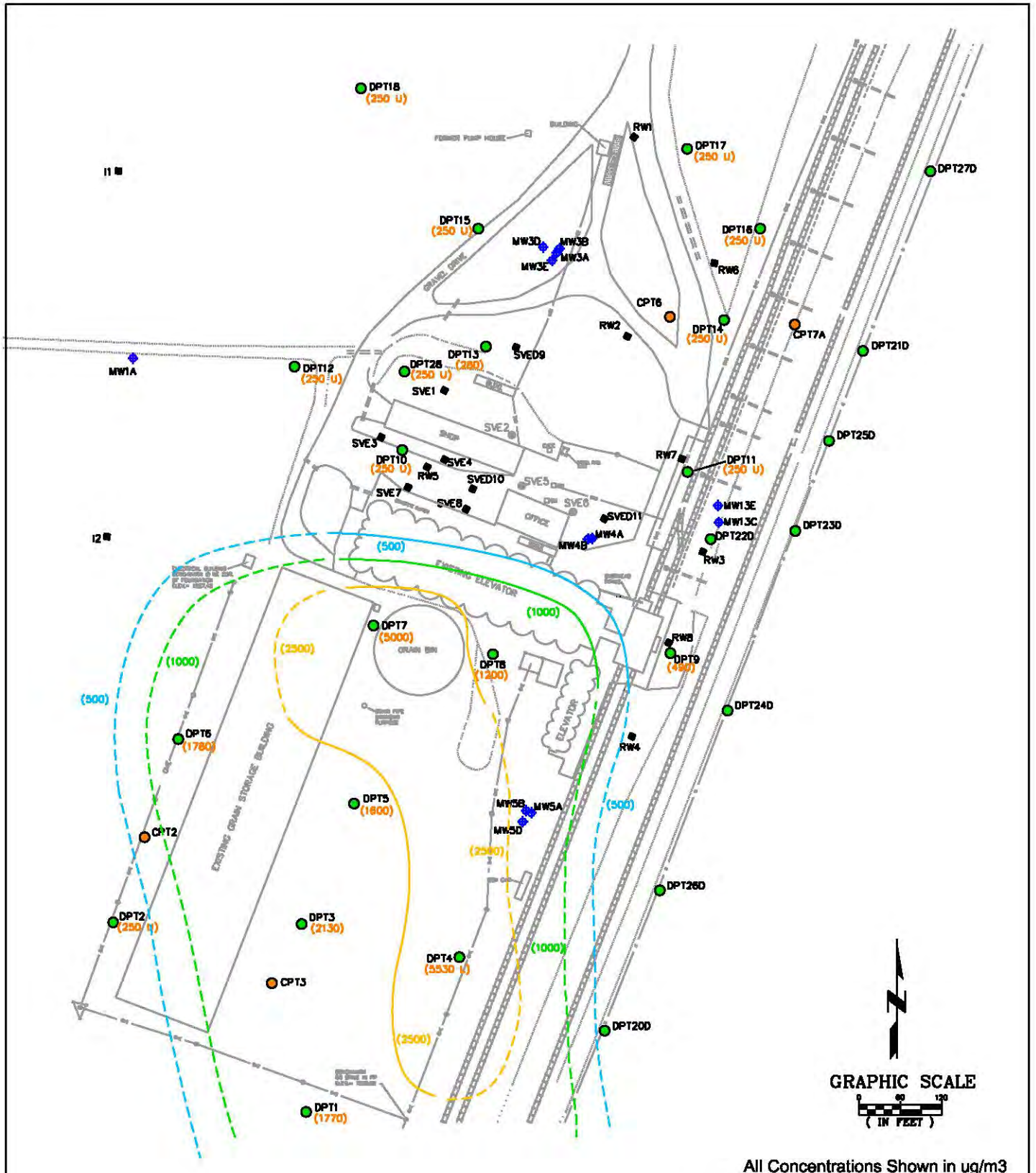
Carbon Tetrachloride in Soil Gas - 40 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

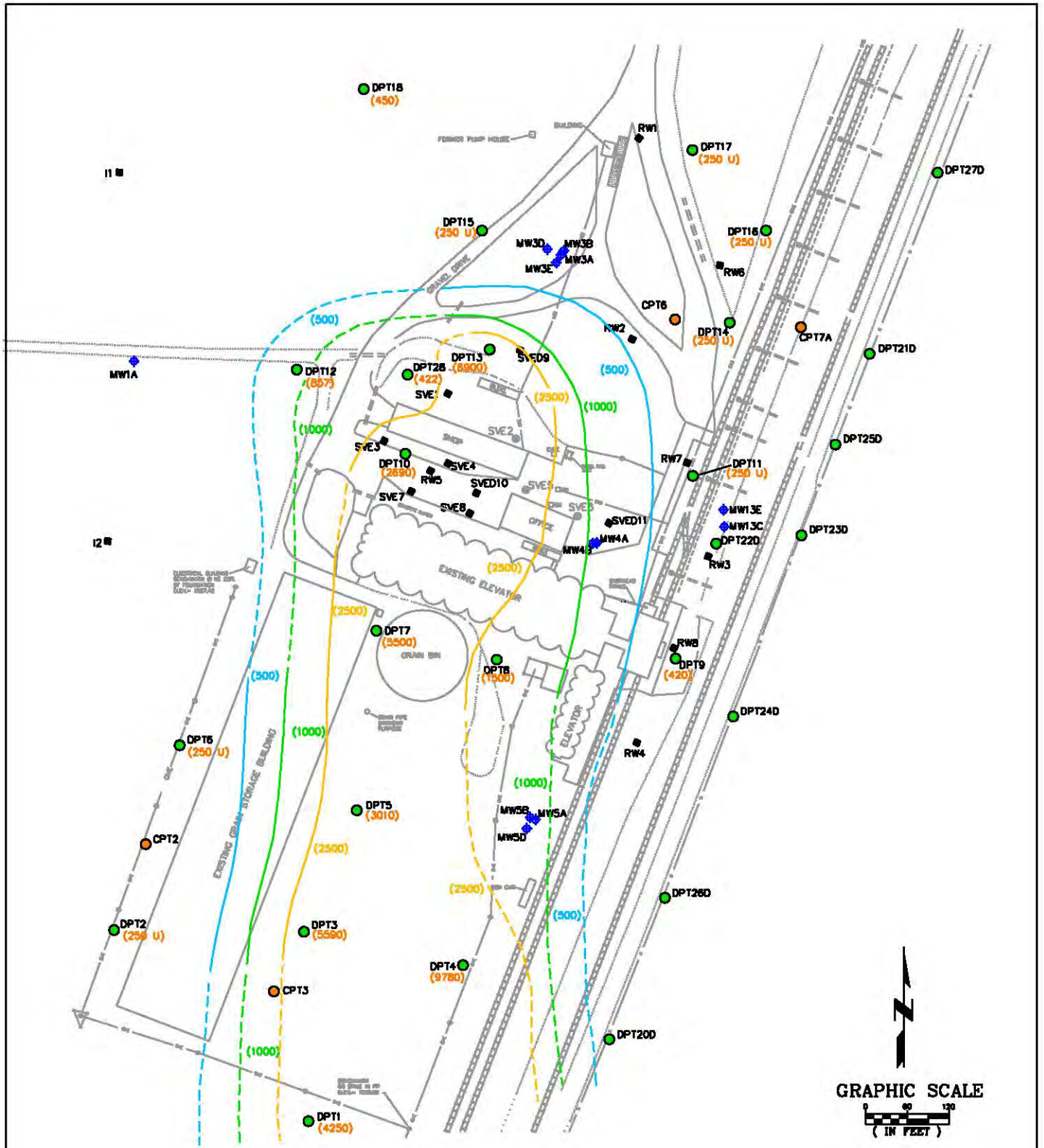
Carbon Tetrachloride in Soil Gas - 50 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

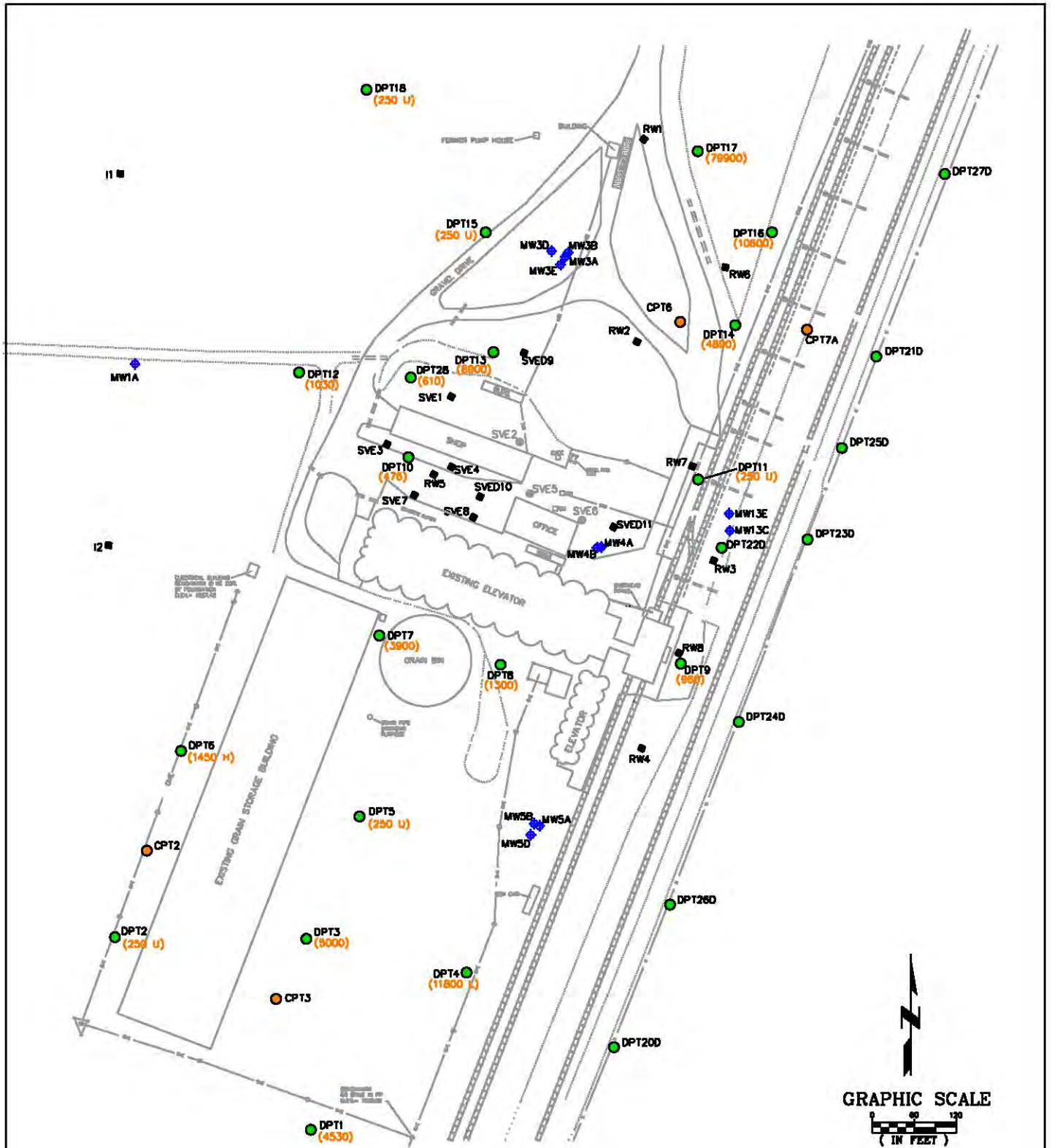
Carbon Tetrachloride in Soil Gas - 60 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 70 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



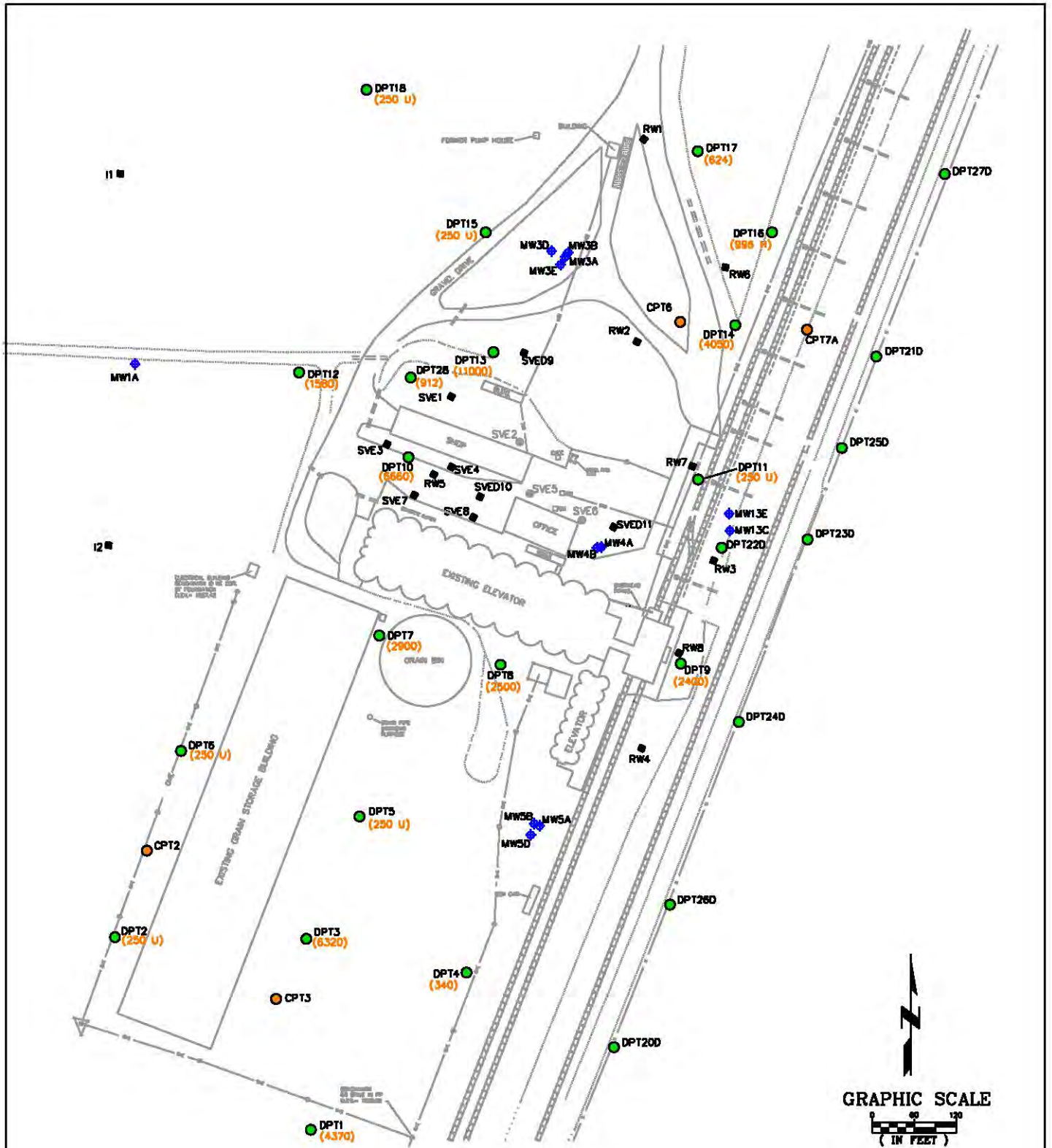
All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 80 ft BGS

SEWP Phase 1 DPT Investigation

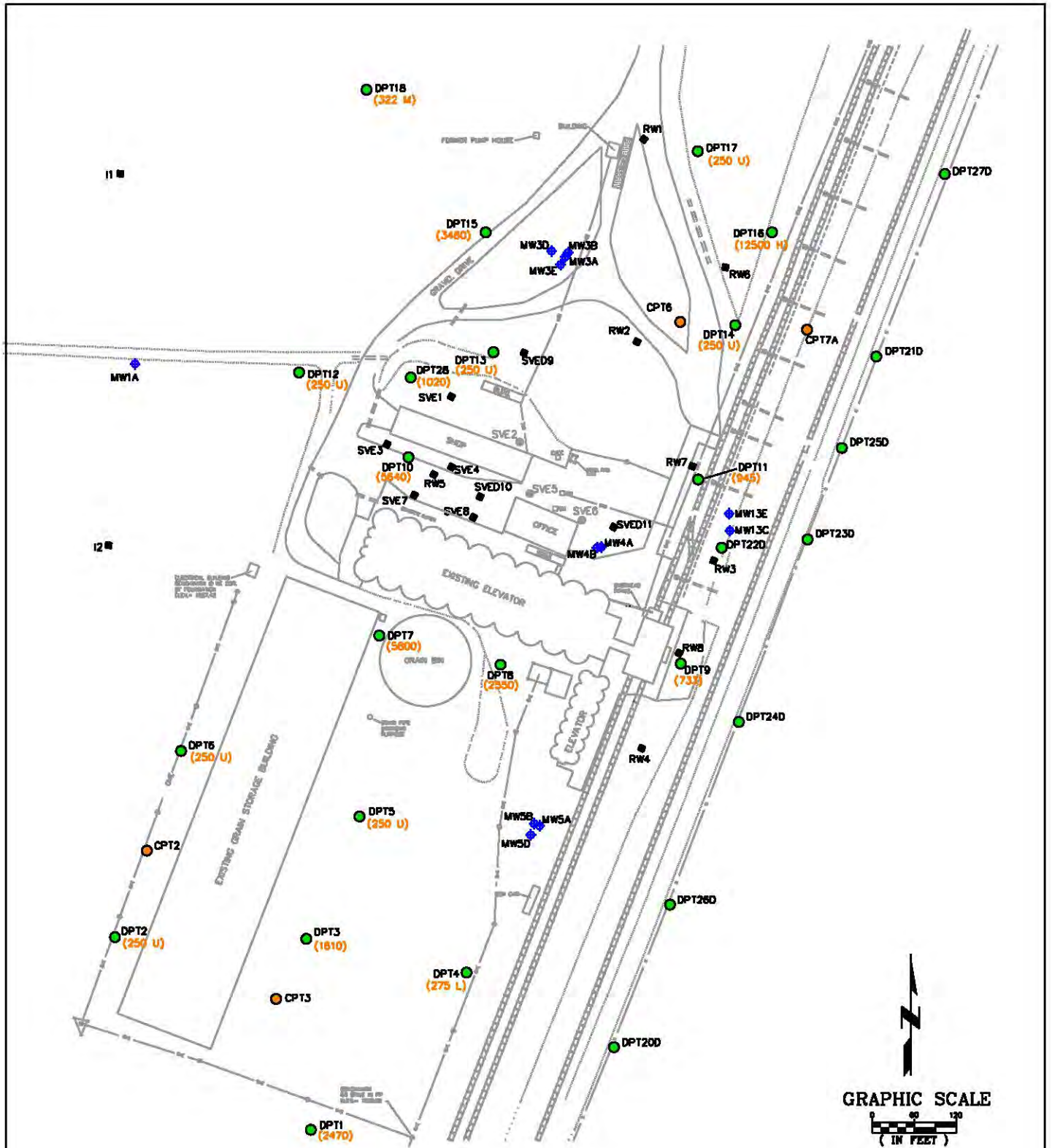
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

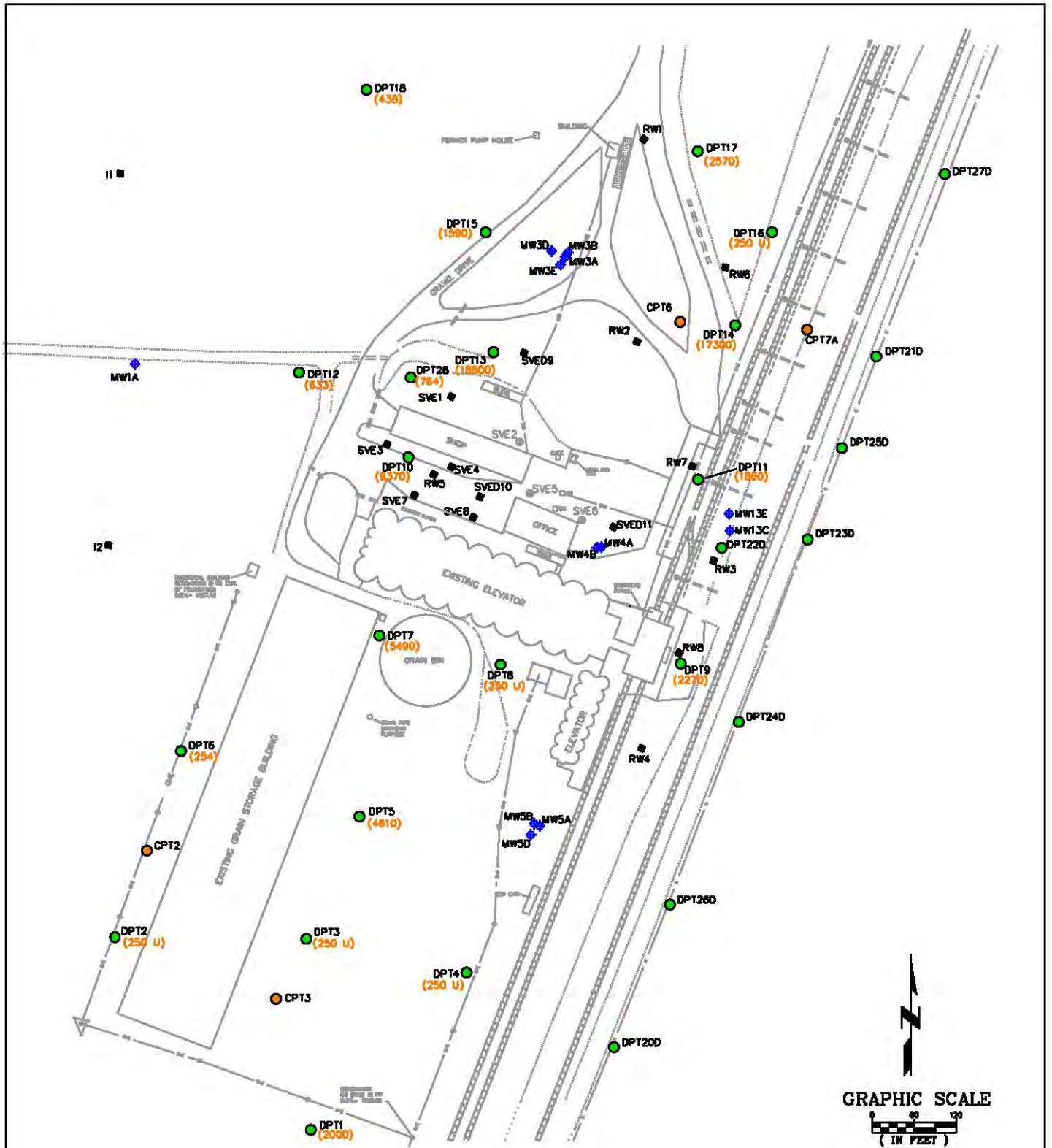
Carbon Tetrachloride in Soil Gas - 90 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

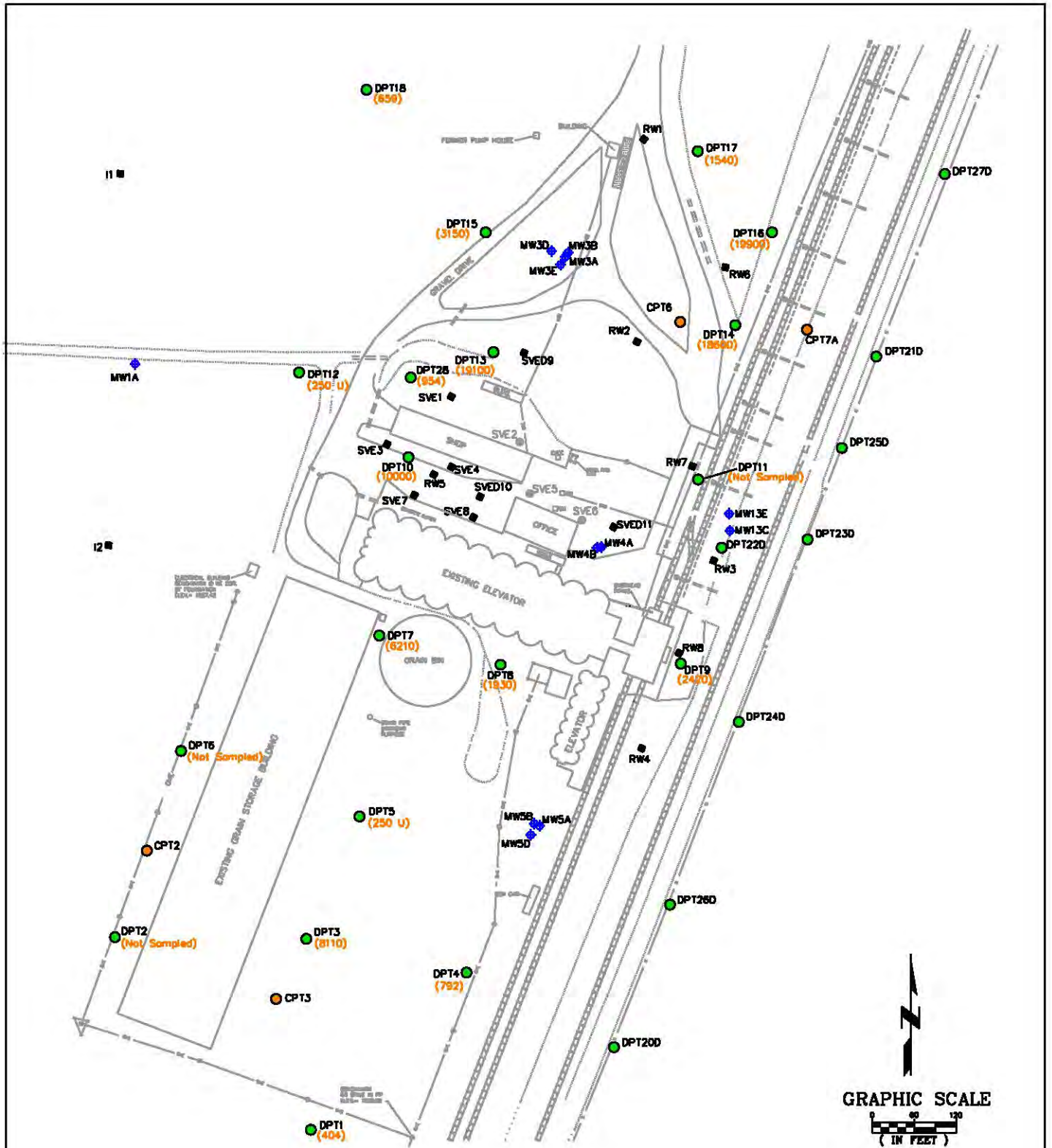
Carbon Tetrachloride in Soil Gas - 100 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 110 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/m3

DRAFT

Carbon Tetrachloride in Soil Gas - 115 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE

US EPA ARCHIVE DOCUMENT

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-01

ECCS Number	G174		G175		G176		G177		G178		G179		G180		G181		G182		G183		G184		G185		G186		G187	
Sample Description	SG01D010GA		SG01D020GA		SG01D030GA		SG01D040GA		SG01D045GA		SG01D060GA		SG01D070GA		SG01D080GA		SG01D090GA		SG01D100GA		SG01D110GA		SG01D110GB		SG01D115GA		SG01D000GC	
Date Collected	2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007	
Date Analyzed	2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	**344**		**478**		**1770**		**4250**		**4530**		**4370**		**2470**		**2000**		**2260**		**404**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	90.17		91.58		95.35		93.31		90.69		95.82		91.22		88.62		89.53		93.61		96.08		90.71		96.12		89.91	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-02

ECCS Number	G161		G162		G163		G164		G165		G166		G167		G168		G169		G170		G171		G172		G173	
Sample Description	SG02D010GA		SG02D020GA		SG02D030GA		SG02D040GA		SG02D050GA		SG02D060GA		SG02D070GA		SG02D080GA		SG02D090GA		SG02D090GB		SG02D100GA		SG02D110GA		SG02D0O0GC	
Date Collected	2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007	
Date Analyzed	2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007	
(ug/m3)																										
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	98.77		98.64		92.95		100.75		95.81		100.39		93.46		90.14		112.73		96.56		119.78		96.48		129.39	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-03

ECCS Number	G93		G94		G95		G96		G97		G98		G99		G100		G101		G102		G103		G104		G105		G106	
Sample Description	SG03D010GA		SG03D020GA		SG03D030GA		SG03D040GA		SG03D050GA		SG03D060GA		SG03D070GA		SG03D080GA		SG03D090GA		SG03D100GA		SG03D110GA		SG03D115GA		SG03D115GB		SG03D000GC	
Date Collected	2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007	
Date Analyzed	2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/13/2007		2/14/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	**2130**		**5590**		**5000**		**6320**		**1610**		250	U	**8110**		**10000**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	103.03		98.91		92.12		99.21		100.77		98.01		99.28		95.95		95.27		95.46		90.42		94.53		108.62		99.35	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-04

ECCS Number	G107		G108		G109		G110		G111		G112		G113		G114		G115		G116		G117		G118		G119		G120	
Sample Description	SG04D010GA		SG04D020GA		SG04D030GA		SG04D040GA		SG04D050GA		SG04D060GA		SG04D070GA		SG04D080GA		SG04D090GA		SG04D100GA		SG04D100GB		SG04D110GA		SG04D115GA		SG04D000GC	
Date Collected	2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007	
Date Analyzed	2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007		2/14/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U,L	250	U,L	250	U	250	U,L	**2470**		**5530**	**L**	**9780**		**11800**	**L**	**340**		**275**	**L**	**267**		**250**	**U,L**	**792**		**1900**	**L**
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	121.38		100.66		102.46		84.58		104.58		81.41		101.14		95.42		105.09		103.09		100.25		88.17		97.54		89.43	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-05

ECCS Number	G79		G80		G81		G82		G83		G84		G85		G86		G87		G88		G89		G90		G91		G92	
Sample Description	SG05D010GA		SG05D020GA		SG05D030GA		SG05D040GA		SG05D050GA		SG05D060GA		SG05D070GA		SG05D080GA		SG05D080GB		SG05D090GA		SG05D100GA		SG05D110GA		SG05D115GA		SG05D000GC	
Date Collected	2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007	
Date Analyzed	2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/12/2007		2/13/2007		2/12/2007		2/12/2007		2/13/2007		2/12/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	**1600**		**3010**		250	U	250	U	250	U	250	U	**4610**		250	U	250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	94.52		100.48		97.45		102.72		96.7		100.93		99.25		97.78		91.17		105.16		98.02		102.42		105.6		98.9	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-06

ECCS Number	G149		G150		G151		G152		G153		G154		G155		G156		G157		G158		G159		G160	
Sample Description	SG06D010GA		SG06020GA		SG06030GA		SG06040GA		SG06050GA		SG06060GA		SG06D070GA		SG06D080GA		SG06D090GA		SG06D100GA		SG06D110GA		SG06D000GC	
Date Collected	2/16/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007	
Date Analyzed	2/16/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007		2/17/2007	
(ug/m3)																								
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	**517**		250	U	**1780**		250	U	**1450**	**H**	250	U	250	U	**254**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	102.76		89.49		92.57		96.85		91.64		94.5		93.92		117.76		91.85		92.87		92.72		92.64	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1	

H-High Calibration Check Standard Recovery-139%

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AOC for Removal Action and Remedial Investigation/Feasibility Study
Docket No. CERCLA-07-2005-0215;
Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-07

ECCS Number	G53		G54		G55		G56		G57		G58		G59		G60		G61		G62		G188		G189		G190		G191		G192	
Sample Description	SG07D010GA		SG07D020GA		SG07D030GA		SG07D040GA		SG07D050GA		SG07D060GA		SG07D070GA		SG07D080GA		SG07D080GB		SG07D090GA		SG07D100GA		SG07D110GA		SG07D110GB		SG07D115GA		SG07D000GC	
Date Collected	10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007	
Date Analyzed	10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		2/18/2007		2/18/2007		2/18/2007		2/18/2007		2/18/2007	
(ug/m3)																														
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	**530**		250	U	250	U	250	U	**1300**		**930**		**1200**		**740**		**810**		**540**		**557**		**469**		**454**		**452**		250	U
Carbon Tetrachloride	**1000**		**390**		**930**		**540**		**3300**		**5000**		**5500**		**3900**		**3500**		**2900**		**5800**		**5490**		**5510**		**6210**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	98.1		97.4		92.6		96.8		97.7		92.1		95.5		97.4		102		93.9		95.17		92.66		92.32		96.7		93.08	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-08

ECCS Number	G63		G64		G65		G66		G67		G68		G69		G70		G71		G72		G193		G194		G195		G196		G197	
Sample Description	SG08D010GA		SG08D020GA		SG08D030GA		SG08D040GA		SG08D050GA		SG08D060GA		SG08D060GB		SG08D070GA		SG08D080GA		SG08D087GA		SG08D100GA		SG08D110GA		SG08D110GB		SG08D115GA		SG08D000GC	
Date Collected	10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007	
Date Analyzed	10/19/2006		10/19/2006		10/20/2006		10/20/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		10/19/2006		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007	
(ug/m3)																														
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	**480**		**530**		**1200**		**1000**		**1500**		**1300**		**2500**		**2550**		250	U	250	U	**1930**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U,L	250	U,L	250	U,L	250	U,L	250	U,L
Surrogate (Dibromofluoromethane)	96.4		98.5		94.1		94.6		100		94.8		94.8		101		97.9		95.2		97.24		101.65		96.49		93.68		97.19	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Soil Gas Analytical Summary
DPT-09

ECCS Number	G21		G22		G23		G24		G25		G26		G27		G28		G29		G30		G31		G265		G266		G267		G268		G269	
Sample Description	SG00D00GC2		SG09D010GA		SG09D020GA		SG09D030GA		SG09D040GA		SG09D050GA		SG09D050GB		SG09D060GA		SG09D070GA		SG09D080GA		SG09D090GA		SG09D100GA		SG09D110GA		SG09D115GA		SG09D115GB		SG09D000GC	
	(Field Blank)																															
Date Collected	10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		3/7/2007		3/7/2007		3/7/2007		3/7/2007		3/7/2007	
Date Analyzed	10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		3/7/2007		3/7/2007		3/7/2007		3/7/2007		3/7/2007	
(ug/m3)																																
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	**410**		250	U	**840**		**890**		**490**		**420**		**960**		**2400**		**733**		**2270**		**2420**		**2580**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**770**		250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	99.8		93.5		98.6		100		99.1		98.3		95.7		93		93		97.5		135		95.43		95.57		94.34		90.75		94.35	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-10

ECCS Number	G1		G2		G3		G4		G5		G6		G7		G8		G9		G10	
Sample Description	SG10D010GA		SG10D020GA		SG10D030GA		SG10D040GA		SG10D050GA		SG10D060GA		SG10D070GA		SG10D080GA		SG10D080GB		SG10D090GA	
Date Collected	10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006	
Date Analyzed	10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006		10/16/2006	
(ug/m3)																				
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U,L	250	U
Surrogate (Dibromofluoromethane)	100		105		102		101		98		100		91.8		94.4		94.4		109	
Dilution Factor	1		1		1		1		1		1		1		1		1		1	

L=LOW RECOVERY ON CALIBRATION CHECK STANDARD

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-10A

ECCS Number	G250		G251		G252		G253		G254		G255		G256		G257		G258		G259		G260		G261		G262	
Sample Description	SG10AD010GA		SG10AD020GA		SG10AD030GA		SG10AD040GA		SG10AD050GA		SG10AD060GA		SG10AD070GA		SG10AD080GA		SG10AD090GA		SG10AD100GA		SG10AD110GA		SG10AD110GB		SG10AD115GA	
Date Collected	3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007	
Date Analyzed	3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007		3/6/2007	
(ug/m3)																										
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	270		250	U	298	
Carbon Tetrachloride	250	U	**833**		**1320**		**1450**		**1850**		250	U	**2690**		**476**		**6660**		**5640**		**9370**		**8680**		**10000**	
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	103.17		101.23		98.23		95.84		96.4		98.02		96.21		93.36		98.96		97.7		98.02		93.59		98.12	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1	

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Soil Gas Analytical Summary
DPT-11

ECCS Number	G11		G12		G13		G14		G15		G16		G17		G18		G19		G20		G263		G264		G265		G266	
Sample Description	SG11D010GA		SG11D020GA		SG11D020GB		SG11D030GA		SG11D040GA		SG11D050GA		SG11D060GA		SG11D070GA		SG11D080GA		SG11D090GA		SG11D100GA		SG11D110GA		SG09D100GA		SG09D110GA	
Date Collected	10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		3/7/2007		3/7/2007		3/7/2007		3/7/2007	
Date Analyzed	10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		10/17/2006		3/7/2007		3/7/2007		3/7/2007		3/7/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**945**		**1860**		**733**		**2270**	
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	101		97.2		99.8		101		95.9		100		99.9		99.1		96.9		96.2		107.38		100.69		95.43		95.57	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Soil Gas Analytical Summary

DPT-12

ECCS Number	G135		G136		G137		G138		G139		G140		G141		G142		G143		G144		G145		G146		G147		G148	
Sample Description	SG12D010GA		SG12D020GA		SG12D030GA		SG12D040GA		SG12D050GA		SG12D060GA		SG12D070GA		SG12D080GA		SG12D090GA		SG12D100GA		SG12D110GA		SG12D110GB		SG12D115GA		SG12D000GC	
Date Collected	2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007	
Date Analyzed	2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/17/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007		2/16/2007	
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	**257**		250	U	250	U	250	U	**857**		**1030**		**1580**		250	U	**633**		**890**		250	U	250	U	250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	107.98		96.58		105.58		90.25		93.07		91.54		106.87		101.47		97.37		91.13		106.34		90.74		102.43		91.96	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Soil Gas Analytical Summary
DPT-13

ECCS Number	G42		G43		G44		G45		G46		G47		G48		G49		G50		G51		G52		G241		G242		G243		G244		G245	
Sample Description	SG13D010GA		SG13D020GA		SG13D030GA		SG13D040GA		SG13D050GA		SG13D060GA		SG13D070GA		SG13D070GB		SG13D080GA		SG13D090GA		SG13D096GA		SG13D100GA		SG13D100GB		SG13D110GA		SG13D115GA		SG13D000GC	
Date Collected	10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		3/5/2007		3/5/2007		3/5/2007		3/5/2007		3/5/2007	
Date Analyzed	10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		3/5/2007		3/5/2007		3/5/2007		3/5/2007		3/5/2007	
(ug/m3)																																
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	**280**		**6900**		**7200**		**8900**		**11000**		**1400**		250	U	250	U	**18800**		**19100**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	102		99.3		106		95.8		98.5		97.4		95.1		95.1		93.9		99.2		100		98.58		98.27		95.69		101.64		101.09	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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AOC for Removal Action and Remedial Investigation/Feasibility Study
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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-14

ECCS Number	G198		G199		G200		G201		G202		G203		G204		G205		G206		G207		G208		G209		G210		G211		G212	
Sample Description	SG14D010GA		SG14D020GA		SG14D030GA		SG14D040GA		SG14D050GA		SG14D060GA		SG14D070GA		SG14D080GA		SG14D000GC		SG14D090GA		SG14D100GA		SG14D110GA		SG14D110GB		SG14D115GA		SG14D001GC	
Date Collected	2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007	
Date Analyzed	2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/20/2007		2/19/2007		2/19/2007		2/19/2007		2/19/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007	
(ug/m3)																														
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**4890**		250	U	**4050**		250	U	**17300**		**18100**		**18600**		250	U
1,2-Dibromoethane	250	U,L	250	U,L	250	U,L	250	U,L	250	U	250	U,L	250	U,L	250	U,L	250	U,L	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	98.68		94.56		95.12		92.2		96.18		92.29		94.25		96.13		94.28		97.41		94.71		95.37		93.69		91.73		96.68	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1	

L-LOW CALIBRATION CHECK STANDARD RECOVERY-67.3%

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-15

ECCS Number	G32		G33		G34		G35		G36		G37		G38		G39		G40		G41		G246		G247		G248		G249	
Sample Description	SG15D010GA		SG15D020GA		SG15D030GA		SG15D040GA		SG15D050GA		SG15D060GA		SG15D060GB		SG15D070GA		SG15D080GA		SG15D090GA		SG15D100GA		SG15D110GA		SG15D115GA		SG15D000GC	
Date Collected	10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		3/5/2007		3/5/2007		3/5/2007		3/5/2007	
Date Analyzed	10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		10/18/2006		3/5/2007		3/5/2007		3/5/2007		3/5/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**3480**		**1590**		**3150**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	110		103		106		102		104		103		102		105		105		101		95.04		100.66		98.62		98.02	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary
DPT-16

ECCS Number	G227		G228		G229		G230		G231		G232		G233		G234		G235		G236		G237		G238		G239		G240	
Sample Description	SG16D010GA		SG16D0180GA		SG16D030GA		SG16D040GA		SG16D050GA		SG16D060GA		SG16D070GA		SG16D080GA		SG16D090GA		SG16D100GA		SG16D110GA		SG16D110GB		SG16D115GA		SG16D000GC	
Date Collected	2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007	
Date Analyzed	2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007		2/21/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U,L	250	U	250	U	**10600**		**996**	**H**	**12500**	**H**	250	U	250	U,L	**19900**		250	U,L
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	95.43		98.19		99.57		94.82		108.69		93.24		95.76		92.74		100.61		110.79		93.92		99.42		97.26		98.65	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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Soil Gas Analytical Summary

DPT-17

ECCS Number	G213		G214		G215		G216		G217		G218		G219		G220		G221		G222		G223		G224		G225		G226	
Sample Description	SG17D010GA		SG17D020GA		SG17D030GA		SG17D040GA		SG17D050GA		SG17D060GA		SG17D070GA		SG17D080GA		SG17D090GA		SG17D100GA		SG17D110GA		SG17D110GB		SG17D115GA		SG17D000GC	
Date Collected	2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007	
Date Analyzed	2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007		2/20/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	1000	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	1000	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	1000	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**2350**		250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	**79900**		**624**		250	U	**2570**		**2130**		**1540**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	1000	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	94.09		94.59		92.32		93.8		96.21		92.77		94.22		91.19		91.26		95.58		97.9		92.92		90.44		97.72	
Dilution Factor	1		1		1		1		1		1		1		4		1		1		1		1		1		1	

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Garvey Elevator Facility, 2315 W. Highway 6, Hastings, NE

Soil Gas Analytical Summary

DPT-18

ECCS Number	G121		G122		G123		G124		G125		G126		G127		G128		G129		G130		G131		G132		G133		G134	
Sample Description	SG18D010GA		SG18D020GA		SG18D030GA		SG18D040GA		SG18D050GA		SG18D060GA		SG18D070GA		SG18D080GA		SG18D090GA		SG18D100GA		SG18D110GA		SG18D110GB		SG18D115GA		SG18D000GC	
Date Collected	2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007	
Date Analyzed	2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/15/2007		2/16/2007		2/16/2007		2/15/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U	250	U	250	U	**450**		250	U	250	U	**322**	**M**	**438**		**268**		**659**		250	U
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	93.42		94.89		94.13		93.51		92.38		94.71		92.45		91.14		90.31		101.33		109.31		103.79		86.33		93.66	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

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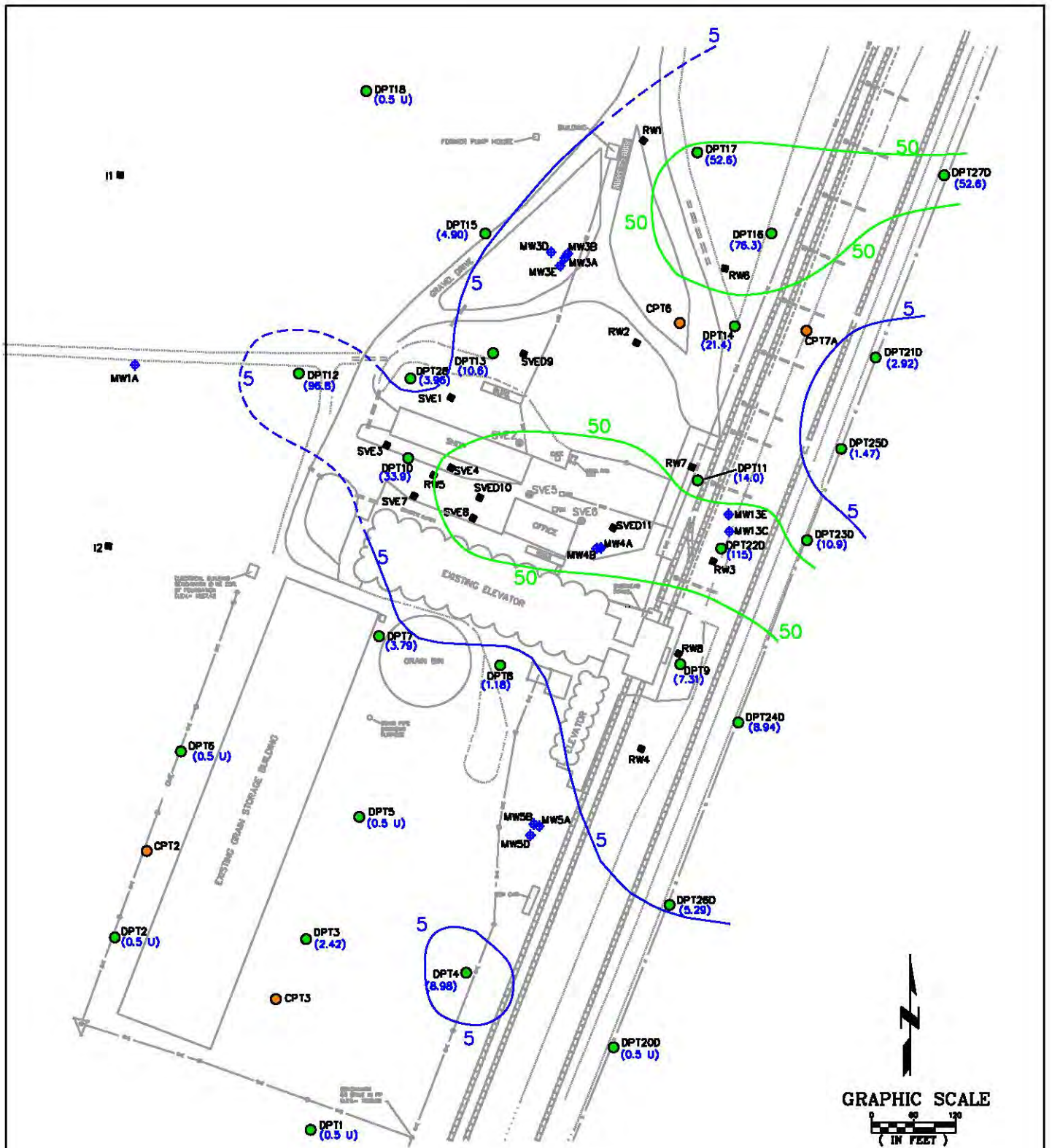
DPT-28

ECCS Number	G270		G271		G272		G273		G274		G275		G276		G277		G278		G279		G280		G281		G282		G283	
Sample Description	SG28D010GA		SG28D020GA		SG28D030GA		SG28D040GA		SG28D050GA		SG28D060GA		SG28D070GA		SG28D080GA		SG28D090GA		SG28D100GA		SG28D110GA		SG28D110GB		SG28D115GA		SG28D000GC	
Date Collected	3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007	
Date Analyzed	3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007		3/8/2007	
(ug/m3)																												
Chloromethane	250	U	250	U	250	U	250	U,M	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Disulfide	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Methylene Chloride	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Chloroform	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Carbon Tetrachloride	250	U	250	U	250	U	250	U,M	250	U	250	U	**422**		**610**		**912**		**1020**		**764**		**617**		**954**		**250**	**U**
1,2-Dibromoethane	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U	250	U
Surrogate (Dibromofluoromethane)	95.18		98.59		94.47		94.73		98.46		93.13		91.35		93.62		94.97		97.82		96.16		98.3		97.61		95.81	
Dilution Factor	1		1		1		1		1		1		1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

ATTACHMENT 4

ENSR GROUNDWATER DATA



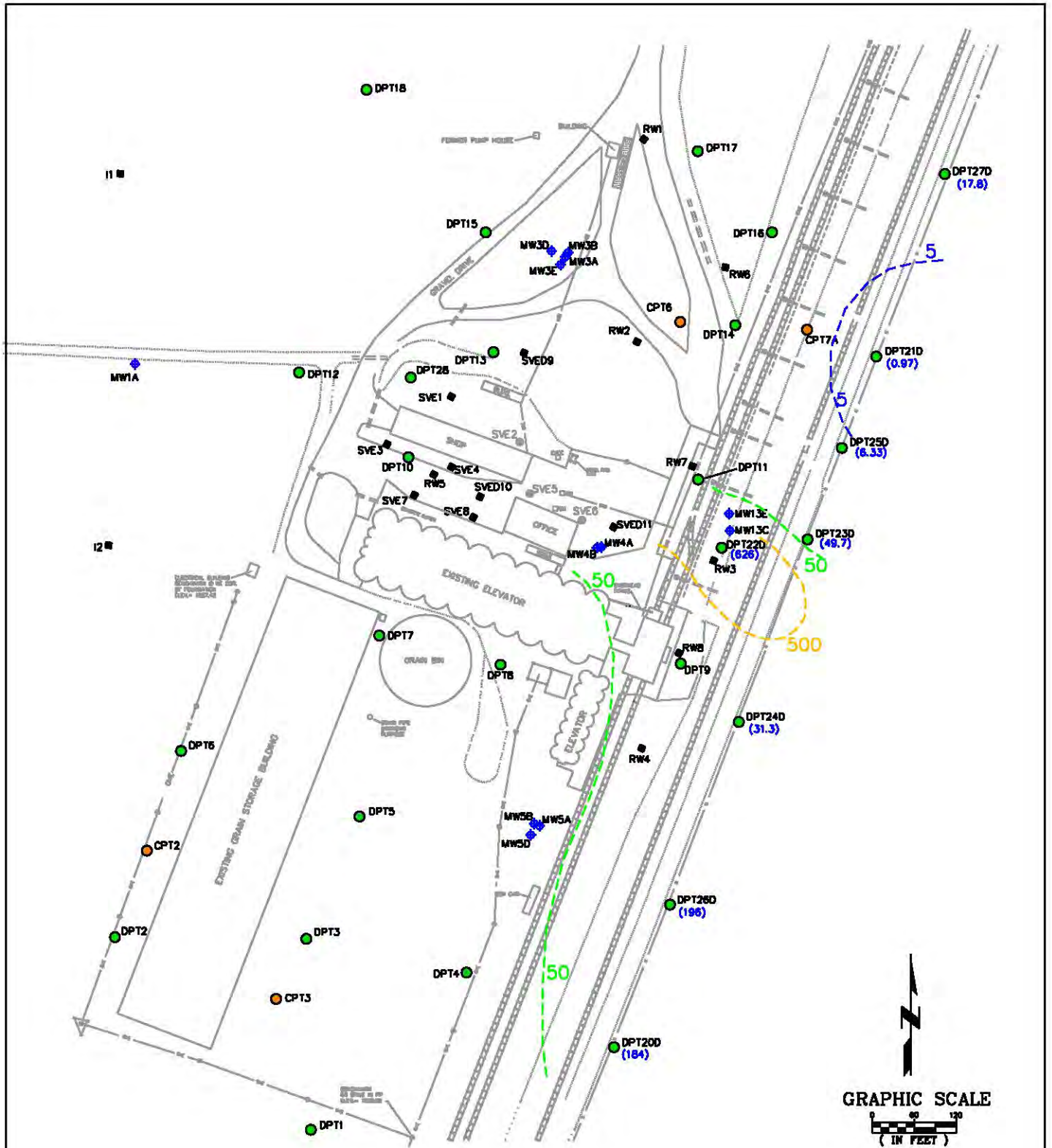
All Concentrations Shown in ug/L

DRAFT

Carbon Tetrachloride in Groundwater - 120 ft

SEWP Phase 1 DPT Investigation

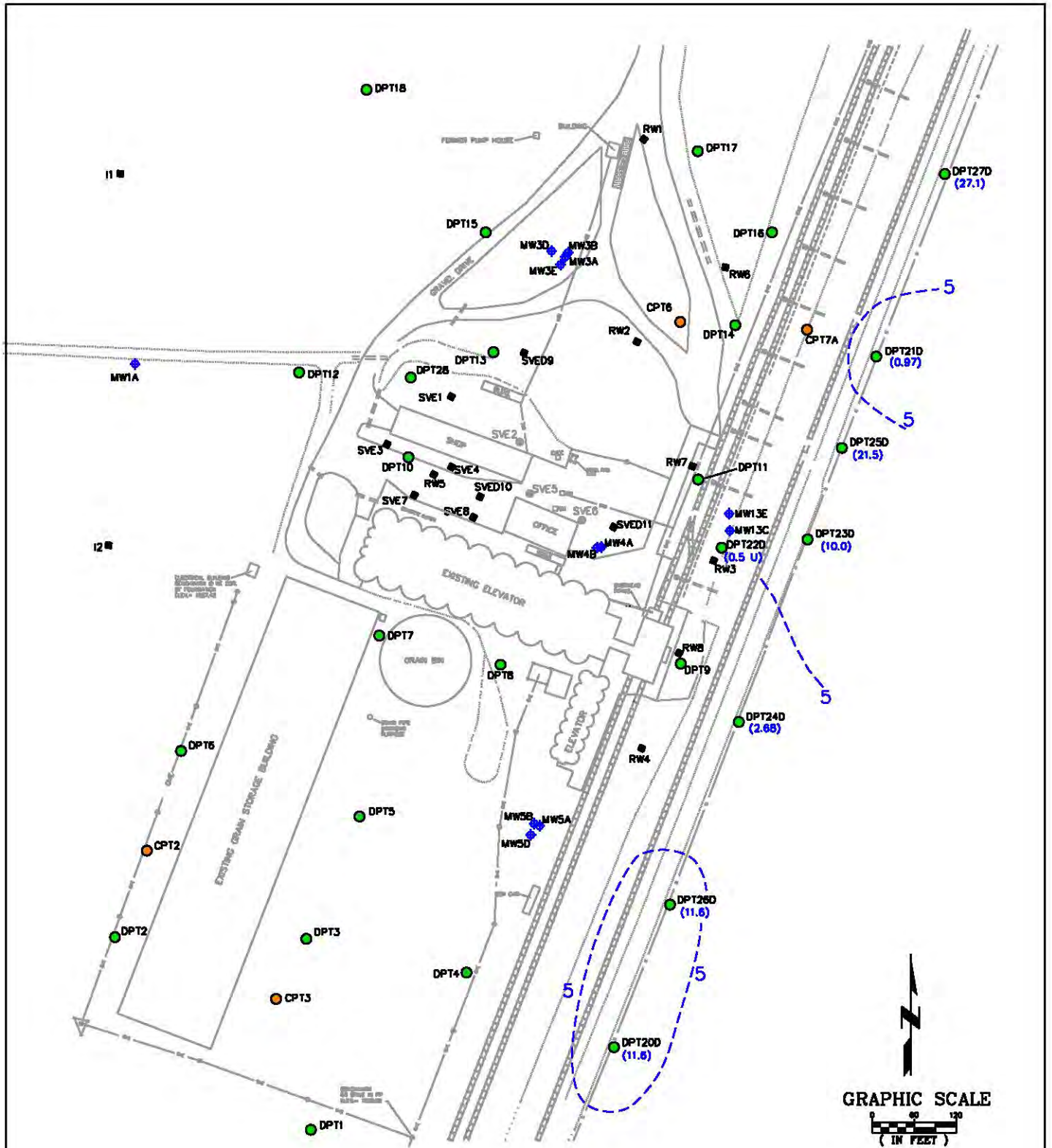
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/L

DRAFT

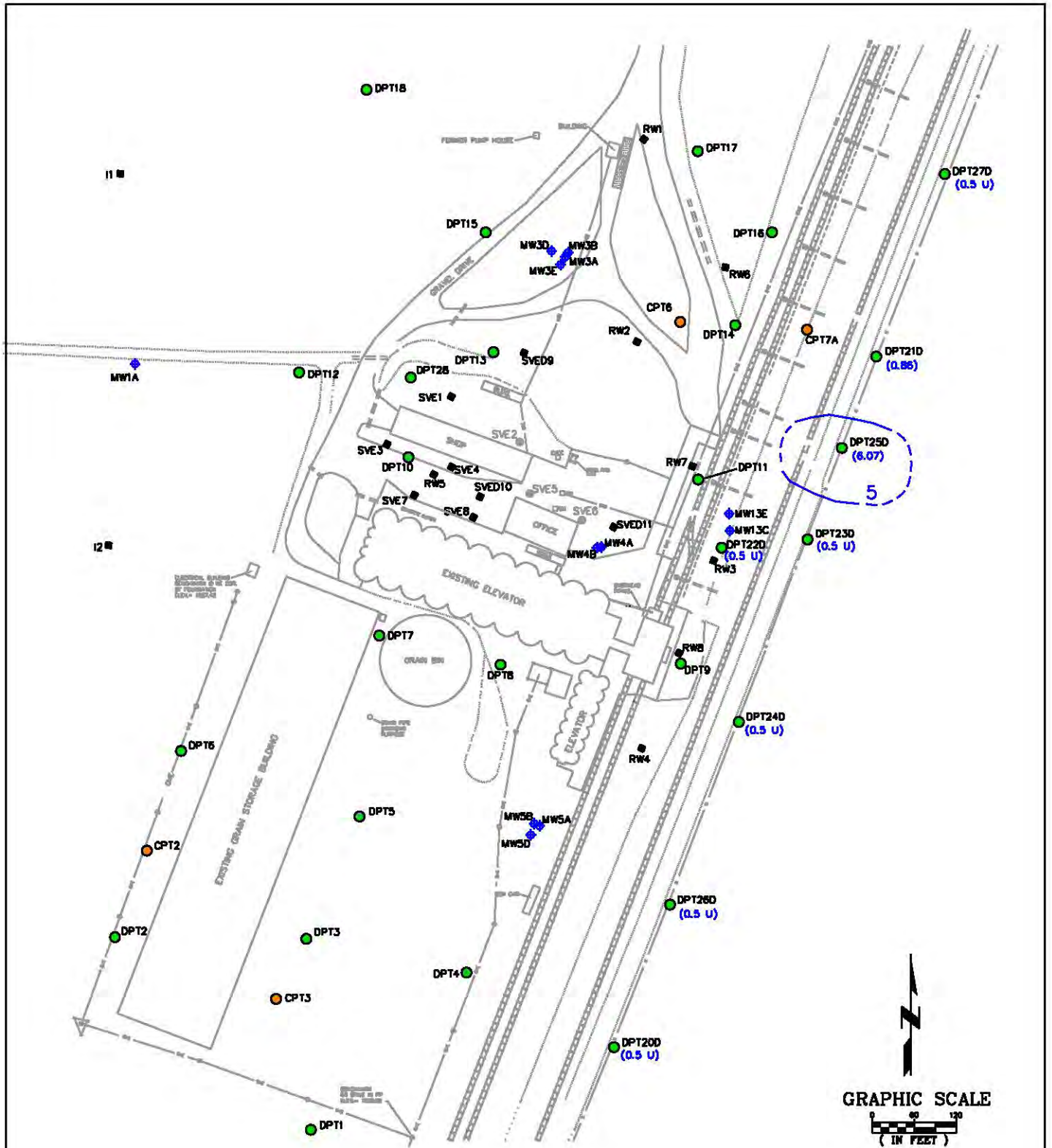
Carbon Tetrachloride in Groundwater - 130 ft
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/L

DRAFT

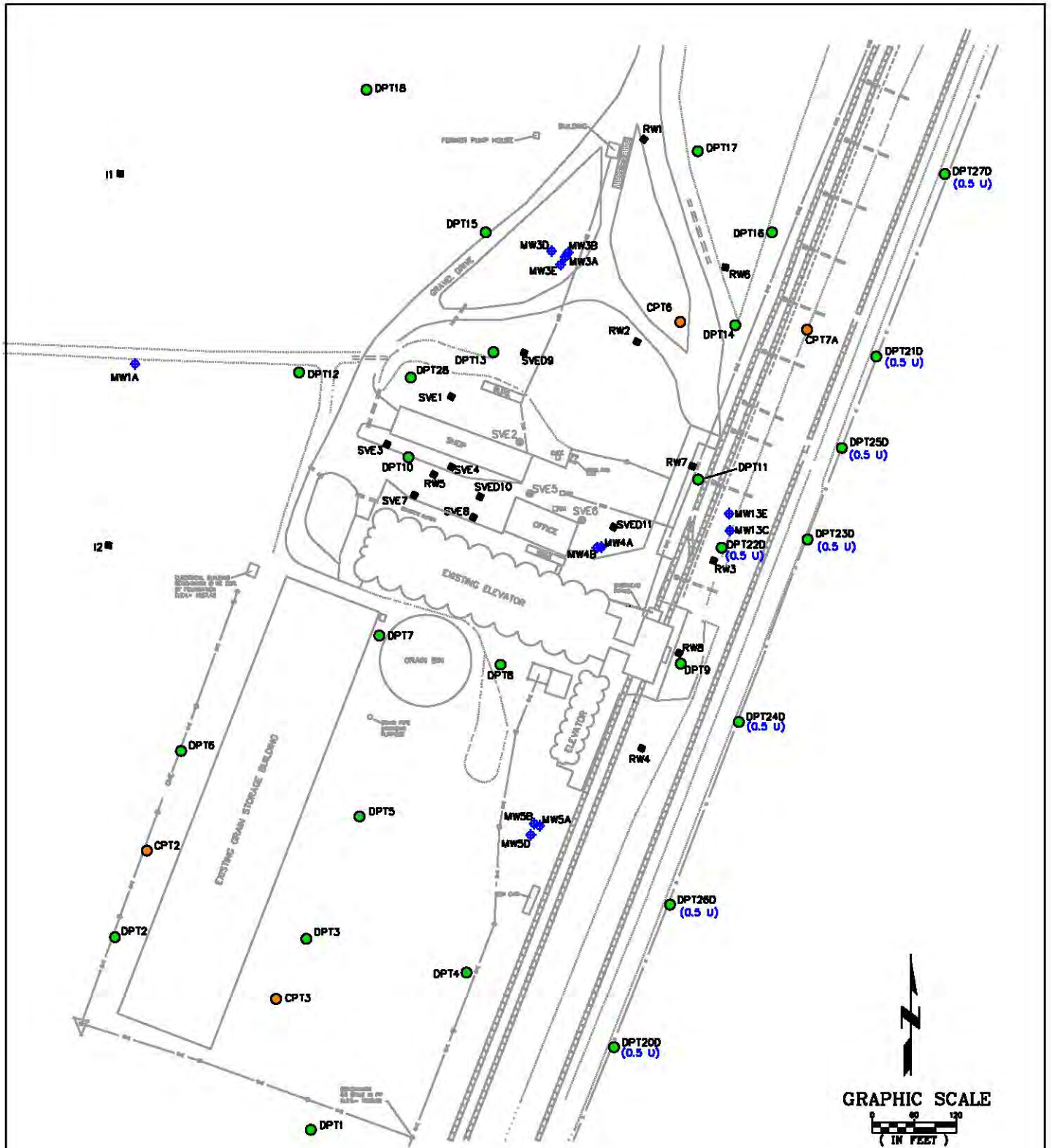
Carbon Tetrachloride in Groundwater - 140 ft
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/L

DRAFT

Carbon Tetrachloride in Groundwater - 150 ft
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown in ug/L

DRAFT

Carbon Tetrachloride in Groundwater - 160 to 230 ft

SEWP Phase 1 DPT Investigation

Garvey Elevator, Hastings, NE

US EPA ARCHIVE DOCUMENT

MW-9A

MW-11A

MW-8A

MW-14A

MW-12A

MW-4A
MW-4B

MW-7A
MW-7C

Beyke Property

Becker Property

MW-16A
(P&A'd)

3

HASTINGS EAST, NEBR.
N4030—W9815/7.5
1969
PHOTOREVISED 1983
DMA 6365 III SE—SERIES V875

HASTINGS WEST, NEBR.
N4030—W9822.5/7.5
1969
PHOTOREVISED 1983
DMA 6365 III SW—SERIES V875

Legend

- Garvey (On-Site)
- (Recovery Well
- A Monitoring Wells
- " Domestic Water Well (not sampled)
- " Domestic Water Well (detected level of CCl4)
- " Domestic Water Well (below detection limits)
- Monitoring Area
- Surface Water
- BDL below detection limtis
- Water

0 375 750 1,500 Feet

1 inch equals 0.124333 miles

ENSR INTERNATIONAL

Garvey Elevators Superfund Site
Carbon Tetrachloride Groundwater Concentrations
Hastings, Nebraska
Annual 2004

Date: 02.18.05 | Project Number: 10264.004.100 | **Figure: 2**

US EPA ARCHIVE DOCUMENT

Figure 1

OFFICE	DRWN. BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
COWELL, 12/05	WR 01/24/2003	HF 01/24/2003	—	794434-E1

LEGEND

- DOMESTIC WELL (IN USE) NO CARBON TETRACHLORIDE (CCl4)
- MONITORING WELL OR NON-DRINKING PRIVATE WELL WITH NO CCl4
- (120,40,ND) CONCENTRATION OF CARBON TETRACHLORIDE IN ug/L FROM WINTER/SPRING 2003 SAMPLING (The first concentration is from the shallowest well of the well cluster and the last one is from the deepest.)
- (ND) NOT DETECTED
- IRRIGATION WELL WITH NO CCl4
- DOMESTIC WELL (IN USE) WITH CCl4
- MONITORING WELL OR NON-DRINKING PRIVATE WELL WITH CCl4
- (120,40,ND) CONCENTRATION OF CARBON TETRACHLORIDE IN ug/L FROM PREVIOUS SAMPLING EVENTS, BUT CLOSEST TO WINTER 2003 (The first concentration is from the shallowest well of the well cluster and the last one is from the deepest.)
- IRRIGATION WELL WITH CCl4

0 1000 2000
SCALE IN FEET

CARBON TETRACHLORIDE GROUNDWATER CONCENTRATIONS

GARVEY ELEVATORS - HASTINGS, NEBRASKA
MOST RECENT RESULTS

DRAWN:	MNA	APP'D:	HF	FIGURE
DATE:	02/12/03	REVISED:	07/08/04	
CHK:	CRF 5	NAME:	794434-e1	PROJECT NUMBER: 10264-002-100

US EPA ARCHIVE DOCUMENT

Groundwater Results
(ug/L)
Garvey Elevator
Hastings, Nebraska

ECCS Number	W26		W25		W20		W21		W19		W24	
Sample Description	GW01D120WA		GW02D120WA		GW03D120WA		GW04D120WA		GW05D120WA		GW06D120WA	
Date Collected	2/18/2007		2/18/2007		2/13/2007		2/14/2007		2/12/2007		2/17/2007	
Date Analyzed	2/21/2007		2/21/2007		2/17/2007		2/17/2007		2/17/2007		2/21/2007	
VOCs by Purge and Trap GC/MS												
Chloromethane	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Carbon Disulfide	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Methylene Chloride	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Chloroform	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Carbon Tetrachloride	0.5	U	0.5	U	**2.42**		**8.98**		0.5	U	0.5	U
1,2-Dibromoethane	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	0.5	U
Surrogate (Dibromofluoromethane)	98.4		97		101.192		101.6		100.32		97.52	
Dilution Factor	1		1		1		1		1		1	
1,2-Dibomoethane	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U
Surrogate (1-Bromo-2-chloroethane)	98.39		96.91		100.78		101.53		105.81		94.38	
Dilution Factor	1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

Groundwater Results
(ug/L)
Garvey Elevator
Hastings, Nebraska

W27		W28		W37		W35		W36		W23		W33		W29	
GW07D120WA		GW08D120WA		GW09D120WA		GW10AD120WA		GW11D120WA		GW12D120WA		GW13D120WB		GW14D120WA	
2/19/2007		2/19/2007		3/7/2007		3/6/2007		3/7/2007		2/16/2007		3/5/2007		2/20/2007	
2/21/2007		2/21/2007		3/8/2007		3/8/2007		3/8/2007		2/17/2007		3/8/2007		2/21/2007	
0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2	U	0.5	U	0.5	U
0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2	U	0.5	U	0.5	U
0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2	U	0.5	U	0.5	U
1.82		0.5	U	**1.42**		**3.43**		**0.92**		**6.8**		0.5	U	0.5	U
3.79		**1.18**		**7.31**		**33.9**		**14.0**		**96.8**		**10.6**		**21.4**	
0.5	U	0.5	U	0.5	U	0.5	U	0.5	U	2	U	0.5	U	0.5	U
97.92		95.72		100.8		97.6		98.52		101.4		99.96		97.16	
1		1		1		1		1		4		1		1	
0.025	U	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U
101.96		106.91		97.61		95.58		97.06		101.2		99.03		110.55	
1		1		1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

Groundwater Results
(ug/L)
Garvey Elevator
Hastings, Nebraska

W34		W31		W30		W22		W38		W39	
GW15D120WA		GW16D120WA		GW17D120WA		GW18D120WA		GW28D120WA		GW28D120WB	
3/6/2007		2/21/2007		2/20/2007		2/15/2007		3/8/2007		3/8/2007	
3/8/2007		2/21/2007		2/21/2007		2/17/2007		3/8/2007		3/8/2007	
0.5	U	2	U	2	U	0.5	U	0.5	U	0.5	U
0.5	U	2	U	2	U	0.5	U	0.5	U	0.5	U
0.5	U	2	U	2	U	0.5	U	0.5	U	0.5	U
0.5	U	**5.68**		**2.96**		0.5	U	**1.53**		**1.54**	
4.90		**76.3**		**52.6**		0.5	U	**3.96**		**4.00**	
0.5	U	2	U,L	2	U,L	0.5	U	0.5	U	0.5	U
97.2		96.44		96.28		101.52		98.56		101.08	
1		4		4		1		1		1	
0.025	U	0.025	U	0.025	U	0.025	U	0.025	U	0.025	U
98.66		90.47		91.41		99.98		93.42		86.56	
1		1		1		1		1		1	

US EPA ARCHIVE DOCUMENT

ATTACHMENT 5

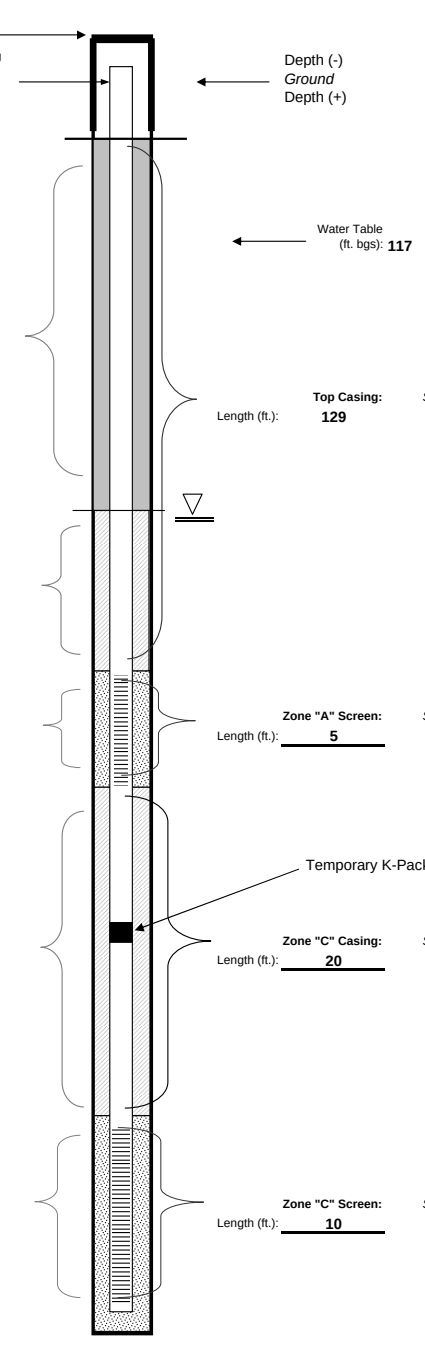
ENSR MULTI-LEVEL WELL DIAGRAMS

WELL INSTALLATION RECORD

WELL ID:	MW - 31	**Date:**	2-May-07	**Client:**	Garvey Elevator	**Ground Elevation (ft.)**	
Total Depth:	162.5	**Depth Unit:**		**Geologist:**	J. Rodriguez		
Contractor:	Boart Longyear	**Project #:**	10264.011.300	**Water Table (ft. bgs):**	116.75	**TOC Elevation (ft.)**	N/A

ENSR | AECOM

Segment Type	Material	Depth (ft) Start	Depth (ft) End	Diameter (in.) Inner	Diameter (in.) Outer	Thickness (ft.)	Slot Type	Slot Size	Fill Material Quantity	Fill Material Density	Comment
Surface Plug											
Protective casing						0					
Annular Backfill	HydratedCement Bentonite	6.0	94.0	4.50	8.25	88					
Top Casing	PVC Sch 80	-2.0	127.0	3.83	4.50	129					
Zone "A" Seal	Bentonite Chips	94.0	126.0	4.50	8.25	32					
Zone "A" Screen	PVC 80	127.0	132.0	3.83	4.50	5	PVC Slotted	0.10			
Zone "A" Filter Pack	Sand	126.0	133.0	4.50	8.25	7					
Zone "C" Casing	PVC Sch 80	132.0	152.0	3.83	4.50	20					
Zone "C" Seal	Bentonite Chips	133.0	149.9	4.50	8.25	17					
Zone "C" Screen	PVC Sch 80	152.0	162.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "C" Filter Pack	Sand	149.9	162.0	4.50	8.25	12					
Sump	PVC Sch 80	162.0	162.5	3.83	4.50	0.5					



	Below Ground Surface (ft)	Elevation (ft)			Below Ground Surface (ft)	Elevation (ft)
Annular Backfill:						
Start:	6.0	-6.0	Length (ft.):	88		
End:	94.0	-94.0				
Top Casing:						
Length (ft.):	129					
Start:	-2.0	2.0				
End:	127.0	-127.0				
Zone "A" Seal:						
Start:	94.0	-94.0	Length (ft.):	32		
End:	126.0	-126.0				
Zone "A" Filter:						
Start:	126.0	-126.0	Length (ft.):	7		
End:	133.0	-133.0				
Zone "A" Screen:						
Length (ft.):	5					
Start:	127.0	-127.0				
End:	132.0	-132.0				
Zone "C" Seal:						
Start:	133.0	-133.0	Length (ft.):	17		
End:	149.9	-149.9				
Zone "C" Casing:						
Length (ft.):	20					
Start:	132.0	-132.0				
End:	152.0	-152.0				
Zone "C" Filter:						
Start:	149.9	-149.9	Length (ft.):	12		
End:	162.0	-162.0				
Zone "C" Screen:						
Length (ft.):	10					
Start:	152.0	-152.0				
End:	162.0	-162.0				

US EPA ARCHIVE DOCUMENT

WELL INSTALLATION RECORD

WELL ID:	MW - 19	**Date:**	30-Apr-07	**Client:**	Garvey Elevator	**Ground Elevation (ft.)**	
Total Depth:	162.5	**Depth Unit:**		**Geologist:**	J. Rodriguez		
Contractor:	Boart Longyear	**Project #:**	10264.011.300	**Water Table (ft. bgs):**	120	**TOC Elevation (ft.)**	N/A

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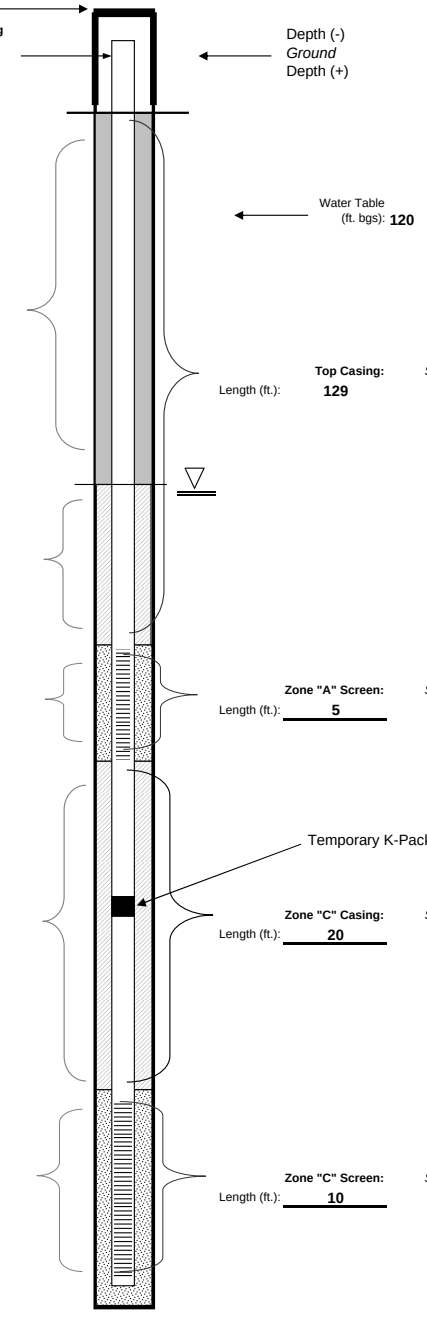
Segment Type	Material	Depth (ft) Start	Depth (ft) End	Diameter (in.) Inner	Diameter (in.) Outer	Thickness (ft.)	Slot Type	Slot Size	Fill Material Quantity	Fill Material Density	Comment
Surface Plug											
Protective casing						0					
Annular Backfill	HydratedCement Bentonite	5.0	115.0	4.50	8.25	110					
Top Casing	PVC Sch 80	-2.0	127.0	3.83	4.50	129					
Zone "A" Seal	Bentonite Chips	115.0	122.0	4.50	8.25	7					
Zone "A" Screen	PVC 80	127.0	132.0	3.83	4.50	5	PVC Slotted	0.10			
Zone "A" Filter Pack	Sand	122.0	133.5	4.50	8.25	12					
Zone "C" Casing	PVC Sch 80	132.0	152.0	3.83	4.50	20					
Zone "C" Seal	Bentonite Chips	133.5	150.0	4.50	8.25	17					
Zone "C" Screen	PVC Sch 80	152.0	162.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "C" Filter Pack	Sand	150.0	162.0	4.50	8.25	12					
Sump	PVC Sch 80	162.0	162.5	3.83	4.50	0.5					



	Below Ground Surface (ft)	Elevation (ft)			Below Ground Surface (ft)	Elevation (ft)
Annular Backfill:						
Start:	5.0	-5.0	Length (ft.): 110			
End:	115.0	-115.0				
Top Casing:						
Length (ft.): 129				Start:	-2.0	2.0
				End:	127.0	-127.0
Zone "A" Seal:						
Start:	115.0	-115.0	Length (ft.): 7			
End:	122.0	-122.0				
Zone "A" Filter:						
Start:	122.0	-122.0	Length (ft.): 12			
End:	133.5	-133.5				
Zone "A" Screen:						
Length (ft.): 5				Start:	127.0	-127.0
				End:	132.0	-132.0
Zone "C" Seal:						
Start:	133.5	-133.5	Length (ft.): 17			
End:	150.0	-150.0				
Zone "C" Casing:						
Length (ft.): 20				Start:	132.0	-132.0
				End:	152.0	-152.0
Zone "C" Filter:						
Start:	150.0	-150.0	Length (ft.): 12			
End:	162.0	-162.0				
Zone "C" Screen:						
Length (ft.): 10				Start:	152.0	-152.0
				End:	162.0	-162.0

US EPA ARCHIVE DOCUMENT

WELL INSTALLATION RECORD

WELL ID:	MW-20	**Date:**	17-Apr-07	**Client:**	Garvey Elevator	**Ground Elevation (ft.)**	
Total Depth:	232.5	**Depth Unit:**	Niobrara Chalk	**Geologist:**	J. Rodriguez		
Contractor:	Boart Longyear	**Project #:**	10264.011.300	**Water Table (ft. bgs):**	116'	**TOC Elevation (ft.)**	

ENSR | AECOM

Segment Type	Material	Depth (ft) Start	Depth (ft) End	Diameter (in.) Inner	Diameter (in.) Outer	Thickness (ft.)	Slot Type	Slot Size	Fill Material Quantity	Fill Material Density	Comment
Surface Plug	Plastic										
Protective casing	Steel	0.0	3.0			3					
Annular Backfill	HydratedCement Bentonite	20.0	111.0	4.50	8.25	91					
Top Casing	PVC Sch 80	-2.0	127.0	3.83	4.50	129					
Zone "A" Seal	Bentonite Chips	111.0	126.0	4.50	8.25	15					
Zone "A" Screen	PVC 80	127.0	132.0	3.83	4.50	5	PVC Slotted	0.10			
Zone "A" Filter Pack	Sand	125.0	134.0	4.50	8.25	9					
Zone "C" Casing	PVC Sch 80	132.0	152.0	3.83	4.50	20					
Zone "C" Seal	Bentonite Chips	134.0	150.0	4.50	8.25	16					
Zone "C" Screen	PVC Sch 80	152.0	162.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "C" Filter Pack	Sand	150.0	164.0	4.50	8.25	14					
Zone "D" Casing	PVC Sch 80	162.0	182.0	3.83	4.50	20					
Zone "D" Seal	Bentonite Chips	164.0	180.0	4.50	8.25	16					
Zone "D" Screen	PVC Sch 80	182.0	192.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "D" Filter Pack	Sand	180.0	194.0	4.50	8.25	14					
Zone "E" Casing	PVC Sch 80	192.0	222.0	3.83	4.50	30					
Zone "E" Seal	Bentonite Chips	194.0	220.0	4.50	8.25	26					
Zone "E" Screen	PVC Sch 80	222.0	232.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "E" Filter Pack	Sand	220.0	232.5	4.50	8.25	13					
Sump	PVC Sch 80	232.0	232.5	3.83	4.50	0.5					

	Below Ground Surface (ft)	Elevation (ft)				Below Ground Surface (ft)	Elevation (ft)
			Top of Well Cap				
			Top of Casing		Depth (-) Ground Depth (+)		
Start:	20.0	-20.0	Annular Backfill:		Top Casing:	-2.0	2.0
End:	111.0	-111.0	Length (ft.):	91	Length (ft.): 129	127.0	-127.0
					Water Table (ft. bgs): 116'		
Start:	111.0	-111.0	Zone "A" Seal:				
End:	126.0	-126.0	Length (ft.):	15			
Start:	125.0	-125.0	Zone "A" Filter:		Zone "A" Screen:	127.0	-127.0
End:	134.0	-134.0	Length (ft.):	9	Length (ft.): 5	132.0	-132.0
					Temporary K-Packer @ 142 bgs.		
Start:	134.0	-134.0	Zone "C" Seal:		Zone "C" Casing:	132.0	-132.0
End:	150.0	-150.0	Length (ft.):	16	Length (ft.): 20	152.0	-152.0
Start:	150.0	-150.0	Zone "C" Filter:		Zone "C" Screen:	152.0	-152.0
End:	164.0	-164.0	Length (ft.):	14	Length (ft.): 10	162.0	-162.0
Start:	164.0	-164.0	Zone "D" Seal:		Zone "D" Casing:	162.0	-162.0
End:	180.0	-180.0	Length (ft.):	16	Length (ft.): 20	182.0	-182.0
					Temporary K-Packer @ 172' bgs.		
Start:	180.0	-180.0	Zone "D" Filter:		Zone "D" Screen:	182.0	-182.0
End:	194.0	-194.0	Length (ft.):	14	Length (ft.): 10	192.0	-192.0
					Temporary K-Packer @ 202' bgs.		
Start:	194.0	-194.0	Zone "E" Seal:		Zone "E" Casing:	192.0	-192.0
End:	220.0	-220.0	Length (ft.):	26	Length (ft.): 30	222.0	-222.0
Start:	220.0	-220.0	Zone "E" Filter:		Zone "E" Screen:	222.0	-222.0
End:	232.5	-232.5	Length (ft.):	13	Length (ft.): 10	232.0	-232.0

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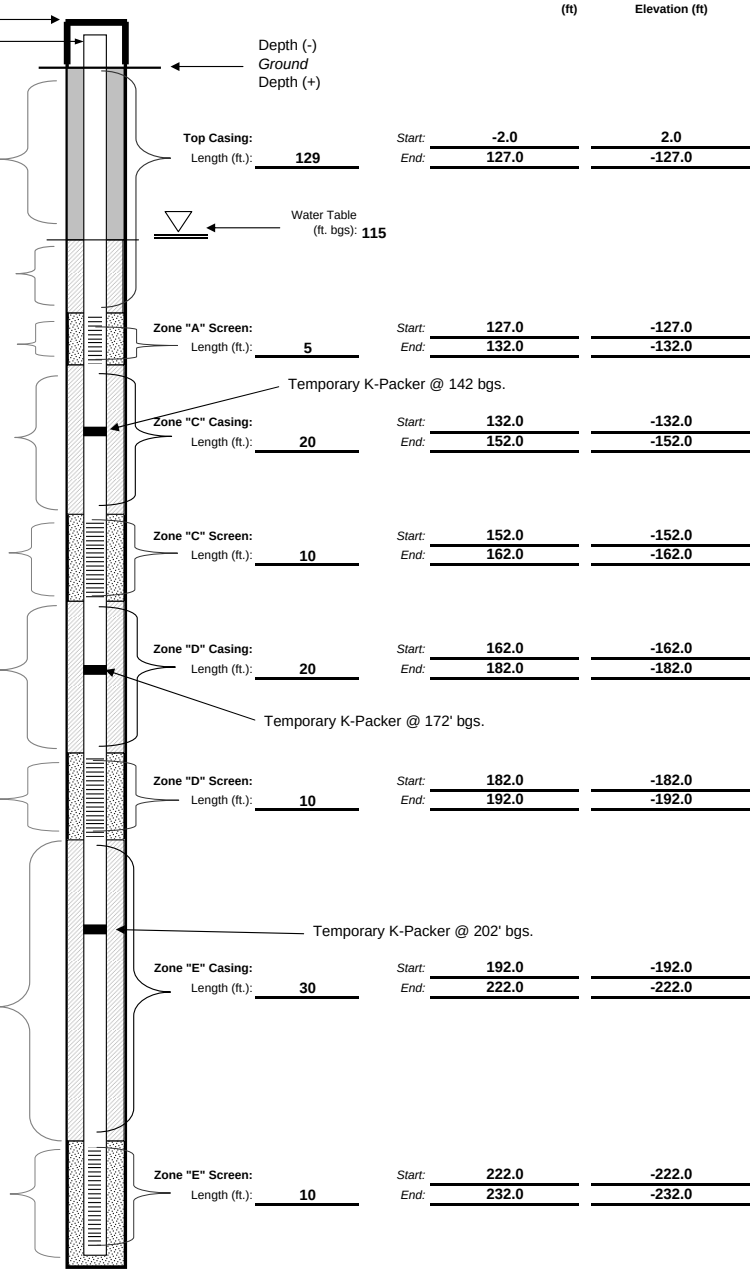
WELL INSTALLATION RECORD

WELL ID:	MW - 30	**Date:**	15-Apr-07	**Client:**	Garvey Elevator	**Ground Elevation (ft.)**	
Total Depth:	232.5 '	**Depth Unit:**	Niobrara Chalk	**Geologist:**	J. Rodriguez		
Contractor:	Boart Longyear	**Project #:**	10264.011.300	**Water Table (ft. bgs):**	115	**TOC Elevation (ft.)**	N/A

ENSR | AECOM

Segment Type	Material	Depth (ft) Start	Depth (ft) End	Diameter (in.) Inner	Diameter (in.) Outer	Thickness (ft.)	Slot Type	Slot Size	Fill Material Quantity	Fill Material Density	Comment
Surface Plug											
Protective casing						0					
Annular Backfill	HydratedCement Bentonite	20.0	115.0	4.50	8.25	95					
Top Casing	PVC Sch 80	-2.0	127.0	3.83	4.50	129					
Zone "A" Seal	Bentonite Chips	115.0	126.0	4.50	8.25	11					
Zone "A" Screen	PVC 80	127.0	132.0	3.83	4.50	5	PVC Slotted	0.10			
Zone "A" Filter Pack	Sand	126.0	133.0	4.50	8.25	7					
Zone "C" Casing	PVC Sch 80	132.0	152.0	3.83	4.50	20					
Zone "C" Seal	Bentonite Chips	133.0	150.0	4.50	8.25	17					
Zone "C" Screen	PVC Sch 80	152.0	162.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "C" Filter Pack	Sand	150.0	164.0	4.50	8.25	14					
Zone "D" Casing	PVC Sch 80	162.0	182.0	3.83	4.50	20					
Zone "D" Seal	Bentonite Chips	164.0	180.0	4.50	8.25	16					
Zone "D" Screen	PVC Sch 80	182.0	192.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "D" Filter Pack	Sand	180.0	194.0	4.50	8.25	14					
Zone "E" Casing	PVC Sch 80	192.0	222.0	3.83	4.50	30					
Zone "E" Seal	Bentonite Chips	194.0	220.0	4.50	8.25	26					
Zone "E" Screen	PVC Sch 80	222.0	232.0	3.83	4.50	10	PVC Slotted	0.10			
Zone "E" Filter Pack	Sand	220.0	232.5	4.50	8.25	13					
Sump	PVC Sch 80	232.0	232.5	3.83	4.50	0.5					

	Below Ground Surface (ft)	Elevation (ft)			Below Ground Surface (ft)	Elevation (ft)
Annular Backfill: Start:	20.0	-20.0	Top Casing: Start:		-2.0	2.0
End:	115.0	-115.0	Length (ft.): 95		127.0	-127.0
Zone "A" Seal: Start:	115.0	-115.0	Length (ft.): 129			
End:	126.0	-126.0	Length (ft.): 11			
Zone "A" Filter: Start:	126.0	-126.0	Zone "A" Screen: Length (ft.): 5	Start:	127.0	-127.0
End:	133.0	-133.0	Length (ft.): 7	End:	132.0	-132.0
Zone "C" Seal: Start:	133.0	-133.0	Zone "C" Casing: Length (ft.): 20	Start:	132.0	-132.0
End:	150.0	-150.0	Length (ft.): 17	End:	152.0	-152.0
Zone "C" Filter: Start:	150.0	-150.0	Zone "C" Screen: Length (ft.): 10	Start:	152.0	-152.0
End:	164.0	-164.0	Length (ft.): 14	End:	162.0	-162.0
Zone "D" Seal: Start:	164.0	-164.0	Zone "D" Casing: Length (ft.): 20	Start:	162.0	-162.0
End:	180.0	-180.0	Length (ft.): 16	End:	182.0	-182.0
Zone "D" Filter: Start:	180.0	-180.0	Zone "D" Screen: Length (ft.): 10	Start:	182.0	-182.0
End:	194.0	-194.0	Length (ft.): 14	End:	192.0	-192.0
Zone "E" Seal: Start:	194.0	-194.0	Zone "E" Casing: Length (ft.): 30	Start:	192.0	-192.0
End:	220.0	-220.0	Length (ft.): 26	End:	222.0	-222.0
Zone "E" Filter: Start:	220.0	-220.0	Zone "E" Screen: Length (ft.): 10	Start:	222.0	-222.0
End:	232.5	-232.5	Length (ft.): 13	End:	232.0	-232.0



US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

ATTACHMENT 6

CONCEPTUAL SITE MODEL CALCULATIONS

Attachment 6-1
Bulk Soil Rule for Potential Leaching Impacts to Groundwater

1. This section summarizes the rationale for leaching to groundwater. It may be used as the basis for future calculations of observed concentrations.

2. The State of Nebraska VCP Remediation Goal tables include soil concentrations that preclude migration of soil contamination to underlying groundwater. This approach assumes that contaminants are leached from the soil, migrate to the groundwater, and eventually enter a receptor well. The calculations follow the recommendations outlined in EPA's Soil Screening Guidance (EPA 1996a,b; 2002). The value derived for PCE is 58 μg/kg. The default VCP Remediation Goal value will be used initially, while data gaps are filled. Thereafter, in the FS, a site-specific value will be used.

3. EPA Soil Screening Guidance. In the Soil Screening Guidance (EPA, 1996a), EPA developed an approach for surface soils to minimize the chance of incorrectly deciding to:

- Screen out areas when the correct decision would be to investigate further (Type I error); or
- Decide to investigate further when the correct decision would be to screen out the area (Type II error).

3.1 EPA Soil Screening Guidance: Simplifying Assumptions for the Migration to Ground Water Pathway

- Infinite source (i.e., steady-state concentrations are maintained over the exposure period)
- Uniformly distributed contamination from the surface to the top of the aquifer
- No contaminant attenuation (i.e., adsorption, biodegradation, chemical degradation) in soil
- Instantaneous and linear equilibrium soil/water partitioning
- Unconfined, unconsolidated aquifer with homogeneous and isotropic hydrologic properties
- Receptor well at the downgradient edge of the source and screened within the plume
- No contaminant attenuation in the aquifer
- No NAPLs present (if NAPLs are present, the SSLs do not apply).

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3.2 EPA Soil Screening Guidance: Soil Screening Level Partitioning Equation for Migration to Ground Water

$$C_s = C_w * [K_d + (\theta_w + \theta_a H')]/\rho_b$$

TABLE F-1.
SOIL SCREENING LEVEL PARTITIONING EQUATION
FOR MIGRATION TO GROUNDWATER

Parameter/Definition (units)	Default	Comment
C_s -- Screening Level in Soil (mg/kg)		
C_w--target soil leachate concentration (mg/L)	Nonzero MCLG, MCL, or HBL x dilution factor	As in Soil Screening Guidance
H'--dimensionless Henry's law constant	chemical-specific	As in Soil Screening Guidance (assume to be zero for inorganic contaminants except mercury)
K_d--soil-water partition coefficient (L/kg)	chemical-specific	As in Soil Screening Guidance For organics: $K_d = K_{oc} * f_{oc}$; For inorganics: see Appendix C (EPA, 2002)
K_{oc}--soil organic carbon/water partition coefficient (L/kg)	Chemical-specific	
f_{oc} fraction organic carbon in soil (g/g)	0.002 (0.2%)	As in Soil Screening Guidance
θ_w--water-filled soil porosity (L_{water}/L_{soil})	0.3	As in Soil Screening Guidance
θ_a--air- filled soil porosity (L_{air}/L_{soil})	$n - \theta_w = 0.13$	As in Soil Screening Guidance
ρ_b--dry soil bulk density (kg/L)	1.5	As in Soil Screening Guidance
n --soil porosity (L_{pore}/L_{soil})	$1-(\rho_b / \rho_s) = 0.43$	As in Soil Screening Guidance
ρ_s/soil particle density (kg/L)	2.65	As in Soil Screening Guidance

3.3 EPA Soil Screening Guidance: Derivation of Dilution Factor

$$d = 1 + (K*I*d)/(I*L)$$

TABLE F-2.
DILUTION FACTOR

Parameter/Definition	Default	Comment
d -- dilution factor (unitless)	20 (0.5-acre source)	As in Soil Screening Guidance
L--source length parallel to ground water flow (m)	Site-specific	
I--infiltration rate (m/yr)	Site-specific	
i--hydraulic gradient (m/m)	Site-specific	
K--aquifer hydraulic conductivity (m/yr)	Site-specific	
da--aquifer thickness (m)	Site-specific	
d--mixing zone depth (m)	Site-specific	

3.4 EPA Soil Screening Guidance, Equation 12: Estimation of Mixing Zone Depth

$$d = (0.0112L^2)^{0.5} + da*\{1 - \exp[(-L*I)/(K*i*da)]\}$$

TABLE A-3
MIXING ZONE DEPTH

Parameter/Definition	Default	Comment
d--mixing zone depth (m)	Site-specific	
L--source length parallel to ground water flow (m)	Site-specific	
I--infiltration rate (m/yr)	Site-specific	
i--hydraulic gradient (m/m)	Site-specific	
K--aquifer hydraulic Conductivity (m/yr)	Site-specific	
da--aquifer thickness (m)	Site-specific	

REFERENCES

EPA. 1996a. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/R-95/128

EPA. 1996b. Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/R-96/018.

EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Interim Guidance.

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Attachment 6-2 DNAPL Groundwater Rule
Saturated Zone Water Concentration Indicating Imminent Presence of DNAPL.

1. Experience suggests that DNAPL may be present upgradient of a monitoring well displaying groundwater concentrations in excess of 1% of the effective solubility of the component of interest, in this case PCE [Environment Agency (2003), USEPA (1992)].

   A concentration of 150 mg/L is the oft-cited effective solubility of PCE. One percent of this is 1.5 mg/L. This value is predicated on being in the near presence of a source and also well within the plume.

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Attachment 6-3
Soil Gas Rule for Vapor Intrusion

The following calculation assumes steady-state. Johnson et. al. (1990) states that the vapor concentration of a volatile chemical at the source of soil contamination may be calculated as follows:

Equation A-3. Vapor Concentration of a Volatile Chemical at the Source of Soil Contamination

$$C_{gas_source}\ (\mu g/m3) = \frac{(H'_{ts} * C_{soil} * \rho_b * UC_{mass} * UC_{volume}}{\theta_w + (K_d \times \rho_b) + (H'_{ts} \times \theta_a)}$$

where:

C_{gas_source} = Vapor concentration at source of contamination (g/cc, converted to µg/m^3 using UC_{mass} and UC_{volume})
H'_{ts} = Henry's law constant (unitless)
C_{soil} = Initial concentration in soil (µg/kg)
ρ_b = Soil dry bulk density (g/cc)
θ_w = Soil water-filled porosity (cc/cc)
Kd = Soil-water partition coefficient (cc/g)
θ_a = Soil air-filled porosity (cc/cc)
UC_{mass} = Unit conversation to convert soil concentration in µg/kg to g/g (1E-09 g/g per µg/kg)
UC_{volume} = Unit conversion to convert vapor concentration in g/cc to µg/m3 (1E+12 µg/m^3 per g/cc)

The above equation is used in INTERCALCS Cell B31 of the Johnson-Ettinger model (SL-ADV.xls) to derive the "Source vapor concentration", C_{gas_source}, term in units of µg/m^3 from an inputted soil concentration in units of µg/kg.

Then, using the Ideal gas law, we can convert the C_{gas_source} calculated as µg/m^3 to ppb(v) using the following equation:

$$C_{gas}\ (ppb[v]) = \frac{C_{gas}\ (\mu g/m^3) \times 24.45}{\text{Molecular Wt.}}$$

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ATTACHMENT 7

HWS SITE CHARACTERIZATION REPORT FIGURE 11

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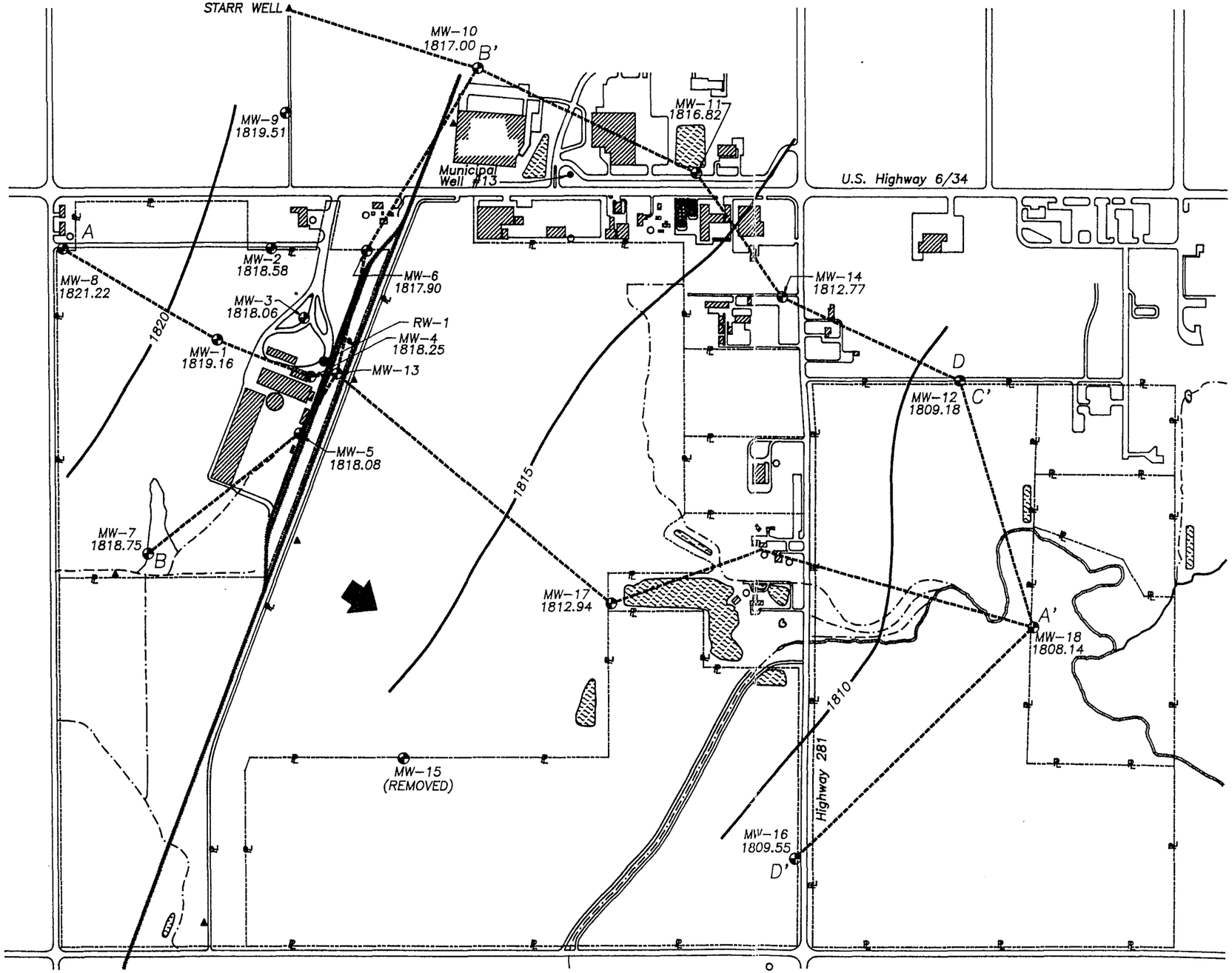

Groundwater Monitoring Well Locations & Water Table Configuration

3-21-95

LEGEND

MW-1 1819.16	Monitoring Well Showing Water Elevation In "A" Wells
RW-1	Recovery Well
1815	Water Table Contour
	Direction Of Groundwater Flow
A-A'	Line of Section Shown in Figure 9 a
B-B'	Line of Section Shown in Figure 9 b
C-C'	Line of Section Shown in Figure 9 c
D-D'	Line of Section Shown in Figure 9 d

N

800 0 400 800

400 200 600

Scale In Feet

Figure 11

GARVEY ELEVATOR
HASTINGS, NEBRASKA

LINCOLN OFFICE
825J St., Box 80358
Lincoln NE, 68501
Phone:(402) 479-2200

HWS Consulting Group, Inc.

SCALE AS SHOWN

DATE 9-14-95

JOB NO. 72-44-0025

FIELD BOOK

FILE NO.

SHEET NO. of

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ATTACHMENT 8

PROPOSED FIELD ACTIVITIES MEMOMORANDUM

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REVISED PROPOSED FIELD ACTIVITIES MEMORANDUM
GARVEY ELEVATOR SITE – HASTINGS, NE

TO: Jim Seiler, EPA PO
FROM: W. Alan Rittgers, P.G., HGL Task Order Manager
THROUGH: Robert C. Overfelt, P.G., CHMM, HGL Program Manager
CC: Brian Zurbuchen, Ph.D., EPA Task Order Project Officer
DATE: April 22, 2009
SUBJECT: Garvey Elevator
CONTRACT NO: EP-S7-05-05
TASK ORDER NOs: 0033/0034

INTRODUCTION

This revised memorandum details initial data collection activities planned for Operable Unit 1 (OU1) of the Garvey Elevator (Garvey) Site located in Hastings, Nebraska (Figure 1.1) that will support an interim Record of Decision (ROD). OU1 consists of contaminated soils and groundwater on the site property. The overall objective of this initial data collection effort is to support the Remedial Investigation/Feasibility Study (RI/FS) activities that are being conducted by HydroGeoLogic, Inc. (HGL) under Region 7 U.S. Environmental Protection Agency (EPA) Architect and Engineering Services (AES) contract EP-S7-05-05, Task Order 0033 and Task Order 0034.

HGL will survey the coordinates and elevations of on-site and near-site wells, and collect water levels from select wells while the groundwater extraction system is operating, and while it is turned off. These data will be compiled with select existing site data into an Interim Data Summary report. Also, knowledge of the influence of the groundwater extraction system will support the rationale for additional on-site monitoring wells proposed to be installed during the primary OU1 RI field activities.

The Draft Work Plan for the primary RI/FS field activities was submitted to EPA Region 7 on December 30, 2008. The Draft Quality Assurance Project Plan (QAPP) submitted in the Work Plan was conditionally approved for the scope of work detailed in this field activities memorandum. The Draft Work Plan and QAPP will be revised further to reflect changes to the primary RI/FS activities. Attachment 1 includes the HGL-signed signature page for the Draft QAPP.

The Garvey Elevator Site has been in operation since 1959. Groundwater beneath the site is contaminated with carbon tetrachloride, which was used with other substances as a grain fumigant. In 1995, Garvey Elevator's contractor (HWS) installed a network of 36 monitoring wells during the course of their investigations at the site. In 1998, HWS and a partner contractor firm installed a groundwater extraction and treatment (GET) system to treat contaminated groundwater, and soil vapor extraction (SVE) system to remediate contaminated

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soils. In 2007, ENSR (a subsequent Garvey contractor) began field work to evaluate the effectiveness of the treatment systems and conduct further investigations at the site in an effort to define source areas for the carbon tetrachloride. This work was conducted under an EPA Administrative Order on Consent (AOC). ENSR installed a line of multilevel wells adjacent to the site property on the east. Garvey Elevators, Inc. declared bankruptcy in March 2008, and on April 10, 2008, EPA ordered ENSR to cease work at the site. EPA Region 7 took over the removal and remedial activities at the Garvey Elevator Site. The Draft RI/FS Work Plan prepared by HGL in December 2008 provides a detailed discussion of background information on the Garvey Site.

PROPOSED FIELD ACTIVITIES

Surveying

Based on information supplied by ENSR to EPA, Garvey's contractor did not survey the wells installed in 2007. Further, well survey information from the earlier HWS has data gaps, or is inconsistent with data ENSR had compiled for these existing wells. Therefore, a complete survey of all wells at the site is necessary to fully evaluate water level measurement data and the groundwater flow system beneath the site.

The field activities will include land surveying (including elevation) of the following on site features: 23 monitoring wells; 1 hydraulic test well; 11 SVE wells; 8 groundwater extraction wells; 2 injection wells; and the former Garvey water supply well. Also, three irrigation wells in the agricultural field immediately to the east of the site property will be surveyed. Survey data will be used to construct accurate site maps, and with elevation data, allow for more complete potentiometric maps for evaluating groundwater flow.

Table 1 in Attachment 2 provides a tabulation of the wells to be surveyed. Figure 1 in Attachment 3 illustrates the well locations based on the current survey information, except for the irrigation wells. The locations of the irrigation wells are not known, but one is located in the crop field shown to the east of the site property on Figure 1, and the other two are reported to be in the same field.

All survey work performed for this initial data collection effort will comply with State and Local regulations, and will be conducted in accordance with Section 3.7 of the Field Sampling Plan (FSP) submitted to EPA in the December 2008 Work Plan. A registered professional land surveyor licensed in the State of Nebraska will be subcontracted to determine by survey the elevations and/or horizontal locations of sample locations in support of the RI/FS. Surveys will incorporate basic controls including existing and new markers and benchmarks. If a benchmark has not been established on the site property, one will be installed at the site using an existing benchmark to tie in the vertical elevation and horizontal coordinates. This new benchmark will be used for all future elevation surveys at the site. Also, another fixed existing site feature will be tied in vertically and horizontally from the existing benchmark. The newly surveyed site feature and the new benchmark will be used for all future horizontal surveys at

the site. The locations for the fixed feature and the new benchmark will be determined in the field based on a site reconnaissance with the licensed surveyor before commencing the survey work.

These controls will be fully documented on the survey and in the field logbooks. All work will be conducted using equipment, personnel, and procedures that will insure compliance with the described accuracy standards. All wells will be surveyed so that all horizontal data will be reported in Universal Transverse Mercator (UTM) North American Datum (NAD) 83, Zone 14 coordinates, and all vertical data will be referenced to North American Vertical Datum (NAVD) 88. Horizontal accuracy will be within ± 0.1 foot; vertical accuracy will be within ± 0.01 foot.

Water Level Measurement

Water levels will be recorded in select monitoring wells to document the influence of the GET system on the groundwater flow regime beneath the site. To date, no evaluation of the GET system on groundwater beneath the site has been conducted. These data are necessary to determine whether additional monitoring wells are required at the site, and to assess whether the current GETS is capturing contaminated groundwater migrating east-southeastward from the site.

Water levels will be collected while the GET system is running; during the recovery phase after the system is turned off and water levels are allowed to return to "normal"; and then after the system is started back up. The total depths of the monitoring wells also will be measured to reconcile the inconsistency between the depths noted by HWS during installation and the depths recorded by ENSR. Table 1 in Attachment 2 indicates the wells from which water levels will be collected to evaluate the GET system influence, and shows the well depth data collected to date.

The proposed sequence of events is as follows:

1. With the GET system operational, water level measurements will be collected manually from all on-site monitoring wells, and recorded for the extraction wells (dedicated transducers). Monitoring well total depth measurements also will be collected at this time. Next, datalogging transducers will be inserted in MW-3A, MW-3B, MW-4A, MW-4B, and MW-13C. In addition, a data logger will be connected to the dedicated transducers installed in the four screened zones of multilevel well MW-30A/C/D/E.
2. Operation of the GET system will be continued for two days, and then the system will be turned off. The system will remain off for five days as the aquifers at the site recover back to pre-pumping conditions. During these five days, and the preceding two days of system operation, the temporary and dedicated transducers will collect recovery water level readings approximately once every hour.

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3. After five days with the system off, water levels will be collected manually from those monitoring wells without transducers, and from the system readout for the transducers in the pumping wells. Then, the system will be turned back on.
4. After five days of continuous system operation, water levels will be collected manually from those monitoring wells without transducers, and from the system readout for the transducers in the pumping wells. This marks the end of the study. The temporary transducers and datalogger will be recovered, data downloaded, and then returned to the vendors.

Standard operating procedures referenced in this section that pertain to the field activities above are included in Attachment 1 of the FSP submitted to EPA in the December 2008 RI/FS Work Plan. Field logbook(s) of site activities will be maintained by the field team in accordance with HGL's SOP, *Field Activity Logbook Entries*, and Section 4.3.3 of the approved QAPP. The water level collection form provided in Attachment 2 of the FSP will be used to maintain a record of the manual water level measurements. These forms, and printouts and electronic files from the temporary transducers, will be maintained in the project file. Field forms and data will be referenced in the field logbooks, as necessary. Water level measurements will be obtained in accordance with EPA Region 7 SOP 2043 *Manual Water Level Measurements* included in Attachment 4 of this document, and collected per Section 3.5.6.1 of the FSP submitted to EPA in the December 2008 RI/FS Work Plan. Field activities will be documented using a digital camera in accordance with CDM SOP 4-2, *Photographic Documentation of Field Activities* (Attachment 1 of the FSP).

Equipment handling and calibration procedures will be conducted in accordance with Section 4.7 of the approved QAPP, and will follow the manufacturer's instructions and CDM SOP 5-1, *Control of Measurement and Test Equipment* included in Attachment 1 of the FSP. Decontamination of water level indicators and transducers will be conducted in accordance with Section 7.2 of EPA Region 7 SOP 2043 *Manual Water Level Measurements* included in Attachment 4. The only exception to the procedure outlined in the SOP is that a solvent will not be used for a final rinse.

REPORTING

The water level measurements, well depths, and survey data will be uploaded into the project EQuIS database. These data also will be included in the Interim Data Summary Report, along with any conclusions from an evaluation of the influence of the GET system on the groundwater system beneath the site.

ATTACHMENTS:

Attachment 1: Approved QAPP Signature Page
Attachment 2: Table 1 Existing Well Summary and Proposed Field Activities
Attachment 3: Figure 1 Well Locations
Attachment 4: EPA Region 7 SOP 2043 *Manual Water Level Measurements*

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ATTACHMENTS

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DRAFT
QUALITY ASSURANCE PROJECT PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA
TASK ORDER NOS.: 0033 AND 0034

PROJECT: Remedial Investigation/Feasibility Study
Garvey Elevator—OU1 and OU2 Sites, Hastings, Nebraska

TASK ORDER NUMBERS: 0033 and 0034

HYDROGEOLOGIC, INC.
PROGRAM MANAGER: Robert Overfelt, P.G., CHMM
TASK ORDER MANAGER: W. Alan Rittgers, P.G.
REGIONAL QC COORDINATOR: Mary Knowles

U.S. ENVIRONMENTAL PROTECTION AGENCY – REGION 7
TASK ORDER PROJECT OFFICER (TOPO): Brian Zurbuchen, Ph.D.

PREPARATION DATE: April 3, 2009
PLAN PREPARER: HGL/CDM
REVISION: 0

APPROVED BY:

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J. Gadt – HGL
L. Splichal – CDM

Table 1
Existing Well Summary and Proposed Field Activities
Garvey Elevator Site - Hastings, NE

Well Location	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Constructed Total Depth[1] (feet bgs)	Measured Total Depth[2] (feet bgs)	Field Activities	Water Level Measurement Type[3]
MW-1A	102	117	118	125	Water levels, TD, Surveying	Water Level Indicator
MW-2A	103	118	118	123.5	Water levels, TD, Surveying	Water Level Indicator
MW-3A	108	123	123	123	Water levels, TD, Surveying	In-Situ Transducer
MW-3B	130.6	133.5	133.5	136	Water levels, TD, Surveying	In-Situ Transducer
MW-3D	171	176	178.5	179.6	Water levels, TD, Surveying	Water Level Indicator
MW-3E	230	235	238.4	243.7	Water levels, TD, Surveying	Water Level Indicator
MW-4A	108.5	123.5	123.5	123.5	Water levels, TD, Surveying	In-Situ Transducer
MW-4B	127	132	134	134	Water levels, TD, Surveying	In-Situ Transducer
MW-5A	107.5	122.5	122.5	122.5	Water levels, TD, Surveying	Water Level Indicator
MW-5B	129	132	132	133	Water levels, TD, Surveying	Water Level Indicator
MW-5D	162	167	169.5	188	Water levels, TD, Surveying	Water Level Indicator
MW-6A	107.5	122.5	122.5	123.5	Water levels, TD, Surveying	Water Level Indicator
MW-6D	163.5	173.5	168	168	Water levels, TD, Surveying	Water Level Indicator
MW-6E	217.6	227.6	237	241	Water levels, TD, Surveying	Water Level Indicator
MW-7A	98	113	113	115	Water levels, TD, Surveying	Water Level Indicator
MW-7B	130	135	140	140	Water levels, TD, Surveying	Water Level Indicator
MW-8A	114.5	129.5	131.5	132	Water levels, TD, Surveying	Water Level Indicator
MW-9A	101.3	116.3	118.3	120	Water levels, TD, Surveying	Water Level Indicator
MW-10A	101.8	116.8	118.8	120	Water levels, TD, Surveying	Water Level Indicator
MW-10B	120	130	125	130	Water levels, TD, Surveying	Water Level Indicator
MW-11A	91	106	108	110	Water levels, TD, Surveying	Water Level Indicator
MW-12A	102.4	117.4	119.4	120	Water levels, TD, Surveying	Water Level Indicator
MW-12C	150	160	165.4	170	Water levels, TD, Surveying	Water Level Indicator
MW-13C	133	135.5	137.5	140	Water levels, Surveying	In-Situ Transducer
MW-13E	230.8	235.8	238.8	238.8	Water levels, Surveying	Water Level Indicator
MW-19A	127	132	162.5	162.5	Water levels, Surveying	Geokon 404 Unit
MW-19C	152	162			Water levels, Surveying	Geokon 404 Unit
MW-20A	127	132	232.5	232.5	Water levels, Surveying	Geokon 404 Unit
MW-20C	152	162			Water levels, Surveying	Geokon 404 Unit
MW-20D	182	192			Water levels, Surveying	Geokon 404 Unit
MW-20E	222	232			Water levels, Surveying	Geokon 404 Unit
MW-30A	127	132	232.5	232.5	Water levels, Surveying	Geokon Datalogger
MW-30C	152	162			Water levels, Surveying	Geokon Datalogger
MW-30D	182	192			Water levels, Surveying	Geokon Datalogger
MW-30E	222	232			Water levels, Surveying	Geokon Datalogger
MW-31A	127	132	162.5	162.5	Water levels, Surveying	Geokon 404 Unit
MW-31C	152	162			Water levels, Surveying	Geokon 404 Unit
RW-1	115	125	Unknown	Unknown	Surveying	N/A
RW-2	116	126	Unknown	Unknown	Surveying	N/A
RW-3	114	124	Unknown	Unknown	Surveying	N/A
RW-4	116	126	Unknown	Unknown	Surveying	N/A
RW-5	117	127	Unknown	Unknown	Surveying	N/A
RW-6	132	147	Unknown	Unknown	Surveying	N/A
RW-7	135	150 (155*)	Unknown	Unknown	Surveying	N/A
RW-8	137	152	Unknown	Unknown	Surveying	N/A
SVE-1	20	50	Unknown	Unknown	Surveying	N/A
SVE-2	20	50	Unknown	Unknown	Surveying	N/A
SVE-3	20	50	Unknown	Unknown	Surveying	N/A
SVE-4	20	50	Unknown	Unknown	Surveying	N/A
SVE-5	20	50	Unknown	Unknown	Surveying	N/A
SVE-6	20	50	Unknown	Unknown	Surveying	N/A
SVE-7	20	50	Unknown	Unknown	Surveying	N/A
SVE-8	20	50	Unknown	Unknown	Surveying	N/A
SVE-9	60	110	Unknown	Unknown	Surveying	N/A
SVE-10	60	110	Unknown	Unknown	Surveying	N/A
SVE-11	60	110	Unknown	Unknown	Surveying	N/A

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Table 1
Existing Well Summary and Proposed Field Activities
Garvey Elevator Site - Hastings, NE

Well Location	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Constructed Total Depth[1] (feet bgs)	Measured Total Depth[2] (feet bgs)	Field Activities	Water Level Measurement Type[3]
IW-1	175	230	Unknown	Unknown	Surveying	N/A
IW-2	175	230	Unknown	Unknown	Surveying	N/A
Irrigation Well #1	Unknown	Unknown	Unknown	Unknown	Surveying	N/A
Irrigation Well #2	Unknown	Unknown	Unknown	Unknown	Surveying	N/A
Irrigation Well #3	Unknown	Unknown	Unknown	Unknown	Surveying	N/A

NOTES:

[1] = Total depth as measured during installation; compiled from project background documents.

[2] = Total depth as measured by ENSR .

[3] = Water level indicator indicates manual data collection using standard electronic water level indicator; In-situ Transducer indicates automatic data collection using programmed In-Situ transducer; Geokon 404 indicates manual data collection using the GK-404 unit and dedicated transducer; Geokon Datalogger indicates automatic data collection using programmed Geokon Datalogger.

* HWS, 1995 Site Characterization Report

bgs = below ground surface

TD = total depth

N/A = Not applicable

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Figure 1
Well Locations

Legend

- Site Boundary
- Pack Tower Stripper
- Recovery Wells
- Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Assumed Location of Multi-Level Well Installed by ENSR
- Injection Well
- Soil Vapor Extraction Well
- Monitoring Well
- Former Garvey Water Well

Note:
Well locations based on survey data from the site background files.

N

0 180 360 720
Feet

Filename: X:/EPA009/Garvey/RI_FS/Well_Locations.mxd
Project: EP9033.01.46.11
Revised: 03/25/09 CV
Source: ENSR GDB 2008, DNR

United States Environmental Protection Agency

HGL HydroGeoLogic, Inc

CDM

U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

MANUAL WATER LEVEL MEASUREMENTS

CONTENTS

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- 7.1 Preparation
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12.0 REFERENCES

13.0 APPENDIX

- A - Groundwater Level Data Form

SUPERCEDES: SOP #2043; Revision 0.0; 10/03/94; U.S. EPA Contract 68-C4-0022.

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MANUAL WATER LEVEL MEASUREMENTS

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1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water and separate phase chemical product (i.e., gasoline, oil, PCE, TCE) in an open borehole, cased borehole, monitor well, or piezometer. These standard operating procedures may be varied or changed as required, dependent on site conditions , and equipment limitations. In all instances, the actual procedures employed will be documented and described in an appropriate site report. Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

Generally, water-level measurements taken in boreholes, piezometers, or monitor wells are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics. Therefore, all water level measurements at a given site should preferably be collected within a 24 hour period. However, certain situations may produce rapidly changing groundwater levels that necessitate taking measurements as close in time as possible. Large changes in water levels among wells may be indicative of such a condition . Rapid groundwater level changes may occur due to:

- Atmospheric pressure changes
- Tidal influences
- Changes in river stage, impoundments levels, or flow in unlined ditches
- Pumping of nearby wells
- Precipitation

2.0 METHOD SUMMARY

A survey mark should be placed on the top of the riser pipe or casing as a reference point for groundwater level measurements. If the lip of the riser pipe is not flat, the reference point may be located on the grout apron or the top of the outer protective casing (if present). The measurement reference point should be documented in the site logbook and on the groundwater level data form (Appendix A), if used. All field personnel must be made aware of the measurement reference point being used in order to ensure the collection of comparable data.

Before measurements are made, water levels in piezometers and monitor wells should be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to equilibrium may take longer. All measurements should be made to an accuracy of 0.01 feet. Water level measuring equipment must be decontaminated and, in general, measurements should proceed from the least to the most contaminated wells.

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Open the well and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds. For electrical sounders lower the device into the well until the water surface is reached as indicated by a tone or meter deflection. Record the distance from the water surface to the reference point. Measurement with a chalked tape will necessitate lowering the tape below the water level and holding a convenient foot marker at the reference point. Record both the water level as indicated on the chalked tape section and the depth mark held at the reference point The depth to water is the difference between the two readings. Remove measuring device, replace riser pipe cap, and decontaminate equipment as necessary. Note that if a separate phase is present, an oil/water indicator probe is required for measurement of product thickness and water level.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this standard operating procedure (SOP).

4.0 POTENTIAL PROBLEMS

1. Cascading water, particularly in open-hole or rock wells, may interfere with the measurement.

2. Some older types of electric sounders are only marked at five-foot intervals. A surveyor's tape is necessary to extrapolate between the 5-foot marks.

3. Oil or other product floating on the water column can insulate the contacts of the probe on an electric sounder and give false readings. For accurate level measurements in wells containing floating product, a special oil/water level indicator is required.

4. Tapes (electrical or surveyor's) may have damaged or missing sections, or may be spliced inaccurately.

5. An airline may be the only available means to make measurements in sealed production wells but the method is generally accurate only to approximately 0.2 foot.

6. When using a steel tape, it is necessary to lower the tape below the water level in order to make a measurement. This assumes knowledge of the approximate groundwater level.

5.0 EQUIPMENT

The electric water level indicator and the chalked steel tape are the devices commonly used to measure water levels. Both have an accuracy of 0.01 feet. Other field equipment may include:

- Air monitoring instrumentation

- Well depth measurement device
- Chalk
- Ruler
- Site logbook
- Paper towels and trash bags
- Decontamination supplies as outlined in Section 7.2 or the current approved site specific work plan
- Groundwater level data forms

6.0 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required, refer to ERT/REAC SOP #2006 Rev 0.0 08/11/94, *Sampling Equipment Decontamination*, and the current approved site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Determine the number of measurements needed, the methods to be employed, and the equipment and supplies needed.
2. Decontaminate or pre-clean equipment, and ensure that it is in working order.
3. Coordinate schedule with staff, clients, and regulatory agency, if appropriate.
4. If this is an initial visit, perform a general site survey prior to site entry in accordance with the current approved site specific Health and Safety Plan.
5. Identify sampling locations.

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7.2 Procedures

Procedures for determining water levels are as follows:

1. If possible, and when applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated.

2. Clean all the equipment entering the well(s) by the following decontamination procedure:

   - Triple rinse equipment with deionized water.
   - Wash equipment with an Alconox solution which is followed by a deionized water rinse.
   - Rinse with an approved solvent (e.g., methanol, isopropyl alcohol, acetone) as per the work plan, if organic contamination is suspected.
   - Place equipment on clean surface such as a teflon or polyethylene sheet to air dry.

3. Remove locking well cap, note well ID, time of day, and date in site logbook or an appropriate groundwater level data form.

4. Remove well cap.

5. If required by site-specific condition, monitor headspace of well with a photoionization detector (PID) or flame ionization detector (FID) to determine presence of volatile organic compounds, and record results in site logbook.

7. Lower water-level measuring device into the well. Electrical tapes are lowered to the water surface whereas chalked steel tapes are lowered generally a foot or more below the water surface. Steel tapes are generally chalked so that a 1-to 5-foot long section will fall below the expected water level.

8. For electrical tapes record the distance from the water surface, as determined by the audio signal or meter, to the reference measuring point and record in the site logbook. For chalked tapes, an even foot mark is held at the reference point, once the chalked section of the tape is below the water level. Both the water level on the tape and the foot mark held at the reference point is recorded. The depth to the water is then the difference between the two readings. In addition, note the reference point used (top of the outer casing, top of the riser pipe, ground surface, or some other reproducible position

on the well head). Repeat the measurement.

9. Remove all downhole equipment, replace well cap and locking steel caps.

10. Rinse all downhole equipment and store for transport to the next well. Decontaminate all equipment as outlined in Step 2 above.

11. Note any physical changes, such as erosion or cracks in protective concrete pad or variation in total depth of well, in field logbook or on groundwater level data form.

8.0 CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation:

$$E_W = E - D$$

where:

E_W	=	Elevation of water above mean sea level (feet) or local datum
E	=	Elevation above sea level or local datum at point of measurement (feet)
D	=	Depth to water (feet)

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented on field data sheets, groundwater level data forms, or within personal or site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan.

3. Each well should be tested at least twice in order to compare results. If results do not agree to within 0.02 feet, a third measurement should be taken and the readings averaged. Consistent failure of consecutive readings to agree suggests that levels are changing because of one or more conditions as indicated in Section 1.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

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11.0 HEALTH AND SAFETY

The results of monitoring the well head and breathing zone with a FID or PID, as per section 7.2, may indicate the need to upgrade the personal protection level according to the current approved site Health and Safety Plan.

12.0 REFERENCES

Driscoll, F.G. 1986. Groundwater and Wells. Second Edition. Chapter 16. *Collection and Analysis of Pumping Test Data*. pp 534-579. Johnson Filtration Systems Inc. St. Paul, Minnesota.

U.S. Environmental Protection Agency, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document, pp. 207.

U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods. EPA/540/p-87/001 Office of Emergency and Remedial Response Washington, D.C. 20460.

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APPENDIX A
Groundwater Level Data Form
SOP #2043
February 2000

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MANUAL WATER LEVEL MEASUREMENTS

FORM 1. Groundwater Level Data Form

PAGE __ OF __

SITE NAME:_____ LOGGER NAME: _____

LOG DATE: _____ WBS #: RIA _____

Well I.D.	Time	Elevation of well[1] (T.O.C.)	Depth to bottom of well (ft)	Depth to water (ft)	Depth to product (ft)	COMMENTS (pH, temperature, specific conductance)

TOC: top of casing (1) feet above mean sea level

MEASUREMENT REFERENCE POINT FROM __ GROUND SURFACE OR __ TOP OF CASING

Weather Conditions: Temperature(°C):_____ Rain: Heavy Medium Light (Circle one)

Other significant observations:

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APPENDIX A

FIELD SAMPLING PLAN

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FINAL
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA

Prepared for:

U.S. Environmental Protection Agency Region 7
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LIST OF ACRONYMS AND ABBREVIATIONS

2,4-D	2,4-dichlorophyenoxy acetic acid
AES	Architect and Engineering Services
AGP	AGP Grain Marketing LLC
amsl	above mean sea level
ASTM	American Society for Testing and Materials
BART	biological activity reaction test
bgs	below ground surface
BNSF	Burlington Northern and Santa Fe
CDM	CDM Federal Programs
CO_2	carbon dioxide
CSM	Conceptual Site Model
DFT	dipole flow testing
DO	dissolved oxygen
DPT	direct-push technology
DQO	data quality objective
EC	electrical conductivity
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
FSP	Field Sampling Plan
HCl	hydrochloric acid
HGL	HydroGeoLogic, Inc.
HSP	Health and Safety Plan
HTRW	hazardous, toxic and radiological waste
ID	inside diameter
IDW	investigation-derived waste
L/min	liters per minute
mL/min	milliliters per minute
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt

NAD	North American Datum
NAVD	North American Vertical Datum
NDEQ	Nebraska Department of Environmental Quality
NOD	natural oxidant demand
NTU	nephelometric turbidity unit
ORP	Oxidation reduction potential
OU	operable unit
PCB	polychlorinated biphenyl
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RI	Remedial Investigation
ROD	Record of Decision
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon
TOPO	Task Order Project Officer
TSS	total suspended solids
USCS	Unified Soil Classification system
UTM	universal transverse mercator
VOA	volatile organic analysis
VOC	volatile organic compound

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FINAL
FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA

1.0 INTRODUCTION

This Field Sampling Plan (FSP) details the data collection activities planned for the Remedial Investigation/Feasibility Study (RI/FS) at the Garvey Elevator Site (site) located in Hastings, Nebraska (Figure 1.1). RI/FS activities are being conducted by HydroGeoLogic, Inc. (HGL) under Region 7 U.S. Environmental Protection Agency (EPA) Architect and Engineering Services (AES) contract EP-S7-05-05, Task Orders 0033 and 0034. CDM Federal Programs (CDM) is a team subcontractor to HGL on the AES Contract. CDM personnel will have key roles on the Garvey Elevator project. The roles and responsibilities of HGL and CDM project staff are described in Section 3.1 of the Quality Assurance Project Plan (QAPP). The QAPP is included as Appendix B of the RI/FS Work Plan. The site-specific Health and Safety Plan (HSP) is included as Appendix C of the RI/FS Work Plan. These planning documents provide specific details regarding the planned sampling scheme, data quality objectives (DQO) for the field and laboratory data, data management procedures, and health and safety measures to be employed during field activities.

1.1 OBJECTIVES

The purpose of this RI/FS is to collect data necessary to support the selection of an approach for site remediation.

The project objectives are:

- Determine the physical characteristics of the site.
- Determine the nature and extent of contamination in affected media, on site and downgradient of the site, that exceed established Federal or State limits, or in the event such limits have not been promulgated, that pose human health or ecological risks above acceptable limits.
- Update and refine the Conceptual Site Model (CSM) to ensure site characterization is completed in sufficient detail for decision making.
- Assess actual and potential exposure pathways through affected media.
- Prepare a human health risk assessment and a screening level ecological risk assessment that presents an assessment of the risks to human health and the environment.
- Identify, develop and evaluate potential remedial alternatives in a feasibility study report.
- Conduct an ecological investigation to identify potential ecological receptors.

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1.2 SITE LOCATION AND DESCRIPTION

The Garvey Elevator Site is located in the NW1/4 of Section 23, T7N, R10W, approximately 7 miles west of the Adams County/Clay County line in the southwest portion of the City of Hastings, Nebraska (Figure 1.1). The site is bounded on the north by U.S. Highway 6/34, on the east by the Burlington Northern and Santa Fe (BNSF) railroad track, on the west by Marion Road, and on the south by farmland owned by the Walter Family Trust. The site is an area of soil and groundwater contamination that consists of the Garvey Elevator property at 2315 West Highway 6, Hastings, Nebraska. This area has been designated by the EPA as operable unit 1 (OU1).The associated contaminated ground water plume that extends from the site to approximately three (3) miles east of the site has been designated as OU2. The Site layout is shown in Figure 1.2.

Currently, the site is the location of an active 8-million bushel capacity grain storage facility. It was constructed in 1959 and originally owned and operated by Garvey Elevators, Inc., of Fort Worth, Texas. The facility is currently owned and operated by AGP Grain marketing, LLC (AGP).

1.3 SITE HISTORY

The storage facilities at the Garvey Elevator terminal have a total capacity of more than 8 million bushels and consist of a concrete elevator head house and elevator, flat storage building, and steel bins. A liquid grain fumigant was used for pest control from 1959 to 1985. In 1960, Garvey Elevator installed a 3,000 gallon aboveground storage tank for storage of the liquid fumigant. The fumigant, liquid 80-20, was composed of 80 percent carbon tetrachloride 17-18 percent carbon disulfide, and 1 percent ethylene dibromide. The fumigant was transferred through a delivery pipe that connected the storage tank to piping mounted on the side of the elevator and then up the side of the elevator to the distribution gallery. Leaking from the delivery system piping or fittings has contaminated soils in the vadose zone, and groundwater on site and off site. Additional details about site history, regulatory history, and current use is provided in Section 1.2 of the RI/FS Work Plan.

1.4 PHYSICAL CHARACTERISTICS OF THE SITE

The ground surface elevation at the site is approximately 1,925 feet above mean sea level (amsl). The topographic relief is flat with a slight southern to southeastern component. The nearest named surface water feature is Pawnee Creek which is located approximately 1 mile south of the elevator. Pawnee Creek flows northwest to southeast in a meandering channel (Tetra Tech, 2003).

The site is located within the Loess Plains, a portion of the Great Plains physiographic province. The topography of the area is relatively flat, with a slight slope to the east-southeast (USGS 1974, revised 1983). The Platte River valley lies 15 miles north of the site and flows to

the northeast, and the Little Blue River valley lies 10 miles to the south and flows toward the east.

Surface soils in the vicinity of the site consist of silt-loam (USDA, 1974). The Hastings area is underlain by approximately 200 to 240 feet of unconsolidated Pleistocene Age deposits lying unconformably on Upper Cretaceous Age Niobrara Formation, an argillaceous chalk and limestone formation containing interbedded layers of chalky shale (Condra et al., 1947 and Dreeszen et al., 1973). Ground water is generally encountered at depths between 100 and 130 ft below the ground surface. The site-specific geology, hydrogeology, and current understanding of the groundwater contamination are discussed in Section 2 of the RI/FS Work Plan.

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FIGURES

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Filename: X:/EPA009/Garvey/FSP/Site_Loc_Map.mxd
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: ESRI StreetMap USA
Nebraska DNR

Figure 1.1
Site Location Map
Garvey Elevator Site
Hastings, NE

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HGL—Field Sampling Plan,
Garvey Elevator Site—Hastings, NE

Figure 1.2
Current Site Map

Legend

- Site Boundary
- Concrete Paved Area
- Buildings
- Gravel Road
- Railroad

0 200 400 800
Feet

N

Filename: X:/EPA009/Garvey/RI_FS/SiteMap.mxd
Project: EP9033.01.46.13
Revised: 05/13/09 CV
Source: ENSR GDB 2008, DNR

United States Environmental Protection Agency
HGL HydroGeoLogic, Inc
CDM

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2.0 SAMPLING PROGRAM AND ANALYTICAL SUMMARY

The RI investigation activities are listed below and detailed in the following subsections:

- Collect subsurface soil samples from potential source areas using direct-push technology (DPT) for volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and pesticides analysis
- Collect surface soils for VOCs, PCBs, SVOCs, and pesticides analysis
- Collect sediment from drainageways on site, and surface water from the on-site pond, for VOCs, PCBs, SVOCs, and pesticides analysis
- Characterize subsurface soils using electrical conductivity (EC) data and continuous core sampling at select boring locations
- Collect groundwater samples using DPT sampling methods
- Collect subslab soil gas samples and indoor/outdoor air samples to evaluate potential VOCs migration that could be affecting on-site workers.
- Install permanent monitoring wells
- Install one hydraulic testing well.
- Collect groundwater samples from existing monitoring wells, existing multilevel wells, new monitoring wells, and nearby irrigation wells.
- Conduct borehole flow meter testing using the dipole flow testing (DFT) method in the hydraulic test well
- Conduct slug testing in select existing monitoring wells

There are two phases of work encompassing both OUs. The first phase consists primarily of the source area investigation and on-site and off-site DPT groundwater sampling. The second phase of work is primarily is devoted to on-site and off-site well installation and sampling. The following subsections detail the sampling to be conducted for both the OU1 and OU2 investigation. Section 3.0 of this FSP provides the methods and procedures for collection of the samples for both the OU1 and OU2 investigations. Section 6.0 the Work Plan provides a thorough discussion of the rationale for the various sample types, locations, and analyses.

2.1 SOURCE AREA INVESTIGATION (OU1)

Phase I of the source area investigation will include collection of subsurface soil samples, EC logging, and groundwater grab sampling using DPT. Surface soil samples and subslab soil gas and indoor air samples will be collected to complete the risk assessment. Also, sediment and surface water samples will be collected to evaluate surface migration of contaminants from potential source areas, and for the ecological risk assessment.

In Phase II, a hydraulic test well will be installed to determine the aquifer characteristics at the site to provide supporting data for the FS. Additional on-site monitoring wells also may be installed at the site. (The need for additional monitoring wells will be evaluated after the Phase I field work is complete.) Finally, groundwater samples will be collected from new and existing monitoring wells at the site.

2.1.1 Phase I On-Site Groundwater Investigation

The objective of the Phase I on-site groundwater investigation is to delineate potential source areas contributing to the groundwater contamination at the site; obtain additional aquifer characterization data; and to gather current data on the nature and extent of the groundwater contamination. These data will be used to guide placement of additional on-site monitoring wells to be installed during Phase II.

To meet these OU1 objectives, groundwater samples will be collected from five DPT borings: SB-9, SB-12, SB-13, SB-29, and SB-32 (Figure 2.1). Samples will be collected at multiple depths in each boring as follows:

- At locations SB-9, SB-12, SB-13, and SB-29, four groundwater samples will be collected from each of the borings at the following approximate depths:
  - 115 feet below ground surface (bgs) (water table)
  - 120 feet bgs, 125 feet bgs, and 130 feet bgs (top of the uppermost fine-grained unit)
- At location SB-32, groundwater samples will be collected at the following approximate depths:
  - 115 feet bgs (water table)
  - 123 feet bgs (middle of upper aquifer)
  - 130 feet bgs (top of the uppermost fine-grained unit)
  - 135 feet bgs (immediately below fine-grained unit)
  - 143 feet bgs (middle of intermediate aquifer)
  - 150 feet and 155 feet bgs (immediately above and below the lower fine-grained unit)

Before collecting the groundwater samples, EC logging will be conducted using DPT at SB-9, B-13, and SB-29 to an approximate depth of 130 feet bgs, or refusal of the rods and probe. At SB-32, EC logging will be conducted to approximately 150 feet bgs. The EC data will be used to evaluate the lithology beneath the site, particularly the presence and depth of the fine-grained units reportedly located at depths of approximately 130 feet to 135 feet bgs and 150 feet to 155 feet bgs.

Following the EC logging, a standard DPT drilling rig will be used to collect discrete groundwater samples. The sample depths will be adjusted as needed based on EC data to accommodate targeted sampling to evaluate potential contamination pooled on the top of the fine-grained units.

Groundwater samples and associated quality assurance/quality control (QA/QC) samples that will be collected are listed in Table 2.1. A total of 23 VOC groundwater samples, 4 pesticide and 4 SVOC samples will be collected among the 5 DPT groundwater borings on site. QC samples submitted include duplicate samples matrix spike/matrix spike duplicate (MS/MSD) samples, trip blanks (VOC samples only) and one rinsate blank for all analyses. Duplicate samples are collected at a frequency of 10 percent, while MS/MSD samples are collected at a frequency of 5 percent. Samples will be collected in accordance with the procedures stated in Section 3.5.4.2 and submitted to the EPA Region 7 laboratory for analysis for LDL VOCs.

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Each borehole will be abandoned in accordance with the procedures outlined in Section 3.4.3.

2.1.2 Phase II On-Site Groundwater Investigation

The Phase II activities will occur after Phase I is complete, to allow time to evaluate the Phase I data, and to complete a Work Plan addendum to include additional on-site monitoring wells, if necessary.

2.1.2.1 Hydraulic Conductivity Test Well

One hydraulic test well (HTW-40) will be installed at an upgradient location near well MW-33. Figure 2.2 illustrates the proposed well location. The hydraulic conductivity test well will be installed using reverse rotary drilling techniques to a depth of approximately 233 feet bgs. Construction materials will include a 4-inch Schedule 80 polyvinyl chloride (PVC) casing with a slotted screen across the medial and lower aquifer from approximately 140 to 233 feet bgs. This will allow measurement of the vertical hydraulic gradients in the aquifer. The well will be developed by pumping from the screened zone until the groundwater parameters have stabilized. Drilling, installation, and development procedures for the hydraulic testing well are discussed in Section 3.4.

The DFT to be conducted in HTW-40 is discussed below in Section 2.1.2.4.

2.1.2.2 Additional Monitoring Wells

Additional monitoring wells may be installed on site. Tentative well locations are identified on Figure 2.2. The decision to install new on-site monitoring wells, and final locations and depths (i.e. aquifers to be monitored) of the wells will be determined based on:

- Data collected during the Focused FS and the Interim Record of Decision (ROD) data gathering field effort; and
- Data collected during the Phase I activities at the site.

An addendum to this work plan will be submitted for the monitoring wells once the method of installation, number, locations, depths, and analyses have been confirmed.

If additional monitoring wells are installed, two soil samples will be collected at each of the two fine-grained units based on lithology observed during the current drilling and logs from previous drilling activities on site. These samples will be used to evaluate the ability of the two fine-grained units to retard downward migration of contaminants, and to evaluate the two fine-grained units regarding chemical retardation characteristics, and for other chemical data necessary for the focused feasibility. The samples will be collected with a thin-wall sampler (i.e. Shelby tube) to comply with American Society for Testing and Materials (ASTM) standards for undisturbed samples. These soil samples will be submitted to a subcontracted laboratory for geotechnical analysis including grain size distribution, moisture content, soil porosity calculations, permeability, and bulk density. One sample of saturated sand also will be collected for maximum index density and unit weight using a vibratory table. Geotechnical sample collection procedures are discussed in Section 3.5.5. Samples also will be collected

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from each of these two intervals and submitted for total organic carbon (TOC), pH, and natural oxidant demand (NOD). Subsurface soil sampling procedures are discussed in Section 3.5.4.

A subcontracted lab will perform the natural oxidant demand analyses, and TOC and pH samples will be submitted to the Region 7 EPA laboratory for analysis. Table 4.2 in the QAPP lists the analytical requirements for the soil samples.

2.1.2.3 Monitoring Well Sampling

Existing and potential new on-site monitoring wells will be sampled to characterize groundwater contamination detected during previous investigations. The existing on-site monitoring wells will be sampled during four separate sampling events. The locations of existing on-site monitoring wells are shown in Figure 2.3. A total of 32 existing monitoring wells will be sampled during each event. In addition to the 32 investigation samples, 8 samples will be submitted for QA/QC purposes: 4 duplicates, 2 MS/MSDs, 1 trip blank, and 1 rinsate blank. Samples to be collected from existing on-site monitoring wells are listed in Table 2.2.

The on-site monitoring wells will be sampled using the low-flow purge and sample techniques discussed in Section 3.5.4.3. Twelve monitoring wells are multi-level wells that contain dedicated pumps. The remaining wells require the use of a non-dedicated pump for sampling. This pump will be decontaminated prior to each use following the procedures discussed in Section 3.6.1.

Groundwater samples will be submitted to the EPA Region 7 laboratory for analysis for LDL VOCs. A subset of eight existing monitoring wells will be sampled for monitored natural attenuation (MNA) parameters including alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, methane, ethane, and ethene. Test kits will be run in the field on samples from these wells for carbon dioxide (CO_2) and ferrous iron. Additionally, a subset of nine discrete sampling horizons will be sampled for groundwater treatment evaluation parameters including total suspended solids (TSS), total dissolved solids (TDS), and total phosphorus. Locations for these analyses will be pre-selected based on historical analytical results. A biological activity reaction test (BART®) test kit for biofouling bacteria will also be run in the field. The EPA Region 7 laboratory will complete the analyses for the groundwater treatment evaluation parameters and monitored natural attenuation (MNA) parameters. A list of on-site wells to be sampled is provided in Table 2.2. The analyses for the new monitoring wells will be included in the Work Plan addendum.

Section 4.2 of the QAPP (Appendix B of the RI/FS Work Plan) provides the analytical method, container, and preservation information for collection of these analytical parameters.

2.1.2.4 Aquifer Testing

DFT will be performed along the entire well screen in the hydraulic test well at various depths to measure the flow rates at various depth horizons to determine the characteristics of the aquifer. The results of the hydraulic tests will be used with other hydrogeologic data collected

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during RI activities to evaluate aquifer conditions and support completion of the FS. Section 3.5.2 below includes further discussion of the flow meter testing procedures.

Slug testing will be conducted on up to six selected on-site monitoring wells to provide aquifer characteristics of the groundwater beneath the source areas. The wells chosen for testing will be based on the Phase I DPT groundwater sample results, and proximity to particular source areas. The data will be used during the evaluation of the remedial alternatives during the focused FS. The slug testing procedures are discussed in detail Section 3.5.3.

2.1.3 Source Area Soils Investigation

Subsurface and surface soils will be collected for one or more of the following: VOCs, PCBs, pesticides, and SVOCs, depending on the potential source area at which they are installed. A detailed rationale for the soil sampling locations, depths, and the sample analyses is included in Section 6.2. and Table 6.1 of the Work Plan. The soil borings are illustrated on Figure 2.1. Subsurface soils will be collected in accordance with the procedures stated in Section 3.5.4. Surface soils will be collected from 0 foot to 1 foot bgs in accordance with the procedures stated in Section 3.5.7. Each borehole will be abandoned in accordance with the procedures outlined in Section 3.4.3.

2.1.3.1 VOCs

During Phase I of the OU1 field investigation, subsurface and surface soils will be collected at the known source area where the former fumigant tank was situated, and 13 other potential VOC source areas that may have been associated with the liquid grain fumigant (see Figure 3.1 in the Work Plan).

At 25 of the 27 boring locations depicted on Figure 2.1, a DPT rig will be used to collect continuous soil samples from the ground surface to approximately 20 feet bgs. Grab soil samples will be collected approximately every 5 feet or at locations with high photoionization detector (PID) readings from 5 feet bgs to 20 feet bgs, for a total of 4 soil samples per boring location. Table 2.3 lists the soil borings to be drilled.

To provide a vertical soil profile below the former fumigant AST, continuous soil sampling will be collected at one boring (SB-2) from the ground surface to groundwater table (approximately 115 feet bgs) (Figure 2.1). A photoionization detector (PID) will be utilized to screen the soil cores for organic vapors every foot, and a descriptive log of the soil column will be completed. From 5 feet bgs, grab soil samples will be collected approximately every 5 feet to a depth of 25 feet bgs and then at an interval of 10 feet (or at locations with high PID readings) to the total depth of 115 feet bgs for a total of 14 soil samples at boring SB-2.

To evaluate possible liquid fumigant contamination in surface soils, 25 surface soil samples will be collected for VOCs analysis. The sample locations generally correspond to the 20-foot deep subsurface VOC soil boring locations (Figure 2.1). The only exception to this is that instead of collecting a surface soil sample for VOCs at SB-3 in the area of the former fumigant

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AST, the surface soil sample will be collected at deep boring location SB-2 because it is situated at the location of the tank in exposed soil.

Soil samples for VOCs analysis and associated QC samples that will be collected are listed in Table 2.3. A total of 143 investigation soil samples will be collected during the VOC source areas investigation. In addition, 25 samples will be submitted for QA/QC purposes: 15 duplicates, 7 MS/MSDs, 2 trip blanks, and 1 equipment rinsate blank. The samples will be submitted to the EPA Region 7 laboratory for analysis of VOCs.

2.1.3.2 PCBs

Subsurface soil samples will be collected for PCB analysis at the two current and one former electrical transformers on site. Five borings will be completed to collect subsurface soil samples for PCBs analysis as follows:

- Two borings (SB-18 and SB-19) will be completed adjacent to the transformers on the south side of the main grain silos toward the east end.
- Two borings (SB-20 and SB-21) will be completed adjacent to the transformers at the west end of the main silos.
- One boring (SB-17) will be installed where the former transformer was located along the rail spur south of the silos.

The proposed boring locations are illustrated on Figure 2.1. Except for SB-18, the borings will be completed to a depth of 10 feet, with samples collected at 5 feet and 10 feet bgs. Because SB-18 also is to be used for evaluation of the former steel grain bin located at that location, it will be completed to 20 feet bgs. At SB-18, subsurface soil samples will be collected every 5 feet from 5 feet to 20 feet bgs. A descriptive log of the soil cores will be completed for each soil boring.

Surface soils also will be sampled for PCBs analysis at the five borings completed to evaluate PCBs in subsurface soils.

Soil samples for PCBs analysis and associated QC samples that will be collected are listed in Table 2.3. A total of 17 investigation soil samples will be collected during the PCBs potential source areas investigation. In addition, 4 samples will be submitted for QA/QC purposes: 2 duplicates, 1 MS/MSD, and 1 equipment rinsate blank. The analytical samples will be submitted to the EPA Region 7 laboratory for PCBs analysis.

2.1.3.3 Pesticides

Six subsurface DPT soil borings will be sampled for pesticides at potential source areas, as follows:

- Chemical Storage Shed (SB-24)
- Former Chemical Storage Shed (SB-31)
- Fumigant Applicator Wash Area (SB-4, SB-5)
- Former Drum Storage Area (SB-23)

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- Construction Debris Disposal Pit (SB-29)

The proposed boring locations are illustrated on Figure 2.1. Because of the generally ubiquitous presence of certain pesticides in rural areas, one pesticides background location along the truck access road from Marion Drive to the facility will be sampled at the same depths as the source area samples. All borings will be completed to 20 feet bgs, and sampled from every 5 feet from 5 feet to 20 feet bgs. A descriptive log of the soil cores will be completed for each soil boring.

Surface soils to be analyzed for pesticides will be collected from the six proposed boring locations, and at the background soil boring location.

Soil samples for pesticides and SVOCs analysis and associated QC samples that will be collected are listed in Table 2.3. A total of 20 investigation soil samples will be collected during the pesticide potential source areas investigation. In addition, 4 samples will be submitted for QA/QC purposes: 2 duplicates, 1 MS/MSD, and 1 equipment rinsate blank. The samples will be submitted to the EPA Region 7 laboratory for analysis for organochlorine pesticides, organophosphorus compounds (including malathion), chlorinated herbicides (including 2,4-dichlorophyenoxy acetic acid [2,4-D]), and SVOCs.

2.1.4 Surface Water Pathway Investigation

Eleven sediment samples and one surface water sample will be collected on site from the intermittent drainage features. Seven sediment samples (SD-1 to SD-7) will be collected from the intermittent drainageways on the cropland west of the elevator facility buildings that drain to the south (Figure 2.4). Location SD-2 is located at the outlet of the on-site pond that receives runoff from this drainage system; while SD-1 is located in the pond itself. The other five locations are situated in the upgradient of the pond. Location SD-5 is situated at a background location upgradient of potential influence from site runoff. A surface water sample will be collected at SW-1 in the pond, and is collocated with sediment location SD-1.

Four sediment samples (SD-8 to SD-11) will be collected from the north-flowing drainage ditch between the rail spur and the railroad tracks along the eastern site property boundary (Figure 2.4). Location SD-8 is situated at a background location upgradient of potential influence from site runoff.

Sediment samples and associated QC samples that will be collected are listed in Table 2.4. A total of 11 investigation sediment samples will be collected during the surface water pathway investigation. Four QA/QC samples will also be collected: 1 duplicate, 1 MS/MSD, 1 equipment rinsate blank, and 1 trip blank (VOCs only). The samples will be submitted to the EPA Region 7 laboratory for analysis for VOCs, SVOCs, PCBs, organochlorine pesticides, organophosphorus compounds (including malathion), and chlorinated herbicides (including 2,4-D). Sediment samples will be collected in accordance with the procedures stated in Section 3.5.8.

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One surface water investigation sample will be collected during the surface water pathway investigation (Table 2.4). In addition, one field duplicate, one MS/MSD sample, and a trip blank (VOCs only) will be collected for QA/QC purposes. The samples will be submitted to the EPA Region 7 laboratory for analysis for VOCs, SVOCs, PCBs, organochlorine pesticides, organophosphorus compounds (including malathion), and chlorinated herbicides (including 2,4-D). The surface water sample will be collected in accordance with the procedures stated in Section 3.5.9.

2.1.5 Subslab Soil Gas and Indoor Air Investigation

The purpose of the vapor intrusion/indoor air investigation is to determine whether site-related VOCs (primarily carbon tetrachloride) are present in the air in on-site buildings that employees work in due to possible vapor intrusion.

Six subslab soil gas samples (SG-1 to SG-6) and six indoor air samples (IA-1 to IA-6) will be collected in the office and shop building (Figure 2.5). Four soil gas samples (SG-7 to SG-10) and four indoor air samples (IA-7 to IA-10) will be collected in the eastern portion of the Quonset maintenance building (Figure 2.6). The maintenance shop has a concrete floor in the eastern half of the building; the western half of the building has a dirt and gravel floor.

In conjunction with the collection of subslab soil gas samples and air samples, two outdoor "background" air samples (OA-1 and OA-2) will be collected for comparison to the indoor air samples to assist in characterizing the possible contribution of outdoor (ambient) air to results observed for indoor air (USEPA, 2002). The locations for samples OA-1 and OA-2 will be situated outside the primary entrances to both these buildings (Figures 2.5 and 2.6).

Subslab soil gas and air sampling procedures are detailed below in Sections 3.5.10 and 3.5.11, respectively. Subslab soil gas and air samples that will be collected are listed in Table 2.5. A total of 10 soil gas, 10 indoor air, and two outdoor air, and two duplicates (one each of indoor air and outdoor air) samples will be collected during the subslab soil gas and indoor air investigation. Subslab soil gas duplicates will not be collected because of sample dilution concerns. Subslab soil gas samples should consist of soil gas vapors pooled immediately beneath the floors of buildings, and collection of duplicates may exhaust these vapors and dilute the sample with soil gas extracted from the soil matrix. The analytical samples will be submitted to the EPA Region 7 laboratory for TO-15 VOCs analysis.

2.2 DOWNGRADIENT GROUNDWATER INVESTIGATION (OU2)

The objective of the off-site groundwater investigation is to delineate the overall horizontal and vertical extent of the groundwater contaminant plume downgradient from the site. Phase I of the downgradient groundwater investigation will include EC logging and groundwater sampling using a DPT rig. Off-site groundwater will be characterized along three transects downgradient of the Garvey facility.

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In Phase II, permanent monitoring wells will be installed at five locations to monitor the groundwater plume in select areas after the horizontal and vertical extent of the contamination has been delineated. Samples will be collected from new and existing monitoring wells, and aquifer testing will be conducted in select monitoring wells.

2.2.1 Phase I Downgradient Investigation

Groundwater grab samples will be collected from DPT borings along three transects downgradient of the Garvey Elevator site. Transects 1 and 2 will be located mid-plume at Wabash Avenue (six borings) and Showboat Boulevard (seven borings), respectively (Figure 2.7). The transects will be oriented cross gradient to the contaminant plume to delineate the north and south boundaries of the plume. Transect 3 will consists of four boreholes located cross gradient and near the leading edge of the delineated boundaries of the contaminant plume (Figure 2.7). Additionally, data gathered from the West Highway 6 & Highway 281 site RI/FS activities will be utilized to supplement the transect data.

Each transect will be advanced using standard DPT drilling techniques. A spacing of approximately 500 feet will be used to provide coverage across the anticipated width of the contaminant plume at Transect 1. A spacing of 1,000 feet will be used at Transects 2 and 3. The final transect locations will be jointly determined by the HGL project team and the EPA Task Order Project Officer (TOPO) based on review of historical groundwater data and where site access has been granted by public and private landowners.

EC down-hole logging will be completed at 7 locations (three locations each at Transects 1 and 2, and one location at Transect 3) from ground surface to 170 ft bgs to identify two fine-grained units (at approximately 130 and 150 ft bgs). Existing data suggests that these confining layers are absent south and east of the Garvey Elevator site. To confirm the EC logs, lithologic logs will be made based on visual observation of continuous cores collected at one location on each transect (co-located with an EC boring) to the targeted depths of the fine-grained units.

Depending on availability, the EPA mobile laboratory (Hapsite) may be used to analyze select groundwater samples in the field to obtain real-time analytical data. Samples proposed for analysis in the EPA mobile lab consist of select samples from the northernmost and southernmost borings along each transect. Also, samples from one or more borings at the most downgradient transect will be analyzed to confirm that transect is beyond the leading edge of the plume. These field data will be used to determine the approximate northern and southern margins, and leading edge of the plume.

At each location, groundwater samples will be collected at the water table (estimated at 115 feet bgs) and at 10-foot intervals to the base of the aquifer (estimated to be approximately 240 foot bgs). The sample interval will be adjusted to collect samples at the upper aquifer/fine-grained unit interface and the medial aquifer/fine-grained identified by the EC logging. A total of 14 groundwater samples will be collected at each grid location. As noted in the previous paragraph, select samples may be submitted to the EPA Hapsite for field analysis. All field samples also will be submitted to the EPA Region 7 laboratory for analysis. In addition, 5

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samples will be submitted for QA/QC purposes. These include 2 duplicate samples, 1 MS/MSD sample, one trip blank and one rinsate blank. Samples will be collected in accordance with the procedures stated in Section 3.5.4.2 and submitted to the EPA Region 7 laboratory for analysis for VOCs. Groundwater samples and associated QC samples that will be collected are listed in Table 2.6. Each borehole will be abandoned in accordance with the procedures outlined in Section 3.4.3.

2.2.2 Phase II Downgradient Investigation

2.2.2.1 Additional Monitoring Wells

Ten monitoring wells will be installed at five locations downgradient of the Garvey facility. An optional well also has been proposed at the MW-12 cluster in the deep aquifer. The locations will be based on the DPT groundwater sample results from the three off-site transects. The tentative off-site monitoring well locations are shown on Figure 2.7, and are described as follows:

- MW-41 - Located south of the contaminant plume boundary at Wabash Avenue to supplement West Highway 6 & Highway 281 wells MW-104 (north plume boundary) and MW-105 (middle of contaminant plume at Wabash Avenue).
- MW-42 - Located in middle of the contaminant plume at Showboat Boulevard to supplement West Highway 6 & Highway 281 well MW-106 (north plume boundary).
- MW-43 - Located south of the contaminant plume boundary at Showboat Boulevard.
- MW-44 - Located at furthest downgradient position from estimated plume leading edge (approximately 1 mile east of Showboat Boulevard).
- MW-45 - Located at furthest downgradient position from estimated plume leading edge (approximately 1 mile east of Showboat Boulevard).
- MW-12D – An optional well to add to the existing MW-12 well cluster to monitor the lower aquifer.

Each groundwater monitoring well cluster will consist of two 4-inch monitoring wells and tentatively installed to two discrete depth horizons as follows:

- Medial aquifer (C-well) – 135 feet to 150 feet bgs, 10-foot screen
- Deep aquifer (D/E-well)– 160 feet to 240 feet bgs, 20-foot screen

The actual well construction will be adjusted based on the vertical distribution of contaminants detected in the DPT transect borings. An addendum to this Work Plan will be prepared for the additional on-site monitoring wells and the off-site wells. This addendum will be submitted once the data from the transect groundwater samples has been evaluated, and the proposed well locations are revised as necessary.

Three geotechnical soil samples will be collected from select new monitoring wells to evaluate the physical and chemical aquifer characteristics throughout the off-site area of the plume. The locations for these samples will be based on the Phase I DPT groundwater results from the transect borings, and will be collected from separate well boreholes to evaluate spatial variation of aquifer characteristics.

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The samples will be collected with a thin-wall sampler (i.e. Shelby tube) to comply with ASTM standards for undisturbed samples. These soil samples will be submitted to a subcontracted laboratory for geotechnical analysis including grain size distribution, moisture content, soil porosity calculations, permeability, and bulk density. Geotechnical sample collection procedures are discussed in Section 3.5.5. Samples also will be collected from each of these two intervals and submitted for TOC, pH, and natural oxidant demand. Subsurface soil sampling procedures are discussed in Section 3.5.4.

2.2.2.2 Monitoring Well Sampling

Once the 10 new monitoring wells have been installed, they will be sampled in conjunction with the existing 21 off-site monitoring wells (including nine West Highway 6 & Highway 281 site monitoring wells). Figure 2.7 illustrates the off-site wells that will be sampled. Two rounds of groundwater sampling will be conducted as part of the OU2 RI field program. A total of 30 monitoring wells will be sampled per event. Also, the three irrigation wells in the crop field downgradient to the east and southeast from the site will be sampled during the first monitoring well sampling event. No survey data for the irrigation wells is available, so are not depicted on Figure 2.7. These wells will be surveyed for location and elevation during the field activities.

In addition to the 36 investigation samples, 9 samples will be submitted for QA/QC purposes: 4 duplicates, 3 MS/MSDs, 2 trip blanks, and 1 equipment rinsate blank. The sample quantities are shown in Table 2.6. Groundwater samples and associated QC samples will be collected in accordance with the procedures stated in Section 3.5.4. The wells will be sampled using non-dedicated pumps and low-flow purging and sampling techniques. Purging and sampling procedures are detailed in Section 3.5.6.3. The pump will be decontaminated prior to each use following the procedures discussed in Section 3.6.1.

All well samples will be submitted to the EPA Region 7 laboratory for VOCs. A subset of 11 existing monitoring wells will be sampled for MNA parameters including alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC methane, ethane, and ethene. Test kits will be run in the field on samples from these wells for CO_2 and ferrous iron. Additionally, a subset of 4 wells will also be sampled for groundwater treatment evaluation parameters including, TSS, TDS, total phosphorous, and solvent degrading bacteria. A BART® test kit for biofouling bacteria will also be run in the field. The EPA Region 7 laboratory will complete the analyses for the groundwater treatment evaluation parameters and MNA parameters.

2.2.2.3 Aquifer Testing

Slug testing will be conducted on up to six selected off-site monitoring wells to provide aquifer characteristics of the downgradient, off-site areas affected by the contaminant plume. The data will be used during the evaluation of select remedial options during the FS. The slug testing procedures are discussed in detail Section 3.5.3.

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TABLES

Table 2.1
OU1 DPT Groundwater Sample Quantities

Sample Locations	Analysis		
	VOCs	Pesticides	SVOCs
Investigation Samples			
SB-9	4		
SB-12	4		
SB-13	4		
SB-29	4	4	4
SB-32	7		
Total Investigation Samples	**23**	**4**	**4**
QA/QC Samples			
Number of Duplicates	3	1	1
Number of MS/MSD	1	1	1
Number of Trip Blanks	1	N/A	N/A
Number of Rinsate Blanks	1	1	1
Total Samples	**29**	**7**	**7**

MS/MSD= matrix spike/matrix spike duplicate
N/A = not applicable
VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds
QA/QC = quality assurance quality control

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Table 2.2
OU1 Existing Monitoring Well Sample Quantities

Sample Locations	No. of Samples	Analysis
Investigation Samples		
MW-1A	1	VOCs
MW-2A	1	VOCs
MW-3A	1	VOCs, MNA[2]
MW-3B	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW-3D	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW-3E	1	VOCs, MNA[2]
MW-4A	1	VOCs
MW-4B	1	VOCs
MW-5A	1	VOCs
MW-5B	1	VOCs
MW-5D	1	VOCs
MW-6A	1	VOCs
MW-6D	1	VOCs
MW-6E	1	VOCs
MW-7A	1	VOCs
MW-7B	1	VOCs
MW-8A	1	VOCs, MNA[2]
MW-9A	1	VOCs
MW-13C	1	VOCs
MW-13E	1	VOCs
MW-19A	1	VOCs
MW-19C	1	VOCs
MW-20A	1	VOCs
MW-20C	1	VOCs
MW-20D	1	VOCs
MW-20E	1	VOCs, Treatment Evaluation Parameters [1], MNA[2]
MW-30A	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW-30C	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW-30D	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW-30E	1	VOCs
MW-31A	1	VOCs
MW-31C	1	VOCs
Total Investigation Samples	**32**	
QA/QC Samples		
Number of Duplicates	3	VOCs
Number of MS/MSD	2	VOCs, MNA[2]
Number of Trip Blanks	1	VOCs
Number of Rinsate Blanks	1	VOCs
Total Samples	**39 x 4 rounds**	

[1)] TSS, TDS, total P, BART test kits, solvent degrading bacteria
[2)] alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, total organic carbon (TOC), and methane, ethane, and ethane
QA/QC = quality assurance quality control; VOCs = volatile organic compounds; MNA = monitored natural attenuation

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Table 2.3
OU1 Soil Sample Quantities

Sample Locations	Boring Depth (feet bgs)	Analyses			
		VOCs	PCBs	Pesticides	SVOCs
Investigation Samples					
SB-1	20	5			
SB-2	115	15			
SB-3	20	4			
SB-4	20	5		5	5
SB-5	20	5		5	5
SB-6	20	5			
SB-7	20	5			
SB-8	20	5			
SB-9	20	5			
SB-10	20	5			
SB-11	20	5			
SB-12	20	5			
SB-13	20	5			
SB-14	20	5			
SB-15	20	5			
SB-16	20	5			
SB-17	10		3		
SB-18	20	4	5		
SB-19	10		3		
SB-20	10		3		
SB-21	10		3		
SB-22	20	5			
SB-23	20	5		5	5
SB-24	20	5		5	5
SB-25	20	5			
SB-26	20	5			
SB-27	20	5			
SB-28	20	5			
SB-29	20	5		5	5
SB-30	20	5			
SB-31	20	5		5	5
Total Investigation Samples		**143**	**17**	**20**	**20**
QA/QC Samples					
Number of Duplicates		15	2	2	2
Number of MS/MSD		7	1	1	1
Number of Trip Blanks		2	N/A	N/A	N/A
Number of Rinsate Blanks		1	1	1	1
Total Samples		**168**	**21**	**24**	**24**

This table includes surface and subsurface sample quantities
bgs = below ground surface
MS/MSD= matrix spike/matrix spike duplicate
SVOCs = semivolatile organic compounds
VOCs = volatile organic compounds
PCBs = polychlorinated byphenyls
N/A = not applicable
QA/QC = quality assurance quality control

Table 2.4
OU1 Sediment and Surface Water Sample Quantities

Sample Locations	Analyses			
	VOCs	PCBs	Pesticides	SVOCs
Sediment				
Investigation Samples				
SD-1	1	1	1	1
SD-2	1	1	1	1
SD-3	1	1	1	1
SD-4	1	1	1	1
SD-5	1	1	1	1
SD-6	1	1	1	1
SD-7	1	1	1	1
SD-8	1	1	1	1
SD-9	1	1	1	1
SD-10	1	1	1	1
SD-11	1	1	1	1
Total Investigation Samples	**11**	**11**	**11**	**11**
QA/QC Samples				
Number of Duplicates	1	1	1	1
Number of MS/MSD	1	1	1	1
Number of Trip Blanks	1	N/A	N/A	N/A
Number of Rinsate Blanks	1	1	1	1
Total Samples	**15**	**14**	**14**	**14**
Surface Water				
Investigation Samples				
SW-1	1	1	1	1
Total Investigation Samples	**1**	**1**	**1**	**1**
QA/QC Samples				
Number of Duplicates	1	1	1	1
Number of MS/MSD	1	1	1	1
Number of Trip Blanks	1	N/A	N/A	N/A
Number of Rinsate Blanks	N/A	N/A	N/A	N/A
Total Samples	**4**	**3**	**3**	**3**

This table includes surface and subsurface sample quantities
MS/MSD= matrix spike/matrix spike duplicate
N/A = not applicable
VOCs = volatile organic compounds
PCBs = polychlorinated byphenyls
SVOCs = semivolatile organic compounds
QA/QC = quality assurance quality control

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Table 2.5
OU1 Subslab Soil Gas and Air Sample Quantities

Sample Locations	No. of Samples	Analysis
Subslab Soil Gas		
Investigation Samples		
SG-1	1	VOCs
SG-2	1	VOCs
SG-3	1	VOCs
SG-4	1	VOCs
SG-5	1	VOCs
SG-6	1	VOCs
SG-7	1	VOCs
SG-8	1	VOCs
SG-9	1	VOCs
SG-10	1	VOCs
Indoor and Outdoor Air		
IA-1	1	VOCs
IA-2	1	VOCs
IA-3	1	VOCs
IA-4	1	VOCs
IA-5	1	VOCs
IA-6	1	VOCs
IA-7	1	VOCs
IA-8	1	VOCs
IA-9	1	VOCs
IA-10	1	VOCs
OA-1	1	VOCs
OA-2	1	VOCs
Total Investigation Samples	22	
QA/QC Samples		
Number of Duplicates	2	VOCs
Number of MS/MSD	N/A	VOCs
Number of Trip Blanks	N/A	VOCs
Number of Rinsate Blanks	N/A	VOCs
Total Samples	24	

IA = indoor air
MS/MSD= matrix spike/matrix spike duplicate
N/A = not applicable
OA = outdoor air
VOCs = volatile organic compounds

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Table 2.6
OU2 Groundwater Sample Quantities

Sample Locations	No. of Samples	Analysis
DPT Groundwater Grab Samples		
Transect 1		
TS1-01	14	VOCs
TS1-02	14	VOCs
TS1-03	14	VOCs
TS1-04	14	VOCs
TS1-05	14	VOCs
TS1-06	14	VOCs
Transect 2		
TS2-01	14	VOCs
TS2-02	14	VOCs
TS2-03	14	VOCs
TS2-04	14	VOCs
TS2-05	14	VOCs
TS2-06	14	VOCs
TS2-07	14	VOCs
Transect 3		
TS3-01	14	VOCs
TS3-02	14	VOCs
TS3-03	14	VOCs
TS3-04	14	VOCs
Total of Investigation Samples	**238**	
Number of Duplicates	**24**	VOCs
Number of MS/MSD	**12**	VOCs
Number of Trip Blanks	**3**	VOCs
Number of Rinsate Blanks	**0**	VOCs
Total of Samples	**277**	
New Monitoring Wells		
MW -41C	1	VOCs
MW -41D	1	VOCs
MW -42C	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW -42D	1	VOCs, Treatment Evaluation Parameters[1], MNA[2]
MW -43C	1	VOCs
MW -43D	1	VOCs
MW -44C	1	VOCs, MNA[2]
MW -44D	1	VOCs, MNA[2]
MW -45C	1	VOCs
MW -45D	1	VOCs
Total of Investigation Samples	**10**	
Number of Duplicates	**1**	VOCs
Number of MS/MSD	**1**	VOCs, MNA[2]
Number of Trip Blanks	**1**	VOCs
Number of Rinsate Blanks	**0**	VOCs
Total of Samples	**13 x 2 rounds**	

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Table 2.6 (continued)
OU2 Groundwater Sample Quantities

Sample Locations	No. of Samples	Analysis
Existing Monitoring Wells and Irrigation Wells		
MW-10A	1	VOCs
MW-10B	1	VOCs
MW-11A	1	VOCs
MW-12A	1	VOCs
MW-12C	1	VOCs
MW-14A	1	VOCs
MW-17A	1	VOCs
MW-17C	1	VOCs
MW-17D	1	VOCs, MNA[2]
MW-18A	1	VOCs, MNA[2]
MW-18C	1	VOCs, Treatment Evaluation Parameters[1], NA[2]
MW-18D	1	VOCs, Treatment Evaluation Parameters[1], NA[2]
MW-104A	1	VOCs
MW-104C	1	VOCs
MW-104D	1	VOCs
MW-105A	1	VOCs, MNA[2]
MW-105C	1	VOCs, MNA[2]
MW-105D	1	VOCs, MNA[2]
MW-106A	1	VOCs
MW-106C	1	VOCs
MW-106D	1	VOCs
Irrigation Well 1	1	VOCs
Irrigation Well 2	1	VOCs
Irrigation Well 3	1	
Total Investigation Samples	**24**	
Number of Duplicates	**3**	VOCs
Number of MS/MSD	**2**	VOCs, MNA[2]
Number of Trip Blanks	**1**	VOCs
Number of Rinsate Blanks	**1**	VOCs
Total of Samples	**27 x 2 rounds**	

[1)] TSS, TDS, total P, BART test kits, solvent degrading bacteria
[2)] alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, total organic carbon (TOC), and methane, ethane, and ethene.
MS/MSD= matrix spike/matrix spike duplicate
VOCs= volatile organic compounds

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FIGURES

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Figure 2.1
Proposed On-Site DPT Boring Locations

Legend

- Site Boundary
- Former Steel Grain Bin
- Railroad
- HWS DPT Soil Boring Location
- ENSR DPT Soil Boring Location
- Proposed DPT Soil Boring and Surface Soil Location (20 feet deep)
- Proposed Soil and Groundwater DPT Boring Location
- Proposed DPT Soil Boring Location (20 feet deep)
- Proposed DPT Soil Boring and Surface Soil Location (115 feet deep)
- Proposed DPT Soil Boring and Surface Soil Location (10 feet deep)
- Monitoring Well
- Former Garvey Water Well
- SB-13 Electrical Conductivity Logging Location

Note:
All HWS and ENSR sample locations were non-detect for carbon tetrachloride, unless otherwise noted.

A surface sample will be collected at each soil boring location.

N

0 90 180 360
Feet

Filename: X:/EPA009/Garvey/FSP/Proposed_OnSite_DPT_Boring_Loc.mxd
Project: EP9033.01.46.13
Revised: 05/14/09 CV
Source: ENSR GDB 2008, DNR

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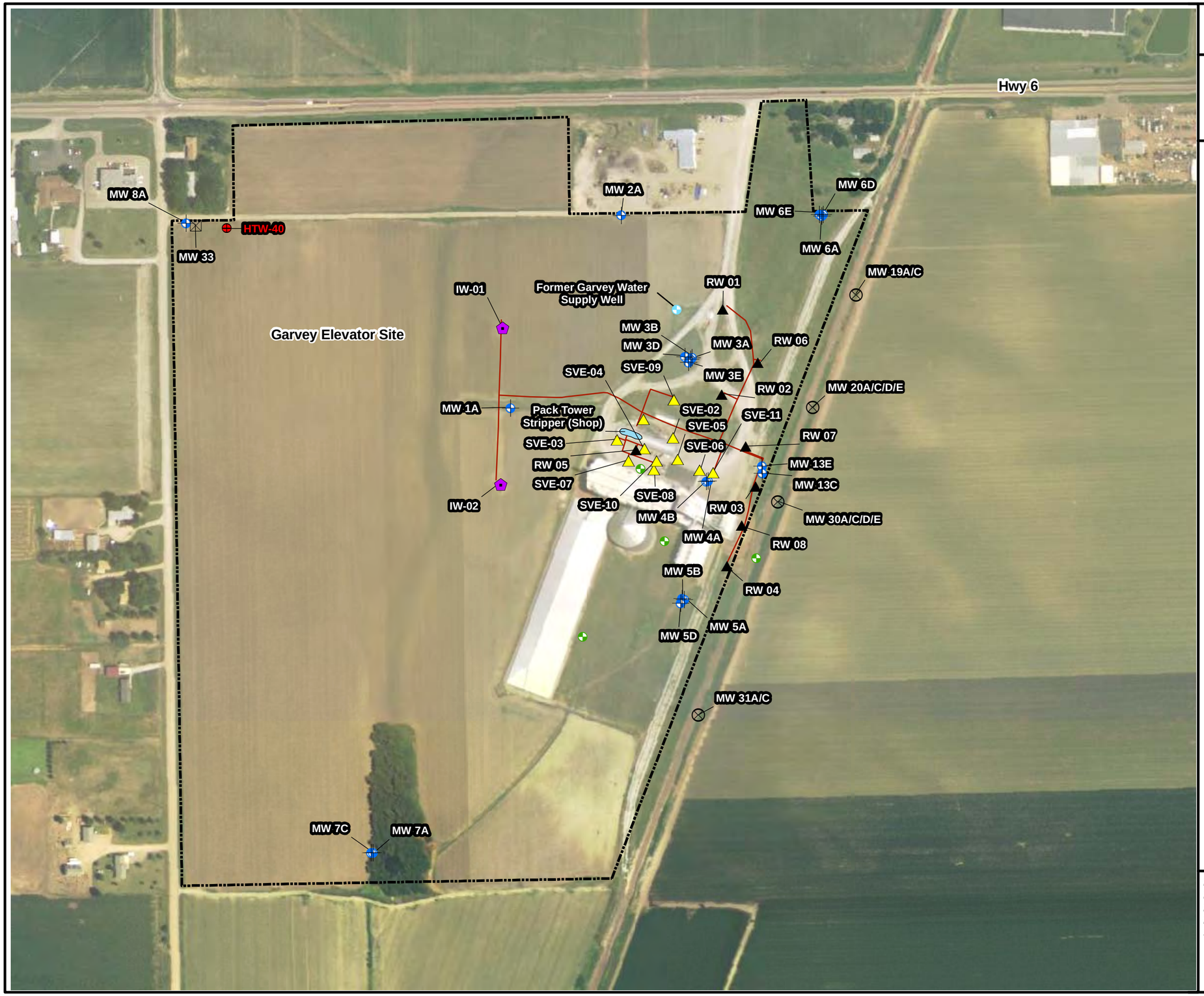
Figure 2.2
Proposed On-Site Well Locations



Legend

- Site Boundary
- Pack Tower Stripper
- GET and SVE System Piping
- Recovery Wells
- Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- Assumed Location of Multi-Level Well Installed by ENSR
- Injection Well
- Soil Vapor Extraction Well
- Monitoring Well
- Potential Monitoring Well Location
- Proposed Hydraulic Test Well Location
- Former Garvey Water Well

0 180 360 720
Feet

N

Filename: X:/EPA009/Garvey/FSP/
Proposed_OnSite_Well_Locations.mxd
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: ENSR GDB 2008, DNR

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Figure 2.3
Existing On-Site Monitoring Wells

Legend

- Site Boundary
- Pack Tower Stripper
- ▲ Recovery Wells
- ☒ Assumed Location of Hydraulic Conductivity Well Installed by ENSR
- ⊗ Assumed Location of Multi-Level Well Installed by ENSR
- Monitoring Well
- Former Garvey Water Well

Note:
Well locations based on survey data from the site background files.

N

0 180 360 720
Feet

Filename: X:/EPA009/Garvey/FSP/OnSite_MW_Locations.mxd
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: ENSR GDB 2008, DNR

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HGL—Field Sampling Plan,
Garvey Elevator Site—Hastings, NE

Figure 2.4
Proposed Sediment/Surface Water Sample Locations

Legend

- Site Boundary
- Culverts
- Buildings
- Former Steel Grain Bin
- Concrete Paved Area
- Gravel Road
- Railroad
- Drainageways
- Proposed Sediment Sample Location
- Proposed Surface Water and Sediment Sample Location

N

0 125 250 500

Feet

Filename: X:/EPA009/Garvey/FSP/
Proposed_Sed_SurfaceWater_Sample_Loc.mxd
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: ENSR GDB 2008, DNR

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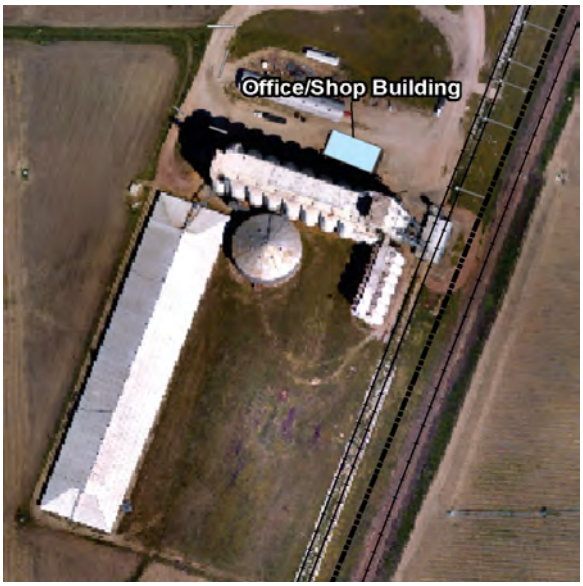

IA-6
SG-6
Maintenance/Storage Room
SG-5
IA-5
SG-4
IA-4
IA-3
SG-3
Bathrooms
Vending Machines
Office
IA-2
SG-2
Lockers
IA-1
AGP Manager Office
HGL Field Office
Break Area
SG-1
Not to Scale
OA-1

Filename: X:\EPA009\Garvey\FSP\ Proposed_OfficeShop_SubSlab_SoilGas_ IndoorAir_Samples.cdr
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: HGL Database

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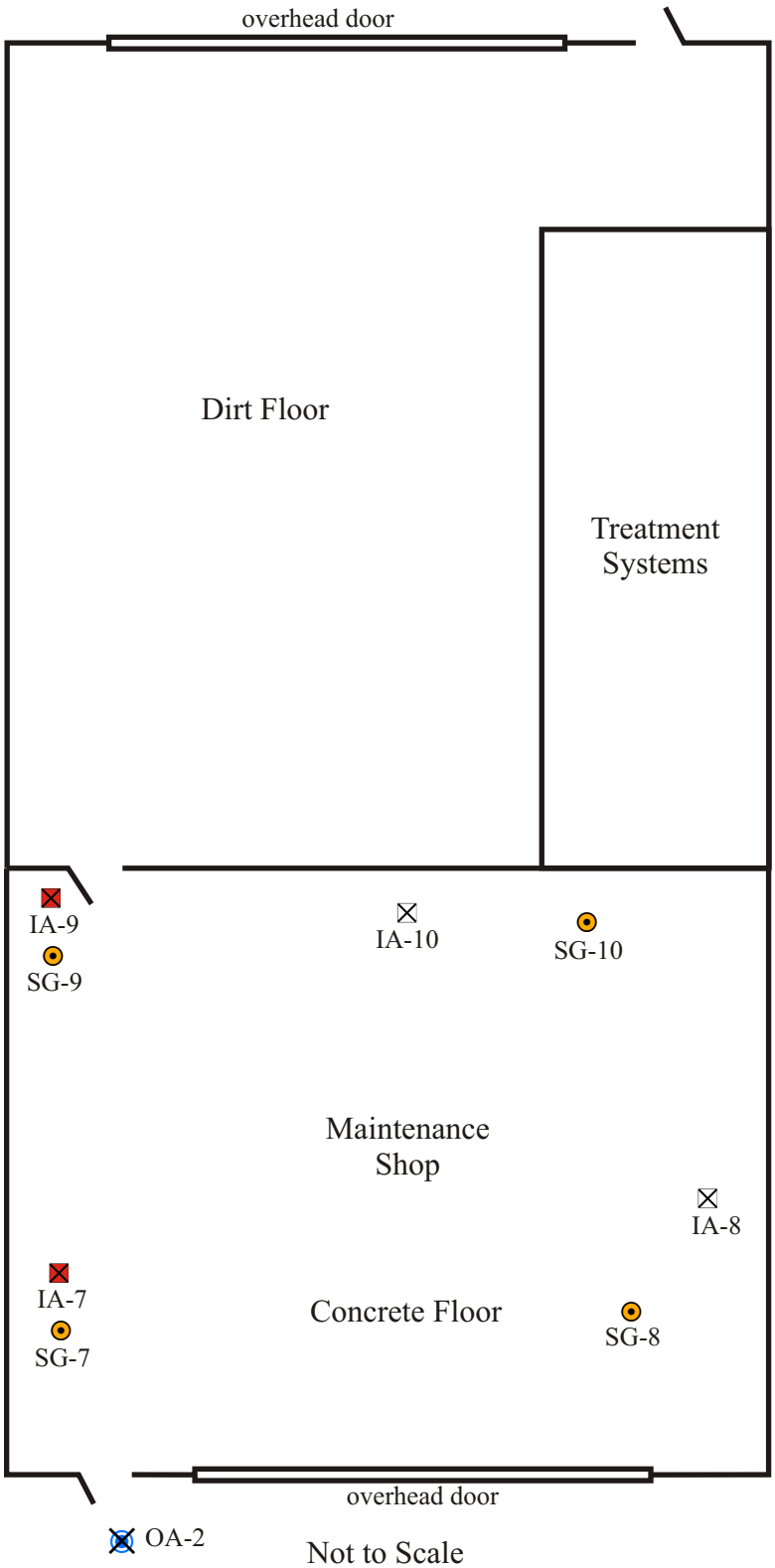
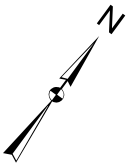
Legend

- Proposed Sub-Slab Soil-Gas Sample Location
- Proposed Indoor Air Sample Location
- Background Air Sample Location

Figure 2.5
Proposed Office/Shop Building Sub-Slab Soil-Gas and Indoor Air Sample Locations





Filename: X:\EPA009\Garvey\FSP\ Proposed_MaintenanceShop_SubSlab_SoilGas_ IndoorAir_Samples.cdr
Project: EP9033.01.46.13
Revised: 05/18/09 CV
Source: HGL Database

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Legend

- Proposed Sub-Slab Soil-Gas Sample Location
- Proposed Indoor Air Sample Location
- Background Air Sample Location

Figure 2.6
Proposed Maintenance Building Sub-Slab Soil-Gas and Indoor Air Sample Locations

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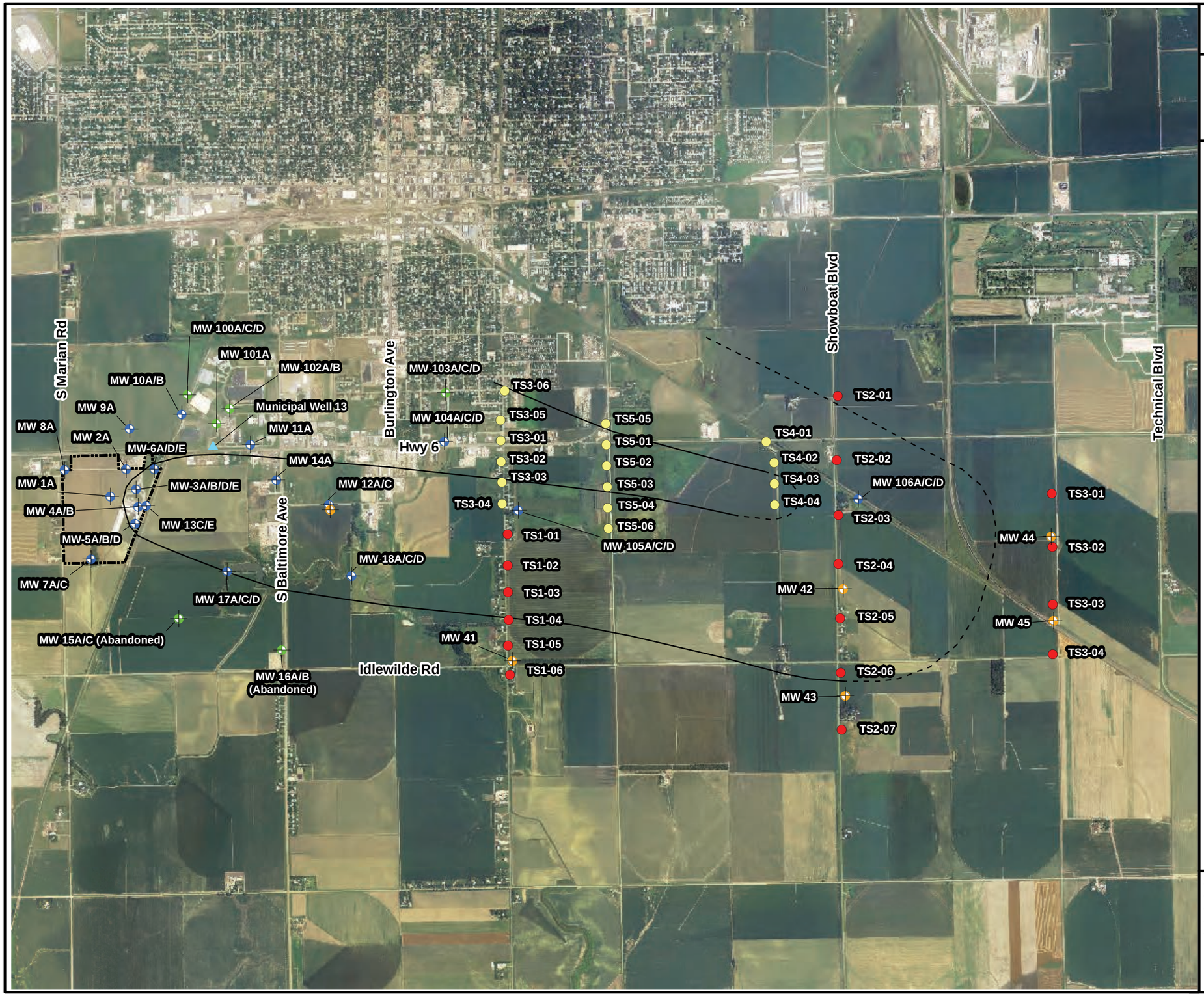
Figure 2.7
Proposed Off-Site Groundwater Transects and Monitoring Well Locations



Legend

- Site Boundary
- Hwy 6 & 281 DPT Transect Boring
- Monitoring Well (Not to be Sampled)
- Municipal Well
- Approximate Boundary of Carbon Tetrachloride MCL (5 µg/L)

Sample Locations

- Proposed Monitoring Well Location
- Proposed DPT Transect Boring
- Monitoring Well (To be Sampled)

N

0 1,250 2,500 5,000
Feet

Filename: X:/EPA009/Garvey/FSP/Proposed_Offsite_GW_Transect_MW_Loc.mxd
Project: EP9033.01.46.13
Revised: 05/15/09 CV
Source: ENSR GDB 2008, DNR

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3.0 FIELD ACTIVITY METHODS AND PROCEDURES

This FSP has been developed to provide the rationale and procedures that will be used to conduct the RI/FS field activities for the Garvey Elevator site. The following is a summary of field activities that will be performed by HGL personnel and/or subcontractors during RI/FS field activities.

- Mobilization
- Locate and mark utility locations
- Purchase or procure equipment and supplies
- Collect EC data using DPT
- Collect subsurface soil samples using DPT
- Collect surface soil samples
- Collect DPT groundwater grab samples (including EPA mobile lab field screening)
- Collect sediment and surface water samples
- Collect subslab soil gas, indoor air, and outdoor air samples
- Install monitoring wells
- Install hydraulic test well
- Record manual groundwater level measurements
- Sample new and existing monitoring wells
- Sample irrigation wells downgradient of site
- Conduct slug testing.
- Conduct site visit for screening level ecological risk assessment
- Conduct photo documentation
- Conduct surveying
- Decontaminate equipment
- Manage investigation-derived waste (IDW)
- Conduct borehole abandonment

The subsections that follow reference EPA Region 7 standard operating procedures (SOPs) where applicable. Referenced SOPs are provided in Attachment 1. Referenced field forms are included in Attachment 2. The site-specific HSP is included as Appendix C of the RI/FS Work Plan.

3.1 MOBILIZATION

HGL will identify and provide all necessary personnel, equipment, and materials for mobilization and demobilization to and from the site for the purpose of conducting the RI/FS field activities. Equipment mobilization entails ordering required supplies and sample containers from EPA Region 7 Environmental Services Division and renting or purchasing any additional equipment or supplies needed. Mobilization activities will include the following:

- Setup of temporary facilities (in AGP office building), and setup of subcontractors
- Obtain utility clearances for on-site work within and immediately surrounding the Garvey Elevator buildings
- Setup of decontamination pad, equipment storage area, and IDW storage area

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- Initial site safety meeting and field planning meeting with all field personnel including subcontractors

3.2 UTILITY LOCATES

HGL will contact the Nebraska utility location "One Call" service (DIGGERS HOTLINE 1-80331-5666) to have all underground utilities clearly marked before the start of the drilling and DPT programs. HGL will verify buried utilities with AGP personnel on site as needed. Boring locations will be adjusted in the field to avoid encountering underground utilities while drilling.

3.3 EQUIPMENT, SUPPLIES, AND CONTAINERS

HGL has identified the equipment and supplies necessary to support the field activities. These items are summarized in Table 3.1.

Unless otherwise stated, the EPA Region 7 laboratory will provide sample containers and any preservatives for samples designated for analysis by the regional laboratory.

All sample containers will be pre-cleaned and traceable to the facility that performed the cleaning. Sampling containers will not be cleaned or rinsed in the field. A list of required containers and preservatives is included in Table 4.1 through Table 4.3 of the QAPP (Appendix B of the RI/FS Work Plan).

3.4 WELL DRILLING, INSTALLATION, AND DEVELOPMENT

The well drilling, installation, development, and borehole abandonment procedures will comply with applicable regulations in Title 178 Nebraska Administrative Code Chapter 12 Water Well Construction, Pump Installation, and Water Decommissioning Standards.

3.4.1 Well Drilling and Installation Procedures

The installation of the hydraulic test well and the 10 monitoring wells (five clusters of two wells) are discussed below.

3.4.1.1 Hydraulic Test Well Installation

The hydraulic test well will be installed using reverse rotary drilling methods. This method was selected to minimize skinning of the borehole wall that could affect test results. Initially, a nominal 16-inch borehole will be drilled to approximately 125 feet bgs. Below this depth to the completion depth, a nominal 10-inch borehole will be drilled. Water will be used as the drilling fluid, with air injected to assist in transporting the cuttings to the surface. No drilling mud will be used, and no air will be injected beneath the water table.

The hydraulic test well screen will extend from the bedrock surface at approximately 240 feet bgs to approximately 135 feet bgs, which will screen the lower and medial aquifers. Because of the higher potential for contamination to exist in the upper aquifer at any particular location,

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the upper aquifer will not be screened, and will be sealed from the lower screened zones at the upper fine-grained unit. A hi-flow screen with an approximate 0.020-inch slot size will be used.

The formation will be allowed to collapse from 240 feet bgs to approximately 127 feet. At this depth, a packer will have been installed on the riser pipe that will extend up to approximately 125 feet bgs (to set immediately below the uppermost confining unit). Next, an approximately 3-foot layer of bentonite chips will be introduced to the annular space before adding high-solids bentonite grout to near the ground surface. The high-solids bentonite grout will be installed via a side-discharge tremie pipe. Figure 3.1 illustrates the typical construction of the hydraulic test well.

Water used during drilling and mixing grout will be clean, pretreated potable water. The site geologist will record the volume of water used. If water is used during the drilling of the hydraulic test well or any of the monitoring wells, three times the amount used will be removed during the development of the well. Information regarding the source of water used and any impact on analytical results will be included in the RI report.

3.4.1.2 Monitoring Well Installation

The drilling method for the 10 new off-site monitoring well clusters and the potential on-site monitoring wells will be provided in the Work Plan addendum submitted after the Phase I field activities have been completed. This addendum will include well installation methods and construction details.

3.4.2 Well Development

The newly installed hydraulic test well and monitoring wells will be developed within 1 week after the well has been constructed, but no sooner than 24 hours after grouting is complete, following the procedures in EPA SOP #2044, *Monitor Well Development* (Attachment 1). The well will be developed by alternately surging and pumping the well over 5-foot intervals across the entire lengths of the various screens. Surging will be accomplished with a surge block attached to a ¾-inch PVC (or equivalent) pipe. Submersible pumps will be used to pump or purge the well. At the hydraulic test well, the pumping rate during development will be at least 3.9 gallons per minute per foot of screen, if possible. This rate coincides with the maximum pumping rate per unit length of the DFT probe to be used in the hydraulic testing well. This should prohibit mobilization of additional fines during the flow testing.

Surging and purging will continue until all formation cuttings have been removed from the well, all water quality parameters have stabilized (as defined below) and three times the volume of water lost during drilling the formation adjacent to the screened zone of each well has been removed.

HGL's field geologist will collect periodic measurements of pH, specific conductance, temperature, and turbidity during development. Development will continue until all parameters

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(temperature, pH, and conductivity) have stabilized to less than 10 percent change for four consecutive readings and the water is clear and free of fines (turbidity <50 nephelometric turbidity units [NTUs]). Readings will be taken at least every 10 minutes during well development. Pumping and surging will not exceed 14 hours on the hydraulic test well, or 8 hours on a monitoring well. Details of the development procedure will be documented on a Well Development Log (Attachment 2).

3.4.3 Borehole Abandonment

Each DPT borehole will be sealed with high-solids bentonite grout after completion of activities at each location. The slurry will be 20 percent by weight sodium bentonite. The grout will be pumped in through a tremie pipe to fill the portion of the borehole that remains open after removal of the rods. Grouting will occur as quickly as possible to minimize the possibility of contaminant migration. Each borehole will be patched with surface material identical to the original (i.e., asphalt or concrete).

3.4.4 Lithologic Logging

Drilling cuttings and cores, and DPT sample cores will be logged for lithology at all soil boring and monitoring well drilling locations. All pertinent borehole drilling information will be recorded on a hazardous, toxic, and radiological waste (HTRW) drilling log. Borings will be logged according to the general procedures described in CDM SOP 3.5 *Lithologic Logging* (March 2007).

The borehole materials will be described using the Unified Soil Classification system (USCS) classification, and be noted for the following (at a minimum):

- Consistency of cohesive materials or apparent density of noncohesive materials;
- Moisture content assessment (e.g., moist, wet, saturated, etc.);
- Color;
- Other descriptive features (e.g., bedding characteristics, organic materials, etc.).

3.5 SAMPLE COLLECTION PROCEDURES

The subsections below outline the procedures to be employed during the collection of the various samples required for the RI/FS at the Garvey Elevator site. Sampling methods will include EC,; surface and subsurface soil sampling; sediment and surface water sampling; groundwater sampling; subslab soil gas and air sampling; and IDW sampling. In addition, decontamination and surveying methods to be utilized in the performance of this investigation are outlined below.

3.5.1 EC Data Collection

The DPT will be equipped with an EC probe so that a continuous log of soil conductivity can be recorded. EC data collection will be subcontracted to an Nebraska Department of Environmental Quality (NDEQ) licensed driller who will use a DPT rig to advance the EC tool to the targeted subsurface depth or refusal if encountered before the targeted depth. All DPT equipment will be thoroughly decontaminated as outlined in Section 3.6 before setting up at each EC location. The

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EC borings will be conducted in accordance with the current Geoprobe® Systems SOP, Technical Bulletin MK3010, May 2003, which is included in Attachment 1. The equipment required to conduct EC data collection is listed in Section 3 of the Geoprobe technical bulletin. Proposed EC sample locations are discussed in Sections 2.1.1.1 and 2.2.1.

3.5.2 Dipole Flow Testing

As part of the sampling activities for the RI field investigation, the EPA TOPO will perform DFT in the hydraulic test well and in selected off-site 4-inch monitoring wells. The DFT is capable of providing reliable estimates of hydraulic conductivity on a small scale. Multiple tests can be performed in a well with a long screen to obtain a vertical profile of hydraulic conductivity. The EPA will provide the equipment, supplies, and personnel, to perform the flow testing. The EPA TOPO will conduct the DFT, with assistance provided by HGL as needed. The number of DFTs and the depths at which they will be performed will be determined by EPA.

An advantage to using the DFT method is that no water is withdrawn from the well, which will reduce IDW water disposal for wells tested within the contaminated groundwater plume (Zlotnik and Ledder, 1996).

3.5.3 Slug Test

To estimate hydraulic conductivity, slug tests will be conducted at up to 12 monitoring wells (6 on-site wells and 6 off-site wells). The slug testing will be conducted on both existing monitoring wells and newly installed monitoring wells. Both slug in (falling head) and slug out (rising head) tests will be performed unless the screen extends above the water table in which case only slug out tests will be used. Data will be recorded in the field using a down well data logging transducer. The data will be downloaded and entered into personal computers at HGL's office. Computer software will be used to estimate the hydraulic conductivity using the appropriate method for the aquifer conditions (e.g., Bouwer and Rice (1976) for the unconfined aquifer and Cooper (1967) and Padadopulos (1973) for the confined aquifer). All slug tests will be conducted in accordance with the HGL Well Slug Test SOP 2.11 (Attachment 1); however, the general slug procedures are summarized as follows:

- A solid 4-inch diameter PVC blank will be used as a slug to be submerged in the well. Or a slug will be fabricated using a 2 to 5-foot length of PVC casing filled with sand and capped water-tight at both ends. Depth to water and total depth of each well will be measured before testing to determine which slug size is appropriate. The largest width and length of slug possible should be used to obtain the maximum displacement of the water. A rope or cable will be long enough so that the slug is submerged but will not hit the transducer probe. Water level, total depth, screen interval, bore hole diameter, slug volume, time of test start and finish will be recorded in the field log book for each well.
- A transducer and data logger will be used to monitor water level recovery. Before initiating the test, the transducer will be placed near the bottom of the well and below the depth the slug will reach.
- The slug will be lowered quickly into the well, such that the data logger can record changes in water levels until 90 percent of the original static elevation has been achieved. After groundwater elevations have returned to static conditions, the slug will then be

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rapidly pulled from the well and readings will be collected with the data logger again until the groundwater elevation recovers to 90 percent of the original static elevation. Water level elevations will be recorded by the pressure transducer at pre-determined, logarithmically increasing time intervals. Alternately, water level elevations can be collected in a fast linear time interval such that approximately two readings per second can be obtained.

3.5.4 Subsurface Soil Sampling

Subsurface soil sampling will be conducted by the DPT subcontractor with HGL oversight in accordance with the HGL SOP *Soil Sampling* (January 2006) included in Attachment 1. Subsurface soils will be continuously sampled using Geoprobe Macrocore samplers that provide 1.5-inch diameter, 4-foot long soil cores contained in acetate sleeves.

The general sampling procedure is as follows:

1) Drive the sample apparatus into the sample material.
2) Retract and disassemble the sample apparatus.
3) Remove the acetate liner.
4) Open the acetate liner with a cutting tool.
5) Screen the soil core using a PID to screen for VOCs.
6) Collect the sample using a cut syringe-type device for measured aliquots (VOCs).
7) Transfer the sample directly to its appropriate sample container.

Soil samples to be analyzed for VOCs will be containerized in pre-tared vials provided by the laboratory (two 5-gram soil aliquots in each vial). Each vial will be preserved by the laboratory with sodium bisulfate.

All samples will be stored on ice in coolers during shipment to the laboratory and maintained at 4°C. Sample preservation, holding times, and container requirements are listed in Tables 4.1 and 4.3 in Section 4.0 of the QAPP. The samples will be labeled and handled in accordance with Section 4.3 of the QAPP.

3.5.5 Geotechnical Soil Sample Collection

Soil samples will be collected from the select monitoring well boreholes on site and off site. The samples will be submitted for grain size distribution, moisture content, soil porosity, permeability, and bulk density analysis. A Shelby tube (or equivalent thin-walled samplers) will meet ASTM standards for collecting undisturbed soil samples for bulk density and permeability. One sample of saturated sand at one location will be collected for maximum index density and unit weight by vibratory table. This analysis requires a 5-gallon bucket of sample volume, and should be collected from contaminant-free aquifer, if possible. The drilling method chosen for the monitoring wells will determine whether it is feasible to collect this sample.

For sample collection, the borehole will be advanced to a zone immediately above the pre-determined sample interval. Then the thin-walled sampler will be deployed downhole to

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retrieve the necessary volume for geotechnical analysis. Previous attempts to collect Shelby tube samples at depth have proven difficult. The field team leader will monitor this sampling activity, and will consult with the HGL task order manager and EPA TOPO if an undisturbed sample cannot be collected.

The on site geotechnical samples may be collected from DPT soil borings if monitoring wells are not installed on site. These samples will be placed in jars for analysis of grain size, moisture content, and porosity. Soil samples will be placed in resealable bags or acetate sleeves for permeability and bulk density analysis. An off-set DPT boring will be advanced to collect additional volume if necessary.

3.5.6 Groundwater Sampling

Groundwater samples will be collected from new monitoring wells, existing monitoring and multilevel wells, and DPT grab samples. All groundwater samples will be submitted to the EPA Region 7 Laboratory for VOCs analysis by EPA Method SW-846 8260B. Select samples will be analyzed for groundwater treatment evaluation parameters including TSS, TDS, and total phosphorous. Select samples will be collected for MNA parameters including alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, methane, ethane, and ethene.

The EPA Region 7 laboratory will complete the analyses. Sample container and preservation requirements for samples collected for groundwater analyses are listed in Table 4.1 of the QAPP. This table provides a list of preservation requirements, holding times, and container requirements for all analytical groups. The samples will be labeled and handled in accordance with Section 4.3 of the QAPP. All samples will be stored on ice in coolers and maintained at 4°C during shipment to the regional laboratory.

The following subsections discuss groundwater level measurement and sampling protocols.

3.5.6.1 Water Level Measurements

Groundwater level measurements will be collected manually from all existing monitoring wells using an electric water level indicator. The multi-level monitoring wells have dedicated transducers at each of the 5 sampling ports in each well. A portable readout unit instrument will be used to gather water pressure data from the transducers for conversion to water levels. Water levels also will be collected from selected DPT groundwater grab sample locations. These water level measurements should be considered screening level because of the minimal equilibration time before the measurement is collected.

Water level measurements will be taken in accordance with EPA Region 7 SOP 2043 *Manual Water Level Measurements* included in Attachment 1. The location, date, time, and groundwater level will be recorded for all wells on the field form included in Attachment 2. Before measurements are made, water levels in newly constructed monitoring wells will be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to equilibrium may take longer. All measurements will be made to an accuracy of 0.01 feet. Water level measuring equipment will

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be decontaminated in accordance with Section 3.6. In general, measurements should proceed from the least to the most contaminated wells. Water level measurement events will be performed in as short a timeframe as possible to minimize variability due to ambient barometric variations.

3.5.6.2 DPT Groundwater Sampling

Groundwater samples collected from DPT boreholes are considered grab samples. These samples will be collected following EPA SOP 4230.15A for groundwater sampling and CDM SOP 3.1, *Geoprobe® Sampling*. The standard procedures for collecting groundwater grab samples are summarized below:

- Initially, the groundwater sampler will be driven to the bottom depth (bedrock surface). The screen will then be exposed at the final depth, and pulled back toward the ground surface to collect samples at each specified interval.
- Samples will be collected through a sampling screen assembly attached to push rods. A minimum of three gallons of water will be purged with an inertial pump or mini bladder pump before sampling to ensure a representative sample from each interval. Three gallons is the volume needed to purge three tubing volumes (250-foot length; 3/8-inch internal diameter [ID]). Clean polyethylene tubing will be used for each sample. Tubing will be disposed of as IDW in accordance with Section 4.0.
- Water quality parameters (pH, temperature, specific conductivity, oxidation-reduction potential [ORP], and dissolved oxygen [DO]) will be recorded on the Groundwater Purging and Sampling Forms (Attachment 2) at the time the samples are collected.
- Groundwater samples will be collected directly from the discharge tubing into the appropriate sample container. The pump rate will be maintained at the same rate used during purging.

The decontamination procedures in Section 3.6 will be followed after each DPT groundwater sample is collected. After sampling has been completed, the boreholes will be abandoned in accordance with the procedures discussed in Section 3.4.3. Water IDW generated during execution of this task will be managed as described in Section 4.0.

3.5.6.3 Monitoring Well Sampling

In addition to the DPT groundwater grab samples, groundwater samples will be collected from the 32 existing on-site monitoring wells, 20 existing off-site monitoring wells, and 10 new off-site monitoring wells.

Groundwater samples will be collected in accordance with the low flow sampling procedures outlined in EPA document *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, EPA/540/S-95/504, April 1996 (Attachment 1).

The standard low-flow procedures for sampling the monitoring wells are summarized below:

- During sampling of existing monitoring wells, each well will be purged and sampled using a portable bladder pump. Combination 3/8-inch ID (water line) and 1/4-inch ID (air line) tubing will be assembled between the compressor, pump, and in-line water

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quality meter. This tubing will be disposed of as described in Section 4.0. Decontamination of the pump will be performed as described in Section 3.6.

- An initial water level will be measured from the well before purging and will be continuously measured during low-flow purging and sampling of the well. Water level measurements will be taken in accordance with EPA Region 7 SOP 4230.15A included in Attachment 1.
- The purge rate shall not exceed 0.5 liters per minute (L/min). The rate will be adjusted to as low as possible to minimize drawdown (ideally <0.1 meter). The water level in the well will be monitored throughout the purging process.
- Physical parameters of pH, temperature, specific conductivity, ORP, DO, turbidity, and water level will be recorded during the purging process on the Groundwater Purging and Sampling Form (Attachment 2). Readings will be recorded every 3 minutes during purging. Monitoring well purging will continue until the parameters have stabilized. Stabilization for the parameters is ± 1°C for temperature, ± 0.1 pH units, ± 3 percent conductivity, ± 10 millivolts (mV) for ORP, and ± 10 percent for DO and turbidity for three consecutive readings.
- Groundwater samples will be collected directly from the discharge hose prior to the flow-through measuring device into the appropriate sample container. The pump rate will be maintained at the same rate used during purging.
- During the sampling phase, the field test kit analysis for DO will be performed and the results noted on the field form (Attachment 2). Sample volume for the ferrous iron, CO_2, and BART biofouling test kits will be collected from designated wells and stored for later same-day analysis in the field office.
- Generated purge water will be containerized and managed in accordance with the procedures detailed in Section 4.0.

3.5.6.4 Multilevel Monitoring Well Sampling

On site monitoring wells include 20 conventional monitoring wells and 12 multilevel wells. Groundwater samples will be collected from the 12 existing on-site multi-level monitoring wells. Section 2.1.1.2 discusses the locations of these wells. The sampling protocols for the multilevel wells is the same as for the existing monitoring wells discussed above in Section 3.5.4.3, except that these wells have dedicated pumps and tubing for each sampling port in every well.

3.5.7 Surface Soil Sampling

Surface soil samples will be collected from a depth of 0 to 1 foot in accordance with the HGL SOP *Soil Sampling* (January 2006) included in Attachment 1. In general, a clean utensil (e.g. trowel, shovel) will be used to remove the soil to the desired depth. Another clean utensil will be used to transfer the sampled soil to an aluminum pie pan. VOC samples will be collected immediately before homogenization. Next, the remaining sample volume will be homogenized in an aluminum pie pan; grass, roots, and gravel will be discarded from the sample prior to containerizing the soil samples in the appropriate non-VOC sample containers. New, disposable pie pans and spoons will be used to prevent cross contamination between samples. The shovel or trowel will be decontaminated in accordance with Section 3.6 below.

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Sample container and preservation requirements for samples collected for groundwater analyses are listed in Table 4.1 of the QAPP. This table provides a list of preservation requirements, holding times, and container requirements for all analytical groups. The samples will be labeled and handled in accordance with Section 4.3 of the QAPP. All samples will be stored on ice in coolers and maintained at 4°C during shipment to the regional laboratory.

3.5.8 Sediment Sampling

The following procedures will be utilized for collecting shallow surface sediment from locations along the intermittent drainage features on site, and from the pond on site. The sampling will be conducted in accordance with EPA Environmental Response Team SOP #2016 *Sediment Sampling*, dated November 1994 (Appendix E).

Sediment samples will be collected at each location using a plastic or stainless steel trowel or scoop (possibly from beneath a shallow aqueous layer). The trowel or scoop will be decontaminated in accordance with the procedures specified in Section 3.6. For the purpose of this sampling activity and sampling method, surface sediment is considered to range from 0 to 6 inches in depth and a shallow aqueous layer is considered to range from 0 to 12 inches in depth. The following procedure will be used to collect sediment with a scoop or trowel:

- Using a decontaminated sampling implement, remove the desired thickness and volume of sediment from the sampling area;
- Transfer the sample into an appropriate sample container containing any analytical method specified preservative. Samples for VOCs analysis should be collected first;
- Surface water should be decanted from the sample container prior to sealing or transfer. Care should be taken to retain the fine sediment fraction during this procedure;
- Collected samples will be placed immediately into a sample cooler and maintained with ice at a temperature of 4° C. Sample container and preservation requirements for samples collected for groundwater analyses are listed in Table 4.1 of the QAPP.

It should be noted that the sediment sampling will proceed from downstream locations to upstream locations in both intermittent drainage ways, if water is flowing at the time of sample collection. This will prohibit cross-contamination of samples due to sediment migration from one sample location to the next.

3.5.9 Surface Water Sampling

A surface water sample will be collected from the on site pond in accordance with EPA SOP #2013 (November 1994). It should be noted that this sample will be collected prior to the collocated sediment sample to minimize turbidity in the water sample caused by the sediment sampling.

Sampling Procedures:

- Submerge the appropriate decontaminated sampling device into the water. VOCs will be collected first to minimize sample agitation and loss of volatile constituents. Volatile Organic Analysis (VOA) vials will be filled leaving no headspace and will be preserved with hydrochloric acid (HCl) to a pH of less than 2. Parameters other than VOCs will

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then be collected. The samples will be poured into the appropriate prepreserved containers;
- Measure pH, temperature, specific conductance, DO, ORP, and turbidity; and
- Place samples into a cooler with ice, cool, and maintain samples to 4 °C.

Sample container and preservation requirements for samples collected for groundwater analyses are listed in Table 4.1 of the QAPP. This table provides a list of preservation requirements, holding times, and container requirements for all analytical groups. The samples will be labeled and handled in accordance with Section 4.3 of the QAPP.

3.5.10 Subslab Soil Gas Sampling

Subslab soil gas samples will be collected beneath the office/shop building and the maintenance shop. These samples will be collected in accordance with HGL SOP 2.29 *Collection of Sub-Slab Vapor Samples Using Summa Canisters*. This SOP and associated Figure 1 Subslab Vapor Port are provided in Attachment 1. In general, the vapor monitoring installation procedures are as follows:

- Using an electric hammer drill, drill a 3/8-inch pilot hole to approximately 2 inches into the concrete slab;
- Using the pilot hole as a center, drill an outer hole to an approximate depth of 1 3/8 inches using a 1-inch diameter drill bit;
- Replacing the 1-inch bit with the 3/8 inch diameter drill bit continue to drill the pilot hole thru the slab and several inches into the sub-slab material;
- Once drilling is completed, the completed hole is monitored with a PID to indicate the presences of VOCs;
- A stainless steel port is assembled and inserted into the pre-drilled hole (Subslab SOP Figure 1, Attachment 1). See SOP for all components of the sampling port;
- Finally, the port is sealed in place with cement.

Following installation, the sampling port is leak checked using helium before sampling is commenced. The sampling procedure is generally as follows (See SOP in Attachment 1 for full instructions):

- Check the summa canister for damage and confirm that the vacuum pressure on the laboratories tag matches that observed in the summa canister;
- Do not use a damaged or leaking canister; record vacuum pressure, etc. (See SOP);
- Verify that the flow controller is properly set to fill a 6-liter summa canister over an 8-hour period. The flow rate should be 11.25 milliliters per minute (mL/min);
- Attach the flow controller to the canister;
- Connect Teflon tubing to the sample port, and collect and record the reading from a PID connected to the Teflon tubing;
- Attach flow controller to Teflon tubing on sample port and slowly open summa canister valve one turn;
- After the canister pressure has been reduced to between 5-inches and 2-inches (this should be at 8-hours); slowly close the valve;
- Remove sampling port and patch hole with concrete to grade (Note: at the discretion of the EPA TOPO, the ports may be left in place until the results are evaluated.)

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The samples will be labeled and handled in accordance with Section 4.3 of the QAPP.

3.5.11 Air Sampling

Indoor and outdoor air samples will be collected in conjunction with the subslab soil gas sampling for a thorough vapor intrusion evaluation. The air sampling will be conducted in accordance with EPA SOP 1704 *Summa Canister Sampling*. The general sampling procedure is as follows:

- Check the summa canister for damage and leaks as above in Section 3.5.10;
- Screen the sample location with a PID;
- Place the Summa canister equipped with a flow controller at the desired sampling location. The height of the Summa canister must be in the breathing zone, approximately 3-6 feet above the floor;
- Open the Summa canister valve and allow a sample to be collected for an 8-hour period (flow rate of 11.25 mL/min). Using an 8-hour collection period allows for direct comparison to time-weighted average exposure limits;
- Close the Summa canister valve; and
- Ship the Summa canister to the selected laboratory according to procedures in the QAPP. The sample will be analyzed using Method TO-15.
- In addition, an inventory of materials stored in each room or adjacent room will be recorded to assist in identifying potential elevator-related sources of air VOCs.

3.5.12 IDW Sampling

IDW soil and water will handled in accordance with Section 4.0. Soil sample collection for disposal will be dependent on the specific requirements of the selected disposal location. At a minimum, a representative sample will be collected and sent to the EPA Region 7 laboratory for toxicity characteristic leaching procedure (TCLP) VOC analysis and/or analyses as required by the disposal facility. Non-hazardous soils will be sent to a municipal Subtitle D landfill for disposal. It is anticipated that soil IDW will be non-hazardous.

Composite VOC samples of IDW water will be analyzed prior to each city approved discharge event to the publicly owned treatment works.

3.5.13 Ecological Investigation

A screening level Ecological Investigation will be conducted to determine whether sensitive environments or endangered species are present at the site to support the ecological risk assessment. No samples will be collected in association with this effort. The Ecological Investigation will consist of:

- Wetland and Habitat Delineation
- Wildlife Observations
- Community Characterization
- Identification of Endangered Species

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3.6 EQUIPMENT DECONTAMINATION

3.6.1 Pump and Sampling Equipment Decontamination

Portable pumps used to sample existing monitoring wells, and other sample equipment that cannot be damaged by water, will be placed in a wash tub containing Alconox or low-sudsing non-phosphate detergent along with potable water. The interior of pumps will be flushed for at least 3 minutes; the exterior (and non-pump equipment) will be scrubbed with a bristle brush or similar utensil. Equipment will be rinsed with tap water in a second wash tub followed by a deionized water rinse. The interior of pumps will be flushed with the rinse waters. For groundwater sampling specifically, new tubing will be used at each location and equipment decontamination will not be required.

3.6.2 Drilling Equipment Decontamination

All downhole drilling equipment will require decontamination prior to and between each use. Decontamination procedures to be followed are provided in EPA SOP 4231.6A, *Sampling Equipment Decontamination* (Attachment 1) and are discussed below.

A decontamination pad will be constructed at the equipment decontamination area to decontaminate the drill rig(s) and associated drilling equipment and materials. The pad will be lined with polyethylene sheeting and will have bermed sides and a back to contain washwater. The pad will also contain a sump to allow the water to pool so it can be pumped into a polyethylene storage tank.

All DPT equipment, drilling equipment, and well materials including probe rods, accessory tools, casings, screens, and sampling equipment will be steam cleaned and devoid of any external oils or greases prior to use in each well. All contact equipment including pumps, hoses, and extension rods will be steam cleaned before each use. Decontamination water will be stored separately from purge water in a large capacity polyethylene storage tank at the equipment decontamination area.

All reusable sampling equipment will be either steam cleaned (large equipment) or cleaned with phosphate-free detergent using the following decontamination procedures (smaller sampling equipment):

- Wash and scrub with phosphate-free detergent (Alconox®)
- Tap water rinse
- Air dry
- Wrap in clean aluminum foil or plastic for transport (if the particular equipment will be used for sampling for chemical analysis)

3.7 SURVEYING

All survey work performed for this project will comply with State and Local regulations. A registered professional land surveyor licensed in the State of Nebraska will be subcontracted to

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determine by survey the elevations and/or horizontal locations of sample locations in support of this RI/FS. Surveys will incorporate basic control for which closures are known, consisting of existing triangulation, traverse station monuments, markers, and benchmarks. These controls will be fully documented on the survey and in the field logbooks. All work will be conducted using equipment, personnel, and procedures that will insure compliance with the accuracy standards defined herein. The project requires that all sampling points as marked by the HGL Field Team Leader be surveyed so that all horizontal data will be reported in Universal Transverse Mercator (UTM) North American Datum (NAD) 83, Zone 14 coordinates, and all vertical data will be referenced to North American Vertical Datum (NAVD) 88. Horizontal accuracy will be within ± 0.1 foot; vertical accuracy will be within ± 0.01 foot. Computations for all control stations and benchmarks will be furnished. The new dataset will be linked/verified with the existing survey data for consistency and to verify accuracy of the new survey data. All topographic and cultural features will be located in a manner to enable the calculation of coordinates of each feature shown on the site map.

The subcontracted surveyor will provide a hardcopy letter report and electronic deliverable to HGL containing all relevant survey information along with a legible copy of the field survey notes recorded. All documents submitted will bear the surveyor's seal, signature, and a certificate that all work was performed under the surveyor's supervision and that all information contained in the survey document is true and accurately represented.

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TABLE

Table 3.1
Field Equipment and Supplies

Sampling Supplies	
Sample containers	Deionized water
Preservatives (hydrochloric acid, nitric acid, sulfuric acid, sodium hydroxide)	Shipping material (packaging tape, bubble wrap)
Baggies	Sampling field forms
Ice	Sample labels
Sample shipping coolers	Chain-of-Custody forms
Alconox	Custody seals
Plastic spray bottles	Tape
Sampling Equipment	
Water quality meter	Calibration solutions
Turbidity meter	1/4-inch ID polyethylene tubing with foot valve (groundwater sampling)
Water level indicator	Combination 3/8-inch ID and 1/4-inch ID polyethylene tubing
12 VDC compressor	Hach test kit – CO_2
Portable bladder pump	Hach test kit – Ferrous Iron
QED controller	Chemetrics test kit – dissolved oxygen
Laptop computer	BART™ test kit – biofouling bacteria
Summa canister flow controllers	Shovel
Trowel	Teflon tubing (subslab soil gas sampling)
Helium tank (soil gas port leak checking)	Aluminum pie pans/spoons
Subslab soil gas port components (see SOP in Attachment 1)	
Health and Safety	
Hard hats	Safety glasses/high visibility vests
Nitrile gloves	Photoionization detector
Rubber gloves	First aid kits
Eye wash station	Fire extinguishers
Tyvek suits	Cotton glove liners
Rubber overboots or booties	Hearing protection
Combustible gas indicator	Multi-gas meter
General Field Operations	
Logbooks	Indelible ink pens
Digital camera	Paper towels
Kimwipes	Trash bags
Plastic sheeting	5-gallon buckets for decontamination
Measuring tape	Utility knives
Munsell color chart	55-gallon open-top drums
Brushes	Clear/duct tape

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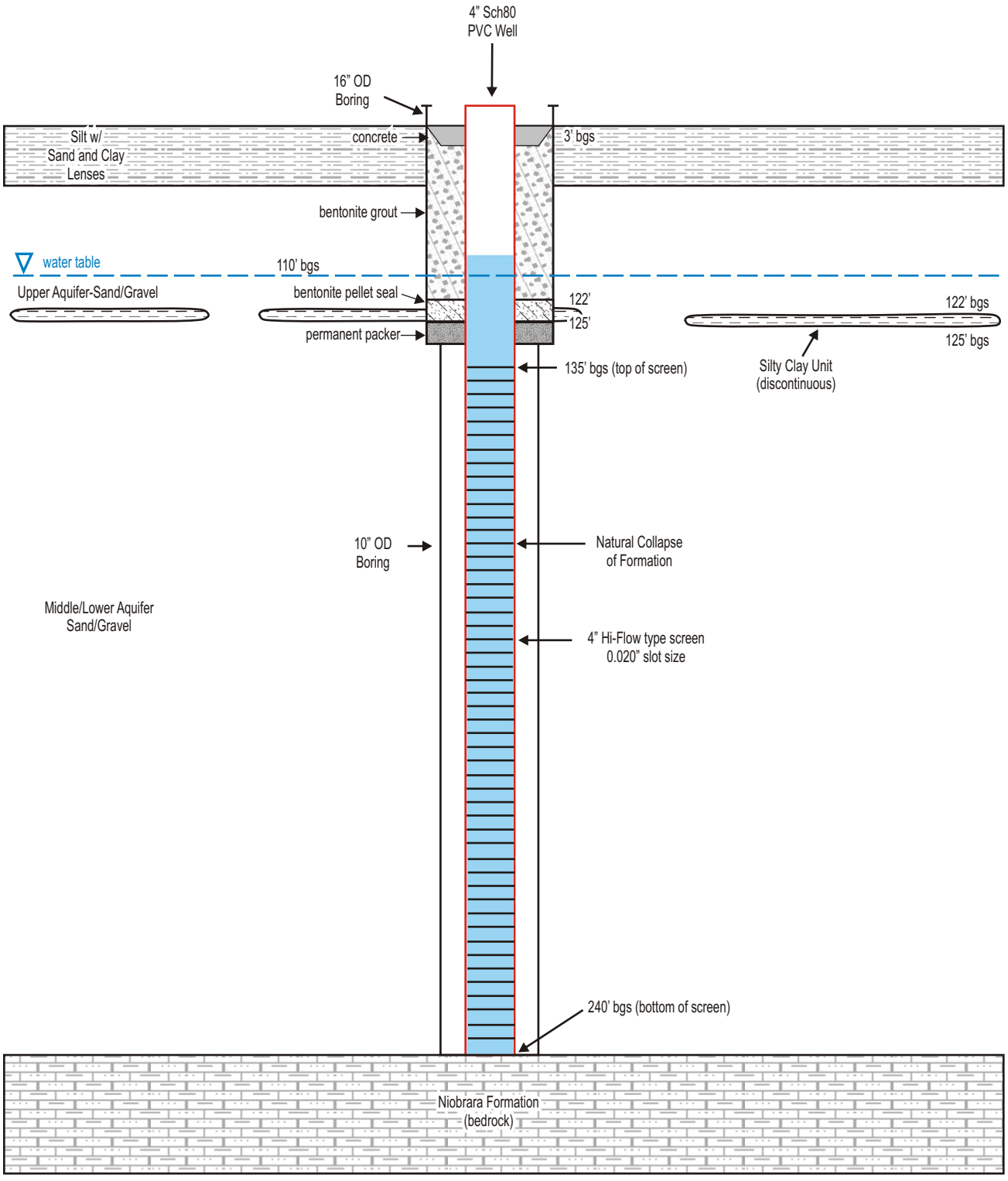
FIGURE



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Filename: X:/EPA009/GarveyFSP/Proposed_Hydraulic_Test_Well.cdr
Project: EP9033.01.46.11
Revised: 12/22/08 CV
Source: HGL

Figure 3.1
Proposed Hydraulic Test Well Construction Diagram

HGL HydroGeoLogic, Inc

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4.0 INVESTIGATION-DERIVED WASTE MANAGEMENT

All IDW will be properly containerized and stored on-site until its final disposition is determined. The IDW that will be generated during the RI field activities will consist of soil cuttings, drilling fluids, well development and purge water, decontamination water, disposable personal protective equipment (PPE), and general municipal refuse. Used PPE and general refuse will be collected in garbage bags and disposed of as solid municipal waste. Contaminated or potentially contaminated IDW will be segregated from uncontaminated IDW. Soil IDW will be containerized in 20 cubic yard roll-off containers and/or closed-top 55-gallon drums and held at a secure location on-site awaiting disposal. Drilling mud and cuttings may require a container to allow solidification before disposal. Containers will be labeled with the site name, boring/monitoring well number, description of contents, and dates of collection. Water IDW will be containerized in either 55-gallon closed-top drums or poly tanks and labeled appropriately.

Samples will be collected for waste characterization to determine proper disposal methods (see Section 3.5.5 for IDW sampling procedures). It is anticipated that most soil IDW will be disposed at the local municipal landfill. Water IDW is expected to be disposed at the publicly owned treatment works, once approved by the city.

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5.0 REFERENCES

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ATTACHMENT 1

STANDARD OPERATING PROCEDURES

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ATTACHMENT 1

STANDARD OPERATING PROCEDURES

1. EPA SOP #2044, *Monitor Well Development*
2. HGL SOP, *Well Slug Test*
3. CDM SOP 4-2 *Photographic Documentation of Field Activities*
4. EPA document *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, EPA/540/S-95/504
5. EPA Region 7 SOP 4230.15A *Groundwater Well Sampling*
6. CDM Federal SOP 3.1, *Geoprobe® Sampling*
7. EPA SOP 4231.6A, *Sampling Equipment Decontamination*
8. EPA Region 7 SOP 2420.5D *Identification, Documentation, and Tracking of Samples*
9. EPA Region 7 SOP 2420.4C, *Field Chain of Custody for Environmental Samples*
10. CDM SOP 2-1, *Packaging and Shipping of Environmental Samples*
11. CDM SOP 4-1, *Field Logbook Content and Control*
12. CDM SOP 3-5, *Lithologic Logging*
13. CDM SOP 5-1, *Control of Measurement and Test Equipment*
14. HGL SOP *Soil Sampling*
15. HGL SOP 2.29 *Collection of Sub-Slab Vapor Samples Using Summa Canisters*
16. EPA SOP 1704 *Summa Canister Sampling*
17. EPA SOP 2043 *Standard Operating Procedures*
18. EPA SOP 2016 *Sediment Sampling*
19. EPA SOP 2013 *Surface Water Sampling*

U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

MONITOR WELL DEVELOPMENT

CONTENTS

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*These sections affected by Revision 0.1.

SUPERCEDES: SOP #2044; Revision 0.0; 2/18/00; U.S. EPA Contract 68-C99-223.

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of monitor well development practices. The purpose of monitor well development is to ensure removal of fine grained sediments (fines) from the vicinity of the well screen. This allows the water to flow freely from the formation into the well, and also reduces the turbidity of the water during sampling. The most common well development methods are: surging, jetting, overpumping, and bailing.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting surging motion forces water into the formation and loosens sediment, pulled from the formation into the well. Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. Channels or voids may form near the screen if the filter pack sloughs away during surging (Keel and Boating, 1987).

Surging with compressed air is done by injecting a sudden charge of compressed air into the well with an air line so that water is forced through the well screen. The air is then turned off so that the water column falls back into the well and the process is repeated. Periodically, the air line is pulled up into a pipe string (educator) and water is pumped from the well using air as the lifting medium (air-lift pumping). The process is repeated until the well is sediment free. Method variations include leaving the air line in the pipe string at all times or using the well casing as the educator pipe.

Jetting involves lowering a small diameter pipe into the well and injecting a high velocity horizontal stream of water or air through the pipe into the screen openings. This method is especially effective at breaking down filter cakes developed during mud rotary drilling. Simultaneous air-lift pumping is usually used to remove fines.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and then allowing the well to recharge to the original level. This process is repeated until sediment-free water is produced.

Bailing includes the use of a simple manually operated check-valve bailer to remove water from the well. The bailing method, like other methods, should be repeated until sediment free water is produced. Bailing may be the method of choice in a shallow well or well that recharges slowly.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with a final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection

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Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

After installation, development of a well should occur as soon as it is practical. It should not occur any sooner than 48 hours after grouting is completed, especially if a vigorous well development method (i.e. surging) is being used. If a less vigorous method (i.e bailing) is used, it may be initiated shortly after installation. The method used for development should not interfere with the setting of the well seal.

Several activities must take place prior to well development. First, open the monitor well, take initial measurements (i.e., head space air monitoring readings, water level, total depth of the well) and record results in the site logbook. Develop the well by the appropriate method to accommodate site conditions and project objectives. Continue until the development water is clear and free of sediments, or until parameters such as pH, temperature, and specific conductivity stabilize. Containerize all purge water from wells with known or suspected contamination. Record final measurements in the site logbook. Decontaminate equipment as appropriate prior to use in the next well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following problems may be associated with well development:

1. Overpumping is not as vigorous as surging and jetting, and is probably the most desirable method for monitor well development. The possibility of disturbing the filter pack is greatest with surging and jetting well development methods.

2. The introduction of external water or air by jetting may alter the hydro chemistry of the aquifer.

3. Surging with air may produce “air locking” in some formations, preventing water from flowing into the well.

4. The use of surge blocks in formations containing clay may cause plugging of the screen.

5. Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casing are especially susceptible to clogging if used in well development applications.

6. Chemicals/reagents used during the decontamination of drilling equipment may complicate well development.

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5.0 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well and the development method. For example, the diameter of most submersible pumps is too large to fit into a two-inch inner diameter (I.D.) well, and other development methods should be used. Obtaining the highest possible yield is not usually an objective in developing monitor wells and vigorous development is not always necessary. Many monitor wells are constructed in fine-grained formations that would not normally be considered aquifers. Specifications for the drilling contract should include the necessary well development equipment (air compressors, pumps, air lines, surge blocks, generators).

6.0 REAGENTS

The use of chemicals in developing wells that will be used to monitor groundwater quality should be avoided if possible; however, polyphosphates (a dispersing agent), acids, or disinfectants are often used in general well development. Polyphosphates should not be used in thinly bedded sequences of sands and clays. The use of decontamination solutions may also be necessary. If decontamination of equipment is required at a well, refer to Environmental Response Team/Response Engineering and Analytical Contract (ERT/REAC) SOP #2006, *Sampling Equipment Decontamination* and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Coordinate site access and obtain keys to well locks.

2. Obtain information on each well to be developed (i.e., drilling method, well diameter, well depth, screened interval, anticipated contaminants).

3. Obtain a water level meter, a depth sounder, air monitoring instruments, materials for decontamination, and water quality instrumentation capable of measuring, at a minimum, pH, specific conductivity, temperature, and turbidity. Dissolved oxygen (DO) and salinity are also useful parameters.

4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted or roll-off tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e., activated carbon) may be used to decontaminate the purge water.

7.2 Operation

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after well completion.

1. Assemble necessary equipment on a plastic sheet surrounding the well.

2. Record pertinent information in the site or personal logbook (personnel, time, location ID, etc.).

3. Open monitor well, take air monitor reading at the top of casing and in the breathing zone as appropriate.

4. Measure depth to water and the total depth of the monitor well. Calculate the water column volume of the well (Equation 1, Section 8.0).

5. Begin development and measure the initial pH, temperature, turbidity, and specific conductivity of the water and record in the site logbook. Note the initial color, clarity, and odor of the water.

6. Continue to develop the well and periodically measure the water quality parameters indicated in step 5 (above). Depending on project objectives and available time, development should proceed until these water quality parameters stabilize, or until the water has a turbidity of less than 50 nephelometric turbidity units (NTUs).

7. All water produced by development of contaminated or suspected contaminated wells must be containerized or treated. Each container must be clearly labeled with the location ID, date collected, and sampling contractor. Determination of the appropriate disposal method will be based on the analytical results from each well.

8. No water shall be added to the well to assist development without prior approval by the appropriate U.S. EPA ERT Work Assignment Manager (WAM) and/or appropriate state personnel. In some cases , small amounts of potable water may be added to help develop a poor yielding well. It is essential that at least five times the amount of water injected must be recovered from the well in order to assure that all injected water is removed from the formation.

9. Note the final water quality parameters in the site or personal logbook along with the following data:

   - Well designation (location ID)
   - Date(s) of well installation
   - Date(s) and time of well development

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- Static water level before and after development
- Quantity of water removed, and initial and completion time
- Type and capacity of pump or bailer used
- Description of well development techniques

7.3 Post-Operation

1. Decontaminate all equipment;

2. Secure holding tanks or containers of development water;

3. Review analytical results and determine the appropriate water disposal method. Actual disposal of the purge water is generally carried out by the On-Scene Coordinator (OSC).

8.0 CALCULATIONS

To calculate the volume of water in the well, the following equation is used:

Well Volume (V) = Br^2 h (cf) [Equation 1]

where:

B	=	pi (3.14)
r	=	radius of monitoring well in feet (ft)
h	=	height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf	=	conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3. [In this equation, 7.48 gal/ft^3 is the necessary conversion factor.]

Monitor well diameters are typically 2-, 3-, 4-, or 6-inches. A number of standard conversion factors can be used to simplify the above equation using the diameter of the monitor well. The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:
where:

V (gal/ft) = Br^2 (cf) [Equation 2]

B	=	pi
r	=	radius of monitoring well (feet)
cf	=	conversion factor (7.48 gal/ft^3)

For example, a two inch diameter well, the volume per linear foot can be calculated as follows:

$$V\ (gal/ft) = Br^2\ (cf) \quad \text{[Equation 2]}$$
$$= 3.14\ (1/12\ ft)^2\ 7.48\ gal/ft^3$$
$$= 0.1631\ gal/ft$$

NOTE: The diameter must be converted to the radius in feet as follows:

$$\frac{\text{Well Diameter (inches)}}{12} \times 0.5 = \text{Well Radius (feet)} \quad \text{[Equation 3]}$$

The volume in gallons/feet for the common size monitor wells are as follows:

Well diameter (inches)	2	3	4	6
Volume (gal/ft)	0.1631	0.3670	0.6524	1.4680

If you utilize the volumes for the common size wells above, Equation 1 is modified as follows: where:

$$\text{Well volume} = (h)(f) \quad \text{[Equation 4]}$$

h = height of water column (feet)
f = the volume in gal/ft calculated from Equation 2

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities, which apply to the implementation of these procedures. However, the following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented in site and/or personal logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

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When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health (OSHA), and corporate health and safety practices.

12.0 REFERENCES

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13.0 APPENDICES

This section is not applicable to this SOP.

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SOP 2.11
WELL SLUG TEST

1.0 PURPOSE

The purpose of this SOP is to define the field methods for the collection of data for determining saturated hydraulic conductivity under in situ conditions by the slug test withdrawal method.

2.0 DEFINITIONS

Hydraulic conductivity: The flow rate of water in gallons per day through a cross-section of one square foot under a unit hydraulic gradient, at the prevailing temperature (gallons per day per square meter [$g/d/m^2$]).

Storage coefficient(s): The volume of water an aquifer releases from or takes in to storage per unit surface area of the aquifer per unit change in head.

3.0 BACKGROUND AND CAUTIONS

The slug test measures the rate at which groundwater stabilizes in a well over time due to the injection or withdrawal of a mass (slug). From this water level fluctuation versus time data, the hydraulic conductivity of the area immediately surrounding a well can be determined. Refer to the site-specific work plan for more information on the scope of work activities for which slug testing is required and the locations of the wells that are to be tested. With the slug test the hydraulic conductivity or transmissibility of an aquifer is determined from the rate of rise or fall of the water level in a well or borehole after a certain volume or "slug" of water is suddenly removed from or added to the well. The slug is inserted or removed and the water level is allowed to reach equilibrium. Then the slug is suddenly removed from the system and the rise or fall in water level is measured with time.

The primary advantages of using slug tests to estimate conductivities are:

- Estimates can be made in situ and errors incurred in the laboratory testing of disturbed samples can be avoided;
- Tests can be performed quickly at relatively low costs because pumping on a well and observing nearby wells are not required;
- The hydraulic conductivity of small, discrete portions of an aquifer can be estimated (for example, sand layers in a clay); and
- Slug tests can limit or eliminate the amount of water removed from a well, which may be costly to dispose of.

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Limitations of slug testing include:

- Only the hydraulic conductivity of the area immediately surrounding the well is estimated, which may not be representative of the average hydraulic conductivity of the local area;
- Certain assumptions made in the analysis process; if the assumptions are inappropriate for the geologic conditions at the site, the slug test data are invalid;
- The storage coefficient, S, usually cannot be determined; and
- Data sufficient for analysis may not be collected if the hydraulic conductivity is relatively high.

The time required for a slug test is a function of the volume of the slug, the hydraulic conductivity of the formation, and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours. If the well is to be used as a monitoring well, take precautions so that contamination does not occur through material introduced into the well. If water is added to the monitoring well, obtain it from an uncontaminated source and transport it in a clean container. Clean bailers or measuring devices before the test. If tests are performed on more than one monitoring well, avoid cross-contamination of the wells. Conduct slug tests on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water-sampling purposes, the measured water level must be within 0.1 foot of the water level before sampling. At least one week should elapse between the drilling of a well and the performance of a slug test.

NOTE: The exact dimensions of the monitoring well, borehole, casing, and sand pack must be recorded to analyze the slug test data correctly. Site workers preparing for field operations should read and understand the procedures outlined in the project- or site-specific Health and Safety Plan (HSP).

4.0 EQUIPMENT LIST

- Water pressure transducer with electronic data logger, if applicable
- Electric water level indicator
- Clean slug of a known volume
- “Teflon” or stainless bailer of a known volume
- Watch or stopwatch with second hand
- Tape measure (subdivided into tenths of feet)
- Semilog graph paper (if required) and straight edge
- Appropriate references and calculator
- Duct tape
- Non-water-soluble black ink pens
- Daily Activity Logs

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- Groundwater Elevation forms
- Slug Test Data forms

5.0 PROCEDURES

The following general procedures should be used to collect and report slug test data. The procedures required for a particular slug test may vary slightly from those described, depending on site-specific conditions. Modifications to the test procedures will be contained in the site-specific work plan. Procedures for conducting the slug test with a pressure transducer and data logger, as well as a water level probe, are described below. Be sure to complete all data collection forms.

Slug Test with Pressure Transducer and Data Logger

Before beginning the slug test, enter the required information into the electronic data logger. Information may vary, depending on the model used. When using different models, consult the operations manual for the proper data-entry sequence to be used.

When the slug test is performed with an electronic data logger and pressure transducer, store all data internally or on computer disks. The information will be transferred directly to the main computer and analyzed. Maintain a computer printout of the data in the files as documentation.

- Determine the static water level in the well, measuring the depth to water periodically for several minutes to several hours, and taking the average of the readings. Additional information should be recorded on the daily activity log.
- Install the transducer and cable in the well below the target drawdown estimated for the test. Be sure this depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at a constant depth.
- After connecting the transducer cable to the electronic data logger, enter the initial water level and transducer design range into the recording device according to the manufacturer's instructions. The transducer design range will be stamped on the side of the transducer. Record the initial water level on the recording device.
- Smoothly lower the slug or bailer into the well. Where the slug contacts the water can be detected by observing the transducer readout.
- Allow the water level to restabilize (within 0.1 foot) and remove the cylinder or bailer. Remove or add the volumes as quickly and smoothly as possible, because the analysis assumes that an instantaneous change in volume is created in the well.
- Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a plot of recovery versus the logarithm of time.
- Lower the slug and repeat the data collection portions of the steps above.

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Slug Test with Water Level Probe

- If the slug test data are collected and recorded manually, record observations on the Slug Test Data form. This method should only be used if an electronic data recorder cannot be obtained. This method cannot be used for aquifers with a high hydraulic conductivity because stabilization of groundwater will occur rapidly. Determine the static water level in the well, measuring the depth to water periodically for several minutes and taking the average of the readings. Record results on the Groundwater Elevation Log form. NOTE: When measuring water level changes, it is important to take the measurements rapidly for accurate results.
- Smoothly lower the slug or bailer into the well. Where the top slug contacts the water can be estimated by marking the depth to water found in part A onto the slug line.
- Measure and record the depth to water and the time at each reading. The moment when the volume is added or removed is Time Zero. Depths should be measured to the nearest 0.1 foot. The number of depth-time measurements necessary to complete the test varies.
- Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a plot of recovery versus the logarithm of time.
- Lower the slug and repeat the data collection portions of the two steps above.
- If using an electronic data logger, follow the steps listed below.
  - ❖ Stop the logging sequence.
  - ❖ Print the data or send to the computer by telephone.
  - ❖ Save memory and disconnect the battery at the end of the day's activities.
- Check all data collection forms for completeness.

6.0 ATTACHMENTS

Attachment 1 – Slug Test Data Form
Attachment 2 – Groundwater Elevation Log

7.0 REFERENCES

Bouwer, H. 1978. "Groundwater Hydrology," McGraw-Hill Book Company, New York, N.Y.

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ATTACHMENT 1
SLUG TEST DATA FORM

SLUG TEST DATA

LOCATION _____ SLUG VOLUME (FT^3) _____

LOCATION I.D. _____ LOGGER CODE _____

LOGDATE _____ ACCEPTANCE CODE _____

TEST METHOD: [ ] SLUG INJECTION OR [ ] SLUG WITHDRAWAL

COMMENTS: _____

_____

_____

ELAPSED TIME (MIN)	DEPTH-TO-WATER (FT)
0.00	

ELAPSED TIME (MIN)	DEPTH-TO-WATER (FT)

ACCEPTANCE CODES: A - ACCEPTABLE R - RECONNAISSANCE U - UNACCEPTABLE N - NOT DETERMINED

_____ _____

FORM COMPLETED BY / DATE TECHNICAL REVIEWER / DATE

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ATTACHMENT 2
GROUNDWATER ELEVATION LOG

Project Name: _____

Project No.: _____

Water Level Indicator ID#: _____ **PID Meter ID#:** _____

Well Identification	Date	Time	Static Depth to Water (from TOC)	Depth to Product (from TOC)	PID Reading	Comments

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Photographic Documentation of Field Activities

Prepared: David O. Johnson
Technical Review: Jo Nell Mullins
QA Review: Laura Splichal
Approved: _____ Signature/Date
Issued: _____ Signature/Date

1.0 Objective

The purpose of this standard operating procedure (SOP) is to provide standard guidelines and methods for photographic documentation, which include still and digital photography and videotape recordings of field activities and site features (geologic formations, core sections, lithologic samples, water samples, general site layout, etc.). This document shall provide guidelines designed for use by a professional or amateur photographer. This SOP is intended for circumstances when formal photographic documentation is required. Based on project requirements, it may not be applicable for all photographic activities.

2.0 Background

2.1 Definitions

Photographer – A photographer is the camera operator (professional or amateur) of still photography, including digital photography, or videotape recording whose primary function with regard to this SOP is to produce documentary or data-oriented visual media.

Identifier Component – Identifier components are visual components used within a photograph such as visual slates, reference markers, and pointers.

Standard Reference Marker – A standard reference marker is a reference marker that is used to indicate a feature size in the photograph and is a standard length of measure, such as a ruler, meter stick, etc. In limited instances, if a ruled marker is not available or its use is not feasible, it can be a common object of known size placed within the visual field and used for scale.

Slates – Slates are blank white index cards or paper used to present information pertaining to the subject/procedure being photographed. Letters and numbers on the slate will be bold and written with black, indelible marking pens.

Arrows and Pointers – Arrows and pointers are markers/pointers used to indicate and/or draw attention to a special feature within the photograph.

Contrasting Backgrounds – Contrasting backgrounds are backdrops used to lay soil samples, cores, or other objects on for clearer viewing and to delineate features.

Data Recording Camera Back – A data recording camera back is a camera attachment or built-in feature that will record, at the very least, frame numbers and dates directly on the film.

2.2 Discussion

Photographs and videotape recordings made during field investigations are used as an aid in documenting and describing site features, sample collection activities, equipment used, and possible

lithologic interpretation. This SOP is designed to illustrate the format and desired placement of identifier components, such as visual slates, standard reference markers, and pointers. These items shall become an integral part of the "visual media" that, for the purpose of this document, shall encompass still photographs, digital photographs, and videotape recordings (or video footage). The use of a photographic logbook and standardized entry procedures are also outlined. These procedures and guidelines will minimize potential ambiguities that may arise when viewing the visual media and ensure the representative nature of the photographic documentation.

2.3 Associated Procedures

- CDM Federal SOP 4-1, Field Logbook Content and Control

3.0 Responsibilities

Field Team Leader (FTL) – The FTL is responsible for ensuring that the format and content of photographic documentation are in accordance with this procedure. The FTL is responsible for directing the photographer to specific situations, site features, or operations that the photographer will be responsible for documenting.

Photographer – The photographer shall seek direction from the FTL and regularly discuss the visual documentation requirements and schedule. The photographer is responsible for maintaining a logbook per Sections 5.1, 5.2.4, and 5.3.1 of this SOP.

4.0 Required Equipment

The following is a general list of equipment that may be used:

- 35mm camera or disposable single use camera (35mm or panoramic use)
- Digital camera
- Extra batteries for 35mm camera
- Video camera
- Logbook
- Indelible black or blue ink pen
- Standard reference markers
- Slates
- Arrows or pointers
- Contrasting backgrounds
- Medium speed, or multi purpose fine-grain, color, 35 mm negative film or slide film (project dependent)
- Data recording camera back (if available)
- Storage medium for digital camera

5.0 Procedures

5.1 Documentation

A commercially available, bound logbook will be used to log and document photographic activities. Review the CDM Federal SOP 4-1, Field Logbook Content and Control and prepare all supplies needed for logbook entries.

Note: A separate photographic logbook is not required. A portion of the field logbook may be designated as the photographic log and documentation section.

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5.1.1 Field - Health and Safety Considerations

There are no hazards that an individual will be exposed to specific to photographic documentation. However, site-specific hazards may arise depending on location or operation. Personal protective equipment used in this operation will be site-specific and dictated through requirements set by the site safety officer, site health and safety plan, and/or prescribed by the CDM Federal Corporate Health and Safety Program. The photographer should contact the site safety officer for health and safety orientation prior to commencing field activities. The site health and safety plan must be read prior to entry to the site, and all individuals must sign the appropriate acknowledgement that this has been done.

The photographer should be aware of any potential physical hazards while photographing the subject (e.g., traffic, low overhead hazard, edge of excavation).

5.2 Operation

5.2.1 General Photographic Activities in the Field

The following sections provide general guidelines that should be followed to visually document field activities and site features using still/digital cameras and video equipment. Listed below are general suggestions that the photographer should consider when performing activities under this SOP:

- The photographer should be prepared to make a variety of shots, from close-up to wide-angle. Many shots will be repetitive in nature or format especially close-up site feature photographs. Consideration should therefore be given to designing a system or technique that will provide a reliable repetition of performance.
- All still film photographs should be made using a medium speed, or multi purpose fine-grain, color negative film in the 35 mm format unless otherwise directed by the FTL.
- It is suggested that Kodak brand "Ektapress Gold Deluxe" film or equivalent be used as the standard film for the still photography requirements of the field activities. This film is stable at room temperature after exposure and will better survive the time lag between exposure and processing. It is suggested that film speed ASA 100 should be used for outdoor photographs in bright sunlight, ASA 200 film should be used in cloudy conditions, and ASA 400 film should be used indoors or for very low-light outdoor photographs.
- No preference of videotape brand or digital storage medium is specified and is left to the discretion of the photographer.
- The lighting for sample and feature photography should be oriented toward a flat condition with little or no shadow. If the ambient lighting conditions are inadequate, the photographer should be prepared to augment the light (perhaps with reflectors or electronic flash) to maintain the desired visual effect.
- Digital cameras have multiple photographic quality settings. A camera that obtains a higher resolution (quality) has a higher number of pixels and will store a fewer number of photographs per digital storage medium.

5.2.2 General Guidelines for Still Photography

Slate Information

When directed by the FTL, each new roll of film or digital storage medium shall contain on the first usable frame (for film) a slate with consecutively assigned control numbers (a consecutive, unique number that is assigned by the photographer as in sample numbers).

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Caption Information
All still photographs will have a full caption permanently attached to the back or permanently attached to a photo log sheet. The caption should contain the following information (digital photographs should have a caption added after the photographs are downloaded):

- Film roll control number (if required) and photograph sequence number
- Date and time
- Description of activity/item shown (e.g., name of facility/site, specific project name, project no.)
- Direction (if applicable)
- Photographer

When directed by the FTL, a standard reference marker should be used in all documentary visual media. While the standard reference marker will be predominantly used in close-up feature documentation, inclusion in all scenes should be considered.

Digital media should be downloaded at least once each day.

Close-Up and Feature Photography
When directed by the FTL, close-up photographs should include a standard reference marker of appropriate size as an indication of the feature size and contain a slate marked with the site name and any identifying label, such as a well number or core depth, that clearly communicates to the viewer the specific feature being photographed.

Feature samples, core pieces, and other lithologic media should be photographed as soon as possible after they have been removed from their in situ locations. This enables a more accurate record of their initial condition and color. When directed by the FTL, include a standard reference color strip (color chart such as Munsell Soil Color Chart or that available from Eastman Kodak Co.) within the scene. This is to be included for the benefit of the viewer of the photographic document and serves as a reference aid to the viewer for formal lithologic observations and interpretations.

Site Photography
Site photography, in general, will consist predominantly of medium and wide-angle shots. A standard reference marker should be placed adjacent to the feature or, when this is not possible, within the same focal plane.

While it is encouraged that a standard reference marker and caption/slate be included in the scene, it is understood that situations will arise that preclude their inclusion within the scene. This will be especially true of wide-angle shots. In such a case, the film/tape control number shall be entered in the photographic logbook along with the frame number and all other information pertinent to the scene.

Panoramic
In situations where a wide-angle lens does not provide sufficient subject detail, a single-use disposable panoramic camera is recommended. If this type of camera is not available, a panoramic series of two or three photos would be appropriate. Panoramas can provide greater detail while covering a wide subject, such as an overall shot of a site.

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To shoot a panoramic series using a standard 35 mm or digital camera, the following procedure is recommended.

- Use a stable surface or tripod to support the camera
- Allow a 20 to 30 percent overlap while maintaining a uniform horizon
- Complete two to three photos per series

5.2.3 General Photographic Documentation Using Video Cameras

As a reminder, it is not within the scope of this document to set appropriate guidelines for presentation or "show" videotape recording. The following guidelines are set for documentary videotape recordings only and should be implemented at the discretion of the FTL.

Documentary videotape recordings of field activities may include an audio slate for all scenes. At the beginning of each video session, an announcer will recite the following information: date, time (in military units), photographer, site ID number, and site location. This oral account may include any additional information clarifying the subject matter being recorded.

A standard reference marker may be used when taking close-up shots of site features with a video camera. The scene may also include a caption/slate. It should be placed adjacent and parallel to the feature being photographed.

It is recommended that a standard reference marker and caption/slate be included in all scenes. The caption information is vital to the value of the documentary visual media and should be included. If it is not included within the scene, it should be placed before the scene.

Original videotape recordings will not be edited. This will maintain the integrity of the information contained on the videotape. If editing is desired, a working copy of the original videotape recording can be made.

A label should be placed on the videotape with the appropriate identifying information (i.e., project name, project number, date, location, etc.).

5.2.4 Photographic Documentation

Photographic activities must be documented in a photographic logbook or in a section of the field logbook. The photographer will be responsible for making proper entries.

In addition to following the technical standards for logbook entry as referenced in CDM Federal SOP 4-1, the following information should be maintained in the appropriate logbook:

- Photographer name.
- If required, an entry shall be made for each new roll/tape control number assigned.
- Sequential tracking number for each photograph taken (for digital cameras, the camera-generated number may be used).
- Date and time (military time).
- Location.
- A description of the activity/item photographed.

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- If needed, a description of the general setup, including approximate distance between the camera and the subject, may be recorded in the logbook.
- Record as much other information as possible to assist in the identification of the photographic document.

5.3 Post Operation

All film will be sent for development and printing to a photographic laboratory (to be determined by the photographer). The photographer will be responsible for arranging transport of the film from the field to the photographic laboratory. The photographer shall also be responsible for arranging delivery of the negatives and photographs, digital storage medium, or videotape to the project management representative.

5.3.1 Documentation

At the end of each day's photographic session, the photographer(s) will ensure that the appropriate logbook has been completely filled out and maintained as outlined in CDM Federal SOP 4-1.

5.3.2 Archive Procedures

1. Photographs and the associated set of uncut negatives, digital media, and original unedited documentary videotape recordings will be submitted to the project files and handled according to contract records requirements. The FTL will ensure their proper distribution.

2. Completed pages of the appropriate logbook will be copied weekly and submitted to the project files.

6.0 Restrictions/Limitations

This document is designed to provide a set of guidelines for the field amateur or professional photographer to ensure that an effective and standardized program of visual documentation is maintained.

It is not within the scope of this document to provide instruction in photographic procedures, nor is it within the scope of this document to set guidelines for presentation or "show" photography.

The procedures outlined herein are general by nature. The FTL is responsible for specific operational activity or procedure. Questions concerning specific procedures or requirements should be directed to the FTL.

Note: Some sites do not permit photographic documentation. Check with the site contact for any restrictions.

7.0 References

U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans, EM 200-1-3*, February 2001, Appendix F.

U.S. Environmental Protection Agency, Region IV, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, Athens, Georgia, November 2001.

U.S. Environmental Protection Agency, National Enforcement Investigations Center, *Multi-Media Investigation Manual*, EPA-330/9-89-003-R, Revised March 1992, p. 85.

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United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

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Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

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I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling

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objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

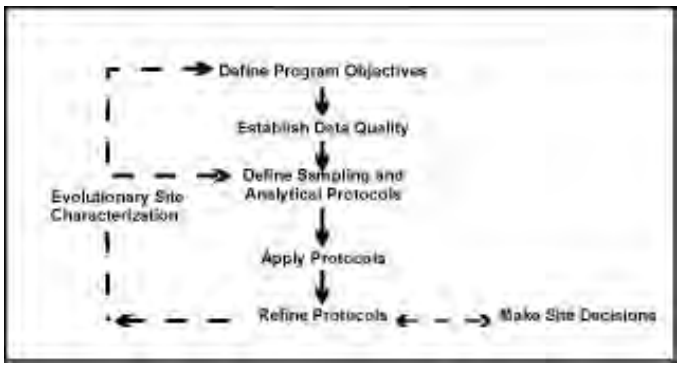

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

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1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-

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flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

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1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over any other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality

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indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of

the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described herein as part of its in-house research program and under Contract No. 68-C4-0031 to Dynamac Corporation. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Figure 2. **Ground Water Sampling Log**

Project _____ **Site** _____ **Well No.** _____ **Date** _____
Well Depth _____ **Screen Length** _____ **Well Diameter** _____ **Casing Type** _____
Sampling Device _____ **Tubing type** _____ **Water Level** _____
Measuring Point _____ **Other Infor** _____

_____

Sampling Personnel _____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

_____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

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Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project _____ **Site** _____ **Well No.** _____ **Date** _____
Well Depth _____ **Screen Length** _____ **Well Diameter** _____ **Casing Type** _____
Sampling Device _____ **Tubing type** _____ **Water Level** _____
Measuring Point _____ **Other Infor** _____

_____

Sampling Personnel _____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

_____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

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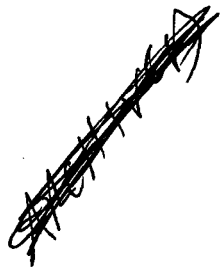
EPA SOP 4230.15A – Groundwater Well Sampling



STANDARD OPERATING PROCEDURE

No. ~~2334.15A~~ ~~4334.6~~ 4230.15A

Groundwater Sample Collection

November 2, 1982

NOTE: This SOP is a pre-existing Environmental Monitoring & Compliance Branch SOP (SOP No. FW012A) which has been incorporated into the Environmental Services Division Operations & Quality Assurance Manual with a new SOP Number.

APPROVED:

Chief, Emergency Planning & Response Branch	Date 1/2/90
Chief, Environmental Monitoring & Compliance Branch	Date 11/17/89
Chief, Laboratory Branch	Date 12/22/89
Regional Quality Assurance Officer	Date 1/10/90

STANDARD OPERATING PROCEDURE

NO. FW012A

GROUNDWATER SAMPLE COLLECTION

BY

Dale I. Bates

APPROVED:

Dale I. Bates — Coordinator — 11/2/82 — Date

Robert B. Dorn — Section Chief — 11/2/82 — Date

Billy Fairless — Branch Chief — 11/2/82 — Date

SOP NO. FW012A

1. PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish uniform procedures for collecting representative samples of groundwater sources.

2. APPLICATION

The procedures outlined in this SOP are applicable to all personnel of the Environmental Services Division involved in the collection of groundwater samples in support of Region VII programs.

3. GENERAL CONSIDERATIONS

a. Since a comprehensive groundwater monitoring study may require the accumulation of extensive hydrogeologic information and consideration of a multitude of factors that affect subsurface water quality and quantity, the design of such a complex study is beyond the scope of this SOP. The development of the study plan will have to address these factors on a case-by-case basis.

b. The procedures contained in this SOP will be restricted to the actual collection of samples and will not address in detail such topics as placement of wells, installation of wells, hydraulic gradient, subsurface and surface soil types and features, topography, land use, drainage patterns, etc.

4. SELECTION OF SAMPLING LOCATIONS

a. The study plan for a specific activity or investigation should provide detailed information as to sampling locations.

(1) As a general rule, a minimum of three wells are normally required to accurately assess subsurface conditions: one in the up gradient portion of the area of interest, one in the middle portion and one in the down gradient portion. In some cases, however, a system of wells may be required to define the subsurface conditions, especially in establishing the depth to the shallow groundwater aquifer and the direction of the groundwater flow. Site conditions and the objectives of the study will determine the total number of wells required.

(2) Existing wells should be utilized when possible and practicable to meet the needs of the study.

(3) The installation of monitoring wells and specific siting of these wells should be addressed in the study plan.

b. Sampling location guidelines applicable to all groundwater sampling activities cannot feasibly be established since each study has unique characteristics based upon its hydrogeological setting. A systematic investigation of an area is normally required to determine the optimum

sampling locations. A review of existing information and investigation of surface and subsurface conditions are all correlated to determine the necessity, extent and location of groundwater sampling points required to meet the study objectives.

c. When selecting sampling points the following factors should be considered:

(1) Movement of groundwater from high to low gradient stagnant areas.

(2) Groundwater movement induced by sampling and production wells.

(3) Inflow-outflow from surface water.

(4) The number and horizontal placement of wells should be governed by the hydrogeologic conditions.

(5) The vertical placement of the sampling point should be governed by locating the withdrawal point at a representative depth to average concentration gradients or at a depth commensurate with the study objectives. The depth should be set so that seasonal fluctuations in the water table do not affect sample collection.

d. Small springs should be sampled in unconsolidated deposits by driving a well point or slotted pipe to a depth of 1 meter or less into the ground adjacent to the spring.

e. Large springs should be sampled in consolidated rock.

5. TYPE OF SAMPLES

a. Normally, only grab samples are manually collected of groundwater, because the movement of water is slow and the water quality does not normally exhibit sudden or drastic changes.

b. The specific objectives of the study should identify the type of samples to collect.

c. The specific parameter to be analyzed may dictate that grab samples be collected.

6. PARAMETERS TO BE ANALYZED

a. The objectives of the particular study should specify the parameters to be analyzed.

b. Some common parameters that indicate overall water quality and quantities of an area, but not specific pollution problems, for planning purposes are: pH, oxidation reduction potential, total coliform, total dissolved solids, nitrate, chloride, water level and TOC.

7. METHOD OF SAMPLING

a. Prior to any groundwater sampling, all wells should be adequately purged to eliminate all fine material from the area of the well screen, if applicable, and to clear the well of stagnant water.

(1) As a general rule, the well should be purged until three to five times the volume of water in the well has been removed. As an alternate procedure, the well can be purged until the conductivity, pH and temperature stabilize.

(2) If a well is pumped dry during purging, it should be allowed to recharge before sampling.

(3) There are various methods available for purging wells: Suction lift pumping (pitcher, centrifugal, roller, piston or peristaltic pumps), pressure ejection pumping, submersible pumping and bailing.

b. Samples may be collected by transporting the water to the surface in a container or transporting the water through a closed conduit and discharging at the surface.

(1) A depth integrated or point sampler may be utilized to collect samples in a container.

(a) A depth integrated sampler is a container equipped with a holding and submerging mechanism which collects water throughout the vertical profile. Other depth integrating samplers known as bailers are lowered through the water and are filled through the bottom inlet which contains a check valve for retaining water when retrieved.

(b) A point sampler is used to collect a sample at a specific depth.

(2) In a closed conduit transport system, a pump, compressed gas or a vacuum is used to transport the water to the surface.

(a) Vacuum systems should not be used for collecting volatile organic samples.

(b) Pressure or vacuum lysimeters may be utilized to collect samples from the vadose zone; i.e., the zone above the water table.

(c) Pressure or air lift piezometers installed in boring can also be used to collect samples in the vadose zone.

c. When sampling wells with inplace plumbing, samples should be collected following purging from a cold water tap as near to the well as possible. Samples should be collected directly into the appropriate sample containers.

8. GROUNDWATER LEVEL MEASUREMENT

a. The measurement of the groundwater in wells is conducted in conjunction with groundwater sampling. The data from such mesurements is needed to determine the "free" water surface and can be used to establish groundwater gradients and ultimately, the direction of groundwater flow.

b. All groundwater level measurements should be made in reference to an established point (usually the top of the casing) on the well casing and be documented in the field records.

c. All measurements should be accomplished prior to purging the well.

d. Some specific techniques for measuring groundwater levels are as follows:

(1) Popper or Bell Sounder. The bell or cup shaped weight that is hollow on the bottom is attached to a measuring tape and lowered in the well. A "plopping" or "popping" sound is heard when the weight strikes the surface of the water. A measurement is made by lifting and lowering the weight in short strokes and reading the tape when the weight barely strikes the water. The length of the weight must be subtracted from the reading if it is not included in the length of the tape.

(2) Weighted Tape. This method is the same as (1) except any type of weight such as a padlock or lead sinker is fastened to the end of the tape.

(3) Chalked Tape. The end (lower 2 to 5 ft) of a steel measuring tape is coated on either side with carpenter's chalk, ordinary blackboard chalk, a dry (non-contaminated) soil or paste that changes color when it gets wet. The end is weighted and lowered into the center of the well until a hollow "plopping" sound is heard when the weight strikes the water. The tape is lowered very slowly for at least another six inches, preferabley to an even foot mark. The tape is carefully withdrawn from the well and the water depth is determind by subtracting the wetted length of tape plus the length of the weight from the total measurement.

(4) Electric Water Level Indicator or Sounder. This device consisting of a spool of small diameter cable with a probe attached to the end. A meter, light and/or buzzer attached to the spool is activated when the sounder probe comes in contact with the water and completes the electrical circuit. The probe is usually required to be submerged to about 1 3/4 inches to fully activate the meter or other indicator.

(5) Other Devices. There are other commercially available water level indicators and recorders. These devices are primarily used for closed systems or permanent monitoring wells.

e. Whenever groundwater measurements are made, caution should be exercised to prevent inadvertent contamination of the well or cross-contamination between wells. The measuring device that comes in contact with the water should be adequately cleaned prior to and between uses.

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Geoprobe® Sampling

Prepared: Kent Hankinson

Technical Review: Sharon Budney

QA Review: Doug Updike

Approved: Michael C. Molloy 2/24/04
Signature/Date

Issued: 3/18/04
Signature/Date

1.0 Objective

The objective of this standard operating procedure (SOP) is to define the requirements for collecting soil, soil gas, and groundwater samples using the Geoprobe® sampling system. Geoprobe is a trade name proprietary to Geoprobe Systems of Salina, Kansas.

2.0 Background

2.1 Discussion

The Geoprobe unit consists of a hydraulically operated hammer device mounted in the back of a van or pickup truck (Figure 1). The Geoprobe system hydraulically advances small-diameter, hollow rods to the desired sampling depth. The specific type of Geoprobe sampling equipment for soil, soil gas, and groundwater collection is then employed.

The use of Geoprobe technology may be a cost-effective alternative to using conventional drilling techniques for collecting subsurface soil, soil gas, and groundwater samples depending on the site-specific geologic and hydrogeologic conditions and sample requirements. The Geoprobe system is generally used to gather screening-level data. The site-specific sampling plans must consider such factors as soil types, presence of cobbles, depth to groundwater, quantity and depth of samples, site access and topography, data quality objectives (DQOs), analytical requirements, and waste handling and disposal requirements prior to selecting the use of the Geoprobe.

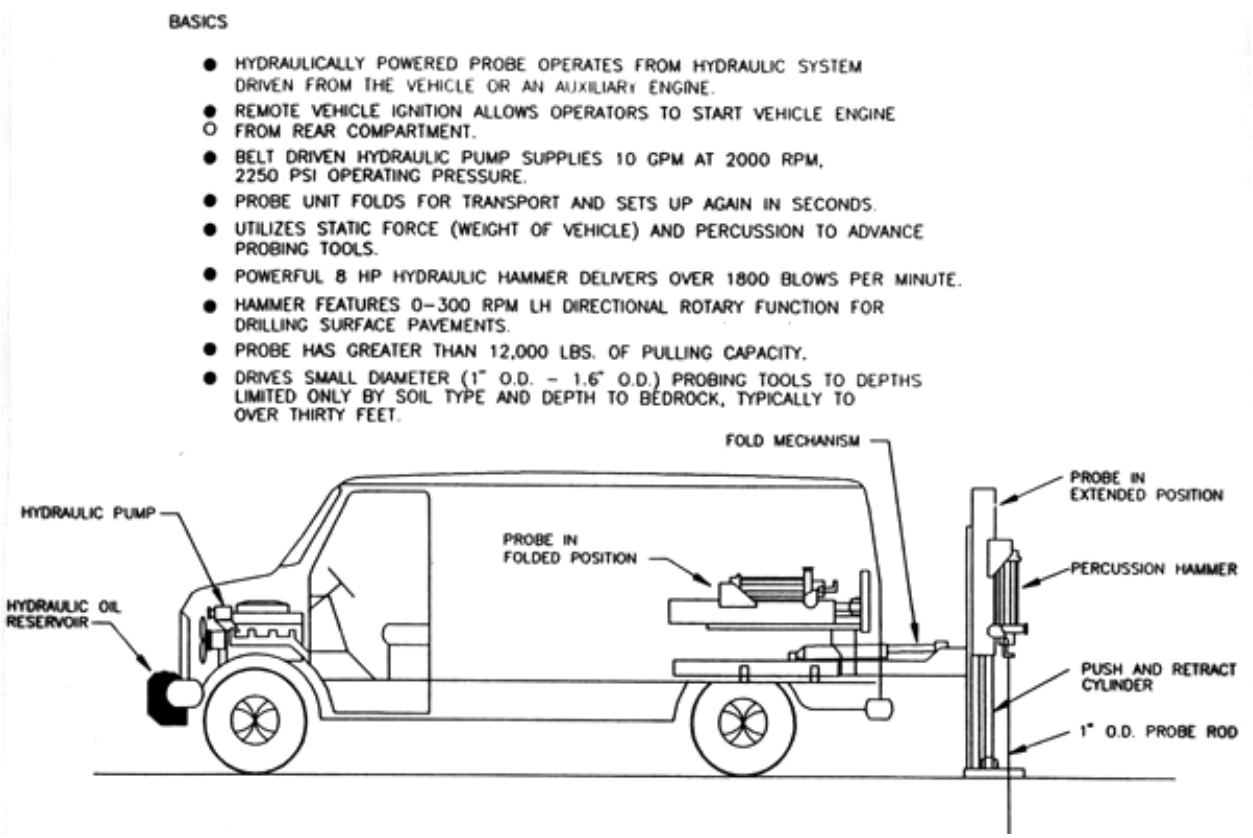
Advantages of using the Geoprobe include:

- Areas usually considered inaccessible by drill rigs because of overhead wires, steep slopes, size constraints, etc., may be accessed with the pickup truck or van-mounted Geoprobe.
- Investigation-derived wastes such as soil cuttings and purge water are minimized with the Geoprobe due to its small diameter rods and because it displaces soil horizontally, not vertically.

Cost savings over conventional drilling techniques may be realized. The Geoprobe is rented/leased on a weekly or monthly basis or purchased for a fixed price as opposed to drilling subcontractors who are generally compensated based on the footage drilled; the Geoprobe may be operated by field personnel rather than subcontractors. A cost evaluation based on project-specific requirements and site conditions should be conducted to determine the most cost-effective method for a particular project.

Two people are required to operate the Geoprobe and conduct sampling and recordkeeping activities. Safety considerations should be addressed when operating the Geoprobe. A safety hazard is present whenever the Geoprobe is operated. The hydraulic system operates with a fluid pressure of over 907 kilograms (kg) (2,000 pounds per square inch [psi]). A leaking hose may produce a stream of hydraulic

Figure 1
Geoprobe Unit



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fluid with sufficient pressure to penetrate skin. Therefore, periodic checks of the hydraulic lines and hoses should be conducted to ensure they are in good condition and connections are tight. Do not attempt to repair or tighten hoses with the engine running and the system under pressure. Use paper or cardboard to check for leaks.

2.2 Definitions

Geoprobe - A hydraulically operated hammer device installed in the back of a van or pickup truck, used to advance a hollow-stem rod into the soil for the purpose of collecting soil, soil gas, or groundwater samples.

Probe-Drive Sampler - A sampling device, similar to a split-spoon sampler, used to collect soil samples with a Geoprobe rig. Three types of soil samplers are available: standard 25- and 60-cm (in 10- and 24-inch lengths), large bore (with an acetate liner), and Kansas stainless sampler.

Extension Rod - Stainless steel rod used to remove stop-pin and drive-point assembly.

Extension Rod Coupler - Stainless steel connector used to join sections of extension rods.

Drive Point - Solid steel retractable point used to advance sample collection device to the required sample depth.

Probe Rod - Hollow, flush-threaded, steel rod similar to a drill rod.

Stop-Pin - Steel plug that threads into the top of the drive cap to hold the drive point in place during advancement of the probe rods.

Drive Cap - Threaded, hardened-steel top cap that attaches to the top of the probe rod; used when advancing the probe rods with the hydraulic hammer.

Pull Cap - Threaded, hardened-steel top cap that attaches to the top of the probe rod; used when retracting the probe rods.

Extruder Rack and Piston - A device used in conjunction with the Geoprobe to force soil sample volume out of the sample tube.

Screen Point Groundwater Sampler - A groundwater sampling device designed for use with the Geoprobe consisting of a well screen encased in a perforated stainless steel sleeve.

Mill-slotted Well Rod and Point - A groundwater sampling device designed for use with the Geoprobe consisting of a Geoprobe probe rod with 15-mil slots, each 5 cm long by 0.05 cm wide (2 inches long x 0.020 inches wide).

Post-Run Tubing System (PRT) - The Geoprobe soil vapor sampling system uses disposable poly-ethylene or Teflon tubing (inserted into the probe rods at the desired sampling depth) and a vacuum.

Expendable Drive Point - Solid steel point attached to the end of the screen point groundwater sampler and PRT expendable point holder.

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2.3 Associated Procedures

- CDM Federal SOP 1-2, Sample Custody
- CDM Federal SOP 1-5, Groundwater Sampling Using a Bailer
- CDM Federal SOP 1-6, Water Level Measurements
- CDM Federal SOP 2-1, Packaging and Shipping Environmental Samples
- CDM Federal SOP 4-1, Field Logbook Content and Control
- CDM Federal SOP 4-3, Well Development and Purging
- CDM Federal SOP 4-5, Field Equipment Decontamination

3.0 Responsibilities

Field Team Leader (FTL) - The field team leader (FTL) is responsible for ensuring that sampling efforts are conducted in accordance with this procedure, associated SOPs, and the site-specific plans.

Sampling Personnel - Field team members are responsible for conducting Geoprobe sampling events in accordance with this procedure, all associated SOPs, and requirements as described in the site-specific plans.

4.0 Required Equipment

General

- Site-specific plans
- Field logbook, chain-of-custody forms, other forms for documenting sample shipment
- Indelible black or blue ink pens and markers
- Sample containers with labels and preservatives
- Insulated coolers
- Bagged ice or "blue ice"
- Plastic zip-top bags
- Waterproof sealing tape
- Temperature, conductivity, pH, dissolved oxygen, and turbidity meters (with clean beakers or other appropriate containers), as required by the site-specific plans
- Monitoring/Screening instruments as required by the site-specific health and safety plan or sampling plan
- Decontamination supplies, as required by SOP 4-5
- Personal protective equipment (PPE), as required by the site-specific health and safety plan (at a minimum, hard hat, steel-toed shoes, safety glasses, and hearing protection are required)
- Latex or appropriate gloves
- Geoprobe rig (van, truck, or skid-mounted) with the following:
  - Probe rods 30-, 60-, and 90-cm lengths (1-, 2-, and 3-foot lengths)
  - Extension rods 30-, 60-, and 90-cm lengths (1-, 2-, and 3-foot lengths), couplers, and handle
  - Piston stop-pins (two each per rig, minimum)
  - Drive caps and pull caps (two each per rig, minimum)
  - Carbide-tipped drill bit for working in concrete- or asphalt-covered areas
  - O-rings

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Geoprobe Soil Sampling Equipment

- Extruder rack and piston (if soil is to be extruded into a sample container - otherwise, the steel sample tube with the standard and Kansas stainless samplers or acetate liner with the large bore Sampler may be shipped to the laboratory, as indicated in the site-specific plans)

- Assembled soil samplers (i.e., standard 25-cm or 60-cm [10-inch or 24-inch] sampler, Kansas stainless sampler, or large bore sampler - refer to the Geoprobe Systems Equipment and Tools Catalog for specific parts for each sampler)

Geoprobe Soil Gas Sampling Equipment

- Expendable drive points (one each per sample location, plus spares)
- Extension rod ram
- 10 millimeter (mm) (3/8-inch) polyethylene (Teflon -lined) tubing and PRT adapter
- Vacuum or sampling system
- Syringe
- PRT adapter
- PRT expendable point holder

Geoprobe Groundwater Sampling Equipment

- Expendable drive points (one each per sample location, plus spares)
- Mill-slotted well point or screen point groundwater sampler assemblies
- Extension rod ram
- 10-mm (3/8-inch) polyethylene (Teflon -lined) tubing
- Check valves (if using Waterra system)
- Peristaltic pump
- Mini-bailer (and thin nylon line)

5.0 Procedures

Procedures common to all three sampling methods are discussed below.

Prior to sampling:

- Arrange utility clearance.
- Decontaminate all Geoprobe equipment according to SOP 4-5, Field Equipment Decontamination.
- Don the appropriate PPE as dictated by the site-specific health and safety plan.
- If the sampling site is in a concrete- or asphalt-covered area, drill a hole using the rotary function and a specially designed 3.75-cm or 5-cm (1.5-inch or 2.0-inch) diameter carbide-tipped drill bit. Otherwise, the area needs to be cleared of heavy underbrush and immediate overhead obstructions.

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After sampling is completed:

- Thread the pull cap onto the top probe rod and retract the probe rods.
- Seal the borehole with sand, neat cement, or bentonite grout, if necessary.
- Record all appropriate data in the field logbook and on the chain-of-custody forms as outlined in CDM Federal SOP 4-1, Field Logbook Content and Control and CDM Federal SOP 2-1, Packaging and Shipping Environmental Samples.
- Decontaminate the sampling equipment according to CDM Federal SOP 4-5 "Field Equipment Decontamination."

5.1 Soil Sampling

Assembly

1. Assemble the sampling device as follows:

   - Screw the cutting shoe to the bottom end of the sample tube (unless using standard probe drive sampler, which has built-in cutting edge).
   - Screw the piston tip onto the piston rod.
   - Screw the drive head onto the top end of the sample tube.
   - If using Teflon liner, insert liner into sample tube.
   - Slide the piston rod into the sample tube, leaving the piston tip sticking out of bottom end of the sample tube.
   - Screw the piston stop-pin onto the top end of the piston rod in a counter-clockwise direction.

2. Attach the assembled sampler onto the leading probe rod. A 30-cm (12-inch) probe rod is recommended to start the 60-cm (24-inch) standard and large bore samplers.

Probing

3. Thread the drive cap onto the top of the probe rod and advance the sampler. Replace the 30-cm (12-inch) rod with a 90-cm (36-inch) rod as soon as the top of the sampler is driven to within 15 cm (6 inches) of the ground surface.

4. Advance the sampler to the interval to be sampled using the hydraulic hammer. Add additional probe rods as necessary to reach the specified sampling depth.

Stop-pin Removal

5. Move the probe unit back from the top of the probe rods and remove the drive cap.

6. Lower the extension rods into the inside diameter of the probe rods using extension rod couplers to join the extension rods.

7. Attach the extension rod handle to the top extension rod and rotate the handle clockwise until the leading extension rod is screwed into the piston stop-pin. Continue to rotate the handle clockwise until the stop-pin disengages from the drive head.

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8. Remove the extension rods and attached piston stop-pin from the probe rods.

Sampling

9. Replace the drive cap, mark the top probe rod with a marker or tape at a distance above the ground equal to the length of the sample tube (either 30 or 60 cm [12 or 24 inches]).

10. Advance the probe rods using the hydraulic hammer the length of the sample tube (either 30 or 60 cm [12 or 24 inches]).

11. Replace the drive cap with the pull cap and retract the probe rod(s). Secure the rod(s) with a clamp or by hand during removal so they do not fall back down the resulting borehole.

12. Detach the sampler from the lead probe rod, verifying that sufficient sample volume was recovered (the length of sample contained within the tube is approximately equal to the length of exposed piston rod).

13. Disassemble the sampler. If the sample is to be analyzed for VOCs, then the sample tube or liner should be sealed immediately by placing a Teflon septa over the ends and covering them with plastic caps.

14. If samples do not require VOC analysis, they may be extruded from the sampler and transferred to the sample jars specified in the site-specific plans or SOP 2-1, Packaging and Shipping Environmental Samples. Samples can be extruded by one of two methods:

    - Using the Geoprobe rig and the extruder rack (Figure 2), position the extruder rack on the foot of the Geoprobe derrick; insert the sample tube into the extruder rack with cutting end up; and position the extruder piston, pushing the sample out of the sample tube using the "probe" function. Catch the sample as it exits beneath the extruder in a sample jar or stainless steel mixing bowl. Samples to be collected for VOCs will be collected directly from the sample tube into the sample jars.

    - Lightly tap the side of the sample tube with a hammer while also lightly pushing the Piston Rod.

15. Label the sample liner or sample jars as required, securing the label by covering it with a piece of clear, waterproof tape.

16. Homogenize the sample in a stainless steel bowl with a stainless steel spoon or spatula. Transfer the sample from the bowl to the sample container.

17. Clean the outside of the sample jars and place individual samples into sealable bags and seal closure.

18. Place samples in a cooler containing ice according to SOP 2-1, Packaging and Shipping Environmental Samples.

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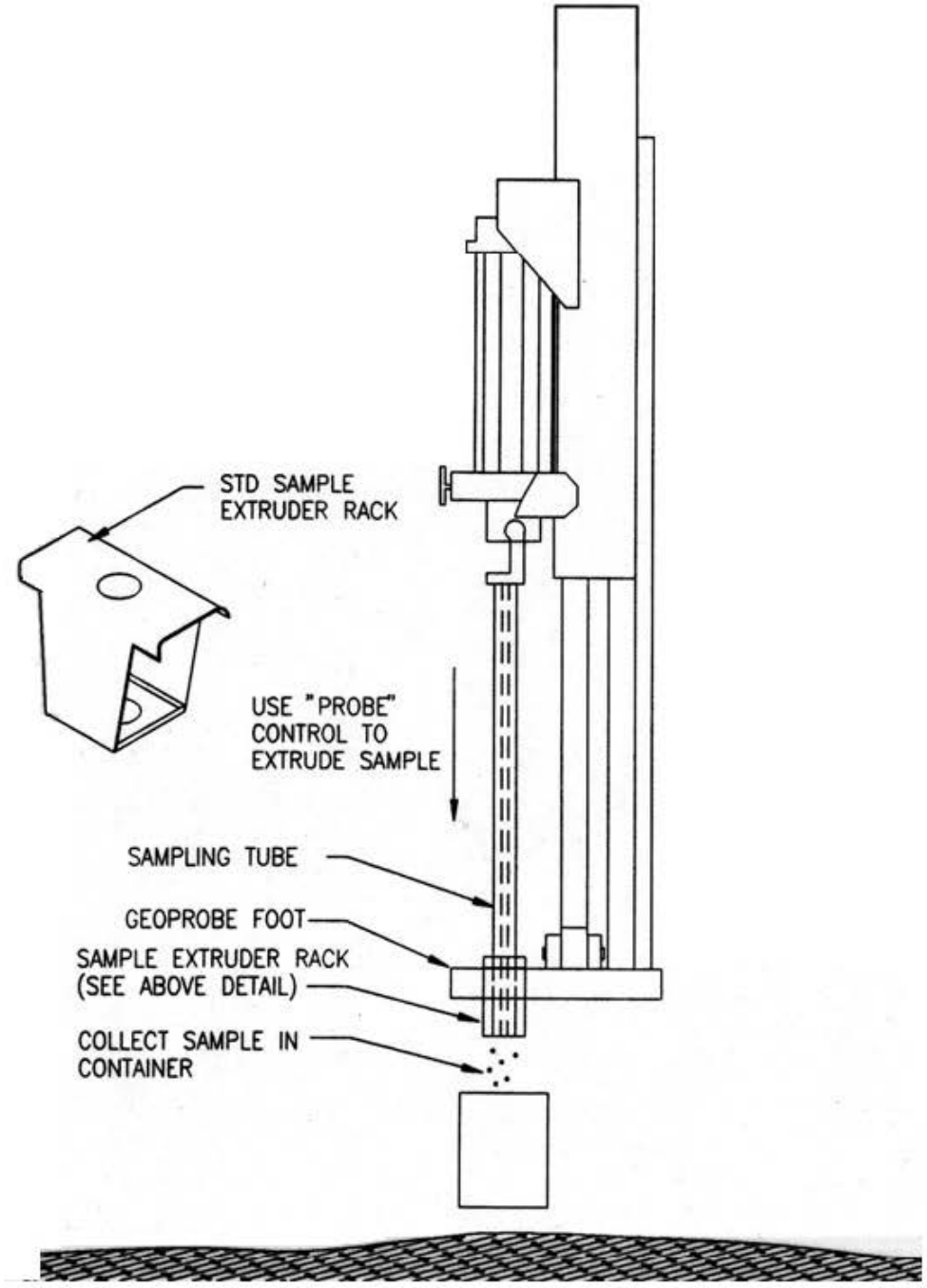
Figure 2
Sample Extruder Rack



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5.2 Soil Gas Sampling

Assembly

1. Assemble the sampling device as follows (Figure 3):

   - Test fit the adapter with the PRT expendable point holder or retractable point holder to ensure that threads are compatible and fit together smoothly.
   - Attach the PRT adapter to flexible tubing equal in length to the depth of sampling (with some additional for sampling activities).
   - Secure PRT adapter with a length of electrician's tape and check the condition of the O-ring attached to the end of the PRT adapter.
   - Screw the PRT expendable point holder into the bottom of the lead probe rod.
   - Attach an expendable drive point to the bottom of the PRT expendable point holder.

2. Attach the assembled sampler onto the leading probe rod. A 30-cm (12-inch) probe rod is recommended to start the 60-cm (24-inch) standard and large bore samplers.

Probing

3. Thread the drive cap onto the top of the probe rod and advance the sampler. Replace the 30-cm (12-inch) rod with a 90-cm (36-inch) rod as soon as the top of the sampler is driven to within 15 cm (6 inches) of the ground surface.

4. Advance the sampler to 1 foot past the interval to be sampled using the hydraulic hammer. Add additional probe rods as necessary to reach the specified sampling depth.

Sampling

5. Replace the drive cap with a pull cap and retract the probe rods approximately 30 cm (1 foot).

6. Move the probe unit back from the top of the probe rods and remove the drive cap.

7. Push the drive point out of the PRT expendable drive point holder with extension rods fitted with a ram.

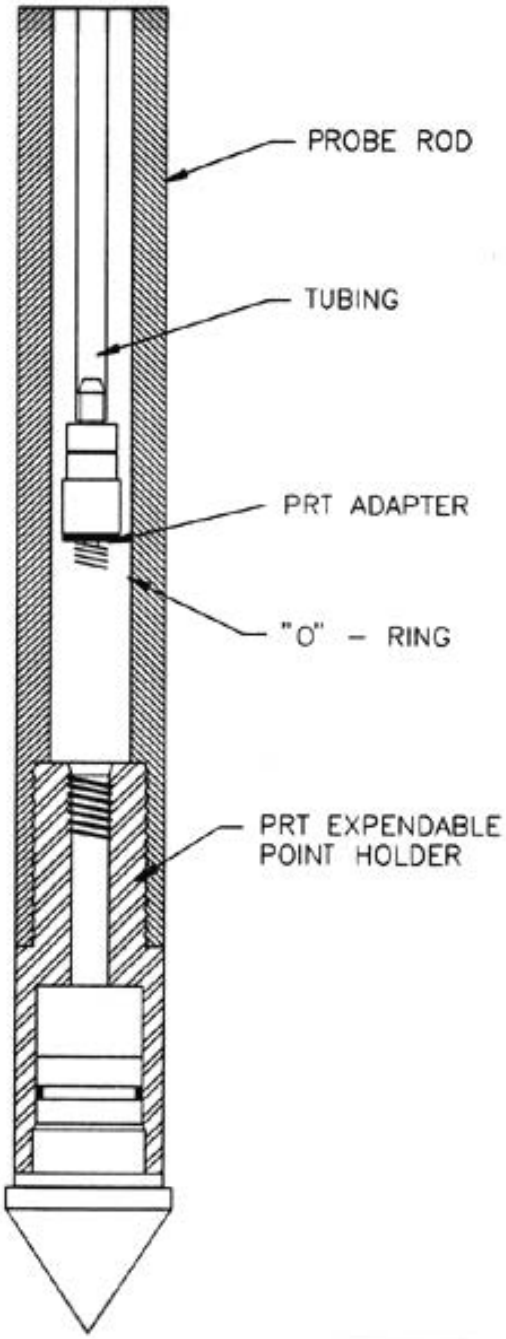
8. Remove the extension rods from the probe rods.

9. Insert the adapter end of the tubing down the inside diameter of the probe rods, feeding the tubing down until the adapter contacts the top of the PRT expendable point holder.

10. Holding the out-of-hole end of the tubing, apply downward pressure while turning in a counter-clockwise direction to screw the adapter into the PRT expendable point holder.

11. Pull lightly on the tubing to ensure that the threads have engaged.

Figure 3
PRT Soil Gas Sampling System



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12. Connect the out-of-hole tubing to a vacuum or sampling system. A short section of inert silicon tubing may be connected to the end of the out-of-hole tubing so that a sample can be collected with a glass gas chromatograph (GC) syringe.

13. Start the vacuum or sampling system and allow the system to operate for 2 to 3 minutes to ensure that a sufficient volume of air has been run through the tubing. Document the depth, vacuum pressure, and purge duration in logbook. **Note**: Make sure the vacuum evacuation pump is able to pull vapors from the formation. Excessive vacuum may occur in clay/clayey units resulting in insufficient sample volume.

14. Collect sample using the method specified in the site-specific plan.

15. Label all sample containers as required, securing the label by covering it with a piece of clear, waterproof tape.

16. Remove the tubing from the probe rods. Dispose of the tubing or set it aside for decontamination.

17. Remove probe rod(s) from hole. Leave tubing in place for longer term monitoring.

5.3 Groundwater Sampling

Assembly

1. Assemble the screen point groundwater sampler (see Geoprobe Systems Equipment and Tools Catalog, Groundwater Sampling Tools, pp. 5.1-5.12) as follows (Figure 4):

   - Push the screen insert and plug into the screen sleeve from the bottom. The bottom end has one drain hole.
   - Push the screen connector over the top end of the screen sleeve and push the screen connector pin into place. The pin must be held in place as it has a loose fit.
   - Insert the screen sleeve, screen connector first, into one end of the sampler sheath.
   - Slide the drive point seat over the end of the screen assembly that protrudes from the sampler sheath. Thread it in until tight using a 22-mm (7/8-inch) wrench.
   - Push the screen assembly just far enough into the sampler sheath that an expendable drive point can be pushed into place in the drive seat.
   - Screw the groundwater drive head with the O-ring end first into the open end of the sampler sheath.
   - O-rings are installed at various critical places in the sampler assembly. Ensure that all O-rings have not been worn and that the connections made at O-ring locations are tight.

   The Mill-slotted well point does not need any assembly.

2. Attach the Mill-slotted well point, or screen point groundwater sampler, onto the leading probe rod. A 30-cm (12-inch) probe rod is recommended to start either groundwater sampler.

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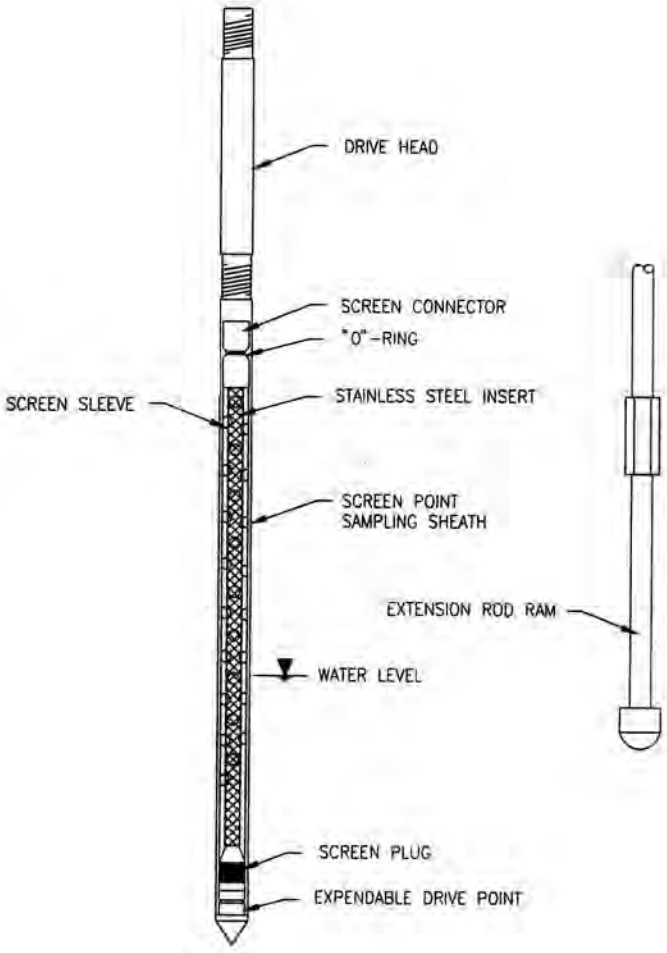
Figure 4
Groundwater Sampling



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Probing

3. Thread the drive cap onto the top of the probe rod and advance the sampler using either the hydraulic hammer or hydraulic probe mechanism on the Geoprobe rig. Replace the 30-cm (12-inch) rod with a 90-cm (36-inch) rod as soon as the top of the sampler is driven to within 15 cm (6 inches) of the ground surface.

4. Advance the sampler to the interval to be sampled using the hydraulic hammer. Add additional probe rods as necessary to reach the specified sampling depth.

Sampling

5. Move the probe unit back from the top of the probe rods and remove the drive cap.

6. The next step varies depending on the type of sampler being used:

   - Mill-slotted well point - measure and record the water level, allowing time for the water level to reach equilibrium.

   - Screen Point groundwater sampler - attach the pull cap to the top probe rod, retract the probe rods approximately 60 cm (2 feet), push the screen into the formation using extension rods fitted with a ram, remove extension rods from the probe rods, and measure and record the water level, allowing time for the water level to reach equilibrium.

7. Label all sample containers as required, securing the label by covering it with a piece of clear, waterproof tape.

8. Collect groundwater samples using one of three methods (as outlined in site-specific plans) described below:

   - Collect sample from the inside diameter of the probe rods using a decontaminated mini-bailer. Follow CDM Federal SOP 1-5, Groundwater Sampling Using a Bailer.

   - Collect sample using a peristaltic pump and flexible tubing system.

   - Collect sample using a check valve (Waterra-type valve) attached to the bottom of 10-mm (3/8-inch) diameter tubing. The tubing is lowered into the probe rods below the top of the water table, check valve-end first. Water sample is collected through the tubing by rapidly oscillating the tubing up and down creating an inertial pump.

9. Clean the outside of the sample containers and place individual samples into sealable bags and seal closure.

10. Place samples in a cooler containing ice according to SOP 2-1, Packaging and Shipping Environmental Samples.

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6.0 Restrictions/Limitations

The Geoprobe sampling system is not designed for collecting large sample volumes, thereby limiting the number of analytical parameters. Sample recovery rates may be reduced in soils with substantial amounts of gravel and/or cobbles. Depending on sampling depths and intervals, a typical sample production rate of between 10 and 15 samples per day can be expected.

The most efficient sampling depth is limited by the geologic and hydrogeologic conditions. Practical, efficient sampling depths should be limited to approximately 6 meters (20 feet) under most conditions. However, sampling depths in excess of 20 meters (65 feet) have been achieved in unconsolidated, homogeneous sandy soils; attainable depths will be greatly reduced in tighter formations and in soils with gravel and cobbles.

The presence of gravel and cobbles in soils will likely damage soil sampling tubes and possibly probe rods, couplers, stop-pins, and other probing equipment. A sufficient supply of replaceable equipment should be kept onsite in the event of damage or breakdowns. This often requires replacement at the project's - not the subcontractor's - expense. A copy of the Geoprobe Systems Equipment and Tools Catalog should also be kept onsite; Geoprobe Systems provides overnight deliveries.

Prior to conducting the Geoprobe sampling event, underground utilities and structures must be demarcated on the ground surface. The local utility companies must be notified at least 72 hours prior to the scheduled sampling event to allow sufficient time to locate and mark the utility lines. The selected sampling location should be a safe distance from the demarcated utility. In some cases, records regarding utility locations may not exist. In any event, a good practice is to push the probe rods the first few feet, rather than hammering, to ensure that no utilities, underground storage tanks, or other subsurface structures are present.

7.0 References

Geoprobe Systems, *The Probe-Drive Soil Sampling System*, September 1991.

Geoprobe Systems, *Equipment and Tools Catalog*, 1992.

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EPA SOP 4231.6A –
Sampling Equipment Decontamination

EPA/540/P-91/005
OSWER Directive 9360.4-03
January 1991

COMPENDIUM OF ERT SURFACE WATER AND SEDIMENT SAMPLING PROCEDURES

2231.6A

Sampling Equipment Decontamination

Surface Water Sampling

Sediment Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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Notice

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Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Surface Water and Sediment Sampling Procedures. Send remarks to:

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(703) 487-4600

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Acknowledgments

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1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

STANDARD OPERATING PROCEDURE

No. 2420.5D

IDENTIFICATION, DOCUMENTATION, AND TRACKING OF SAMPLES

December 16, 2003

by

Harry Kimball

ENSV/RLAB/CATS

APPROVED:

Peer Reviewer — Date: 12/19/03

Manager, Regional Laboratory — Date: 19 Dec 03

Independent QA Reviewer — Date: 12/19/03

Recertified

Reviewer					
Date					

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A. PURPOSE AND APPLICABILITY

The purpose of this standard operating procedure (SOP) is to establish uniform procedures for assigning sample numbers, labeling sample containers, documenting the sample collection process, and for tracking samples.

The collection of samples is an essential step in the process for obtaining information on a variety of environmentally-related conditions and situations. Because the analytical results of samples are used extensively to support regulatory decisions, statutory actions, environmental and health assessments, and litigation proceedings, a critical component of the sample collection process is the proper identification, documentation, and tracking of each sample collected.

The procedures outlined herein are applicable to all samples received by the Region 7 Laboratory (RLAB) for analysis (either in-house analysis or out-source contract lab analysis) and to laboratory-generated quality control (QC) samples. The Regional Sample Control Coordinator (RSCC), or their surrogate, shall ensure, at the time of sample receipt, that samples received by RLAB conform to the identification and documentation requirements of this SOP. This SOP should be provided to all individuals (EPA, state, and tribal staff, plus their contractors) collecting samples for delivery to RLAB to facilitate compliance with these procedures.

B. SUMMARY OF PROCEDURE

1. The identification and documentation of each sample is required in order to provide tangible evidence that shows the data resulting from sample analysis is linked directly to the sample collected. The basic mechanism used to establish this critical link between samples collected and analytical data is the assignment of a unique sample identifier to each sample collected, with supporting written information to document the sampling process. In addition to providing the means for establishing the relationship between samples and analytical results, the assignment of unique sample identifiers provides a means for tracking samples through the analytical data generation process.

2. Sample identification is achieved by labeling each field collected sample with a unique sample identifier. Samples contained in multiple sample containers will bear the same unique sample identifier on each container, plus, each container will be uniquely identified (usually by analysis). Quality control is an integral part of the process of obtaining reliable information about environmental samples, therefore, field and laboratory quality control samples will be uniquely identified in an appropriate and consistent manner.

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3. Sample documentation is accomplished by recording the appropriate information about the sample on a field sheet which bears the sample's unique sample identifier. If samples are delivered to RLAB with sample identifiers that are not consistent with the unique sample identifiers described in this SOP, the RSCC will assign the requisite unique sample identifiers and record the original sample identifier in the LIMS "External Sample Number" field. Laboratory QC samples are documented on the sample prep and/or analysis log.

4. Sample tracking is accomplished by using the Region 7 Laboratory Information Management System (LIMS). The LIMS is used to identify and track the status of all samples analyzed by the EPA Region 7 Laboratory and its contractors. The current LIMS is a product called R7LIMS. R7LIMS and any future LIMS products will follow the sample identification scheme defined in this SOP. Additionally, the LIMS can generate field sheets and tags (sample labels) to facilitate identification and documentation of field collected samples (see SOP 2420.13, "RLAB Procedures for Preparation of Field Sheets and Tags"). The physical location of samples is tracked by chain-of-custody procedures.

5. Because the identification and documentation of samples establishes the foundation for substantiating reported analytical data, it is important that the individuals who collect and/or generate samples follow the procedures contained in this SOP. The procedures contained in SOP No. 2420.4, "Field Chain-of-Custody for Environmental Samples," should be used in conjunction with this SOP to provide complete field sample documentation.

C. DEFINITIONS

The following definitions of commonly-used terms relating to types of samples and sampled matrices are provided for clarification in the sample identification process:

1. Sample. The word 'sample' is an often overworked term. It can refer to a sample collected in the field, a portion of a field sample that has been spiked with additional analytes (matrix spike sample), or a sample generated entirely within the laboratory, such as a method blank. The term 'sample' most often refers to a Field Sample that is of one matrix collected from a specific point (or area if spatially composited) at a specific time (or period of time if temporally composited). A sample may be divided into several different containers, each for a different type of analysis and possibly requiring different methods of preservation (see SOP 2420.6, "Sample Container Selection, Preservation and Holding Times"). It is common for all of these containers to be collectively referred to as being a (one) sample and for all of them to bear the same unique sample identifier.

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2. Field Sample. A representative portion of an environmental matrix (e.g. air, soil, water, etc.) collected from a specific location at a specific time to obtain information regarding environmental conditions and/or effects, process operations and material contents. Field Samples are actual portions of a matrix collected to determine its physical, chemical, or biological constituents and are distinguished from samples used for quality control (QC) purposes. Although QC samples collected in the field are in a sense field samples, the term Field Sample is used to denote a non-QC sample and is sometimes referred to as a "real" or "regular" Field Sample. Field Samples include those collected to evaluate background conditions and are categorized as grab, composite or continuous samples.

   a. Grab Sample. A discrete portion of a matrix collected at a specific location at one instance in time (this period of time is typically defined as not exceeding 15 minutes to allow adequate time for sample collection under most field situations). This type of sample is representative of the environmental condition at the time of collection. This type of sample is commonly used for in-situ determinations and for obtaining information on constituents that require special handling or may be lost if sampled in another manner.

   b. Composite Sample. A portion of a matrix consisting of a mixture of two or more discrete portions (grab samples) collected from a specific location over a period of time or from a specific area (multiple locations) at one time or over a period of time. This type of sample is a representative average of the environmental condition for a definable area and/or period of time. This type of sample is commonly used for assessing environmental conditions.

   c. Continuous Sample. As the name implies, it is a representative portion of a matrix collected in an uninterrupted manner for a period of time. This type of sample is normally associated with in-situ determinations and is, therefore, not usually collected for submittal to a laboratory for analysis. Continuous samples are most commonly used for collecting data of air and water media; e.g., flow, pH, temperature, etc.

3. Split Sample. As the name implies, it is a sample that is separated or split from the total amount of material sampled and sent to a different laboratory for analysis. Soil matrix samples are homogenized then split to ensure uniformity. The Split samples are used to independently verify laboratory analysis.

4. Extract. An extract is the result of the extraction process. The sample extract is labeled by extraction personnel.

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5. Digestate. A digestate is the result of the digestion process. The sample digestate is labeled by digestion personnel.

6. Quality Control Sample. Prepared in the laboratory, in the field, or combination thereof, a QC sample is incorporated into sample collection and/or analysis activities as a means of evaluating the quality of analytical results obtained from Field Samples. This type of sample may be a field-collected sample (e.g. duplicate sample) or a laboratory-generated sample, depending on its intended purpose, to evaluate and/or substantiate analytical results. Additional information on the use of QC samples for calculating data quality may be found in SOP No. 2410.15, "Estimating and Documenting Data Quality". The following types of QC samples are commonly encountered in sampling events and should be sufficient to categorize most QC samples:

   a. Duplicate Sample. It is recognized that there are several interpretations of this term. For the purpose of calculating data quality, there are essentially two types of duplicate samples: field and laboratory, as described below.

      (1) Field duplicate samples refer to two Field Samples collected simultaneously from the same location(s) under identical conditions. A duplicate grab sample consists of collecting two Field Samples at the same location and time. A duplicate composite sample consists of two Field Samples containing multiple grab samples each collected at the same location and time. If automatic samplers are used to collect composite samples, the collection of duplicate composite samples would require two automatic samplers to be collocated and set to collect the individual portions or aliquots at the same times. The dividing (also referred to as "splitting") of a single sample into two portions will be considered field duplicate samples in those situations where the preferred method of simultaneous collection cannot be met due to field conditions (e.g. the media being sampled is non-homogeneous like some soils, gravel, etc.).

      (2) Laboratory duplicate samples refer to equivalent aliquots taken from a single sample received by a laboratory for analysis as unique samples. The process of obtaining the duplicate aliquots should be preceded by ensuring the sample is well mixed.

   b. Blank Sample. A sample that is presumed to be free of contamination from constituents of concern and is designed to detect contamination due to the sampling and/or analysis process (collection, preservation, handling, sampling environment, extraction, analysis, etc.).

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(1) Field Blank. Includes all blank samples which are prepared in or enter the field environment and include trip blanks, equipment blanks, bottle or container blanks, reagent or preservative blanks and tubing blanks. Ideally, a field blank for most analytical parameters should be exposed to the sampling, preservation and handling process used to collect the physical samples, but this may not always be possible (e.g. the field blanks for volatile organics are only transported unopened to and from the sampling environment). The type of field blank should be identified, as well as the group of Field Samples with which it is associated, in the appropriate sample documentation.

(a) Trip Blank. It is a sample that is presumed to be free of contamination from constituents of concern, and is carried into the field and returned while being exposed to the same field conditions which the sample containers experience during the sample shipping process.

(b) Tubing/Equipment Blank. It is a sample free from constituents of concern (normally deionized water that is distilled) and is pumped through or otherwise introduced into the sampling equipment. The process results in exposure of the sample to any constituents of concern which might be contained in or on the surfaces of the sampling equipment.

(c) Preservation Reagent Blank. It is a sample which is originally free from constituents of concern (normally distilled deionized water) and to which the preservative (acid or other chemical) is added in the same concentration and quantity as normally added to a sample. The purpose is to determine if any contaminants of concern exist in the preservative used.

(d) Container Blank. A sample originally free from constituents of concern (normally distilled deionized water) which is introduced into randomly chosen containers at the time of sampling. The purpose of this blank is to determine the existence of contaminants of concern in the sampling containers.

(2) Method Blank. A laboratory QC sample used to assess the level of contamination in the analytical system. A method blank is,

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typically, a portion of a clean matrix that is taken through the entire sample preparation and analysis process.

c. Laboratory QC Sample. A variety of QC samples are used by an analytical laboratory for internal QC purposes. For the purpose of sample identification, all such samples prepared by the laboratory for internal use are classified under this category. Commonly used laboratory QC samples include lab duplicate samples, method blanks, lab control samples, matrix spikes, and lab fortified blanks.

d. Performance Evaluation Sample. A sample that contains a known amount of a chemical constituent or parameter and is introduced for analysis to assess the accuracy of the analytical method. The actual content of the PE sample, either in regard to specific constituents and/or concentrations of constituents, is normally unknown to the receiving analytical laboratory.

e. Performance Testing Sample. Similar to a performance evaluation sample except that it is provided by a NELAC (National Environmental Laboratory Accreditation Conference) certified PT sample provider. Results of the analysis of these samples are used for NELAC accreditation purposes.

f. Some additional Field Samples may be thought of as QC samples due to the location or method of sample collection. These are labeled the same as, and analyzed the same as, other Field Samples.

(1) Rinsate Sample. This type of sample is used to evaluate the effectiveness of field decontamination procedures for sampling equipment. The sample is obtained by collecting the rinse water that is poured over the sampling equipment after decontamination has been completed (the water is normally distilled ionized water prepared in the laboratory and carried to the field).

(2) Background Sample. In some investigations, samples are collected to determine what is representative of the environment for constituents of concern. These samples, normally called background samples, are Field Samples which are collected off-site or upstream of an area that is affected by a contaminant of concern, but are not expected to contain any or significant amounts of the contaminant of concern.

7. Matrix. The matrix (also known as 'media') refers to the substance from which the sample was obtained and/or of which the sample consists. Since the sampled matrix has a direct bearing on how a sample is preserved and on the selection of

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the method to analyze the sample, the identification of the matrix is an important aspect of sample documentation.

a. RLAB Matrix. The RLAB matrix is the matrix name used by RLAB to identify the matrix of the sample. It is the matrix used in the LIMS and in the RLAB Methods.

(1) Air. All samples collected to evaluate or analyze the chemical and physical contents of the air, both indoor and outdoor. The resulting sample may be in different forms depending on the method of collection (e.g. Tenex tube, canister, PUF, etc.).

(2) Solid. All samples obtained of soils, sediments, sludge, dust, and any other solid material.

(3) Tissue. All samples obtained of living organisms; e.g., plants or vegetation, fish, animals, etc., either whole or portions thereof.

(4) Waste. All samples obtained of media that do not logically fit under one of the other specifically defined matrices or contain exceedingly high concentrations of analytes. (Previously referred to as "Hazardous/Other".) Examples of these type samples are wipe samples, drum samples, non-aqueous liquid samples, product or formulation samples and mixed media samples.

(5) Water. All samples obtained of aqueous liquid, e.g., wastewater, surface water, drinking water, groundwater, etc.

b. NELAC Matrix. NELAC has its own list of Quality System Matrices. These matrices are referenced in the RLAB Methods, but are not used in the LIMS or for sample definition/identification.

(1) Aqueous. Any aqueous sample excluded from the definition of Drinking Water matrix or Saline/Estuarine source. Includes surface water, groundwater, effluents, and TCLP or other extracts.

(2) Drinking Water. Any aqueous sample that has been designated a potable or potential potable water source.

(3) Saline/Estuarine. Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.

(4) Non-aqueous Liquid. Any organic liquid with <15% settleable solids.

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(5) Biological Tissue. Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.

(6) Solids. Includes soils, sediments, sludges and other matrices with >15% settleable solids.

(7) Chemical Waste. A product or by-product of an industrial process that results in a matrix not previously defined.

(8) Air and Emissions. Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device.

D. PERSONNEL QUALIFICATIONS

Personnel collecting and/or delivering samples to RLAB should have a basic knowledge and understanding of RLAB sample management procedures including chain-of-custody (SOP 2420.4). RLAB personnel receiving samples must be knowledgeable of the sample log-in process (SOP 2420.1, "Sample Receipt and Log-in"). Personnel defining samples in the LIMS must be familiar with using the LIMS (SOP 2410.20, "R7LIMS Functions and Security") and have an R7LIMS account.

E. SAMPLE IDENTIFICATION

1. Each sample is identified by a unique sample identifier which is assigned to it.

   a. This identifier is used to distinguish an individual sample from all other samples and is used on all documentation relating to collection, handling, analysis and reporting the analytical results of an individual sample.

   b. Since a sample is normally analyzed for a number of different chemical constituents or parameters that require different sample containers and preservation techniques, the same unique sample identifier will be assigned to each portion of the original sample split among individual sample containers. For example, if a sample is split among three individual sample containers in order to properly preserve each portion for the specific parameter or group of parameters to be analyzed, each of the

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individual sample containers would be identified by the same unique sample identifier.

2. The unique sample identifier consists of three parts: the Analytical Services Request Number (ASR Number), Sample Number, and Quality Control Code (QC Code). These are frequently written together, separated by hyphens. The unique sample identifier is sometimes (confusingly) simply referred to as the sample number.

   a. ASR Number - This is the number automatically assigned to an ASR at the time it is defined in the LIMS. Each ASR has its own unique number.

   b. Sample Number - This number is assigned by the responsible Project Manager (or their designee) for each field sample collected for an ASR.

   c. QC Code - This two or three character alpha code is used to identify the nature of the sample for QC purposes. Field personnel will normally only use the following codes to identify field collected samples:

   __ = Field Sample (two underscore characters)
   FD = Field Duplicate
   FB = Field Blank
   FS = Field Spike
   FSD = Field Spike Duplicate

   Laboratory personnel will use the following codes to identify laboratory QC samples:

   MB = Method Blank
   LD = Laboratory Duplicate
   MS = Matrix Spike
   MSD = Matrix Spike Duplicate
   LCS = Laboratory Control Sample
   LFB = Laboratory Fortified Blank
   PE = Performance Evaluation sample
   PT = NELAC Performance Testing sample

3. The following examples are provided to illustrate some unique sample identifiers:

   26-1-__ - Field Sample number 1 for ASR Number 26
   26-1-FD - Field Duplicate of Field Sample above
   26-2-FB - Field Blank submitted for same ASR Number
   87-5-__ - Field Sample number 5 for ASR Number 87

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87-5-MS - Matrix spike of Field Sample above
87-900-LCS - Lab Control Sample number 900 for ASR Number 87

4. Some quality control samples have meaning only when referenced to another sample (i.e. QC Codes of FD, FS, FSD, LD, MS, MSD). To facilitate the identification of the referenced sample, the LIMS has two fields for use with these QC samples: Ref Sample Number and Ref QC Code. Rules for determining the Sample Number, Ref Sample Number, and Ref QC Code for these QC samples are given below.

   a. The QC sample and the referenced sample (the sample that the QC sample is a spike or duplicate of) must have the same ASR Number and Matrix.

   b. Field QC samples (FD, FS, FSD) will be assigned the same Sample Number as the original Field Sample (__) that they are a duplicate or spike of. The Ref Sample Number, and Ref QC Code are automatically assigned by the LIMS and can not be edited by the user.

   c. Lab QC samples (LD, MS, MSD) that are a duplicate or spike of a Field Sample or Performance Testing sample (__, PT) will be assigned the same Sample Number as the original Field Sample or Performance Testing sample that they are a duplicate or spike of. By default, the Ref Sample Number will be set to the Sample Number and the Ref QC Code will be set to "__" by the LIMS. If the sample being spiked or duplicated is a Performance Testing sample, a Ref QC Code of "PT" will need to be manually entered into the LIMS. Note that it is not appropriate for a Field Sample and a Performance Testing sample to have the same Sample Number.

   d. Lab QC samples (LD, MS, MSD) that are a duplicate or spike of any other field collected sample (QC Code of FB, FD, FS, FSD) will be assigned a different Sample Number than the original sample that they are a duplicate or spike of. The Ref Sample Number and Ref QC Code will need to be manually entered into the LIMS. Although not a requirement, it is suggested that a Sample Number in the "800" range be used for the lab QC sample.

   e. MSD samples must have the same Sample Number, Ref Sample Number, and Ref QC Code as their associated MS sample. The MS sample must be defined in the LIMS before the MSD sample can be defined.

5. The following rules are provided for further clarification of the unique sample identifier assignment process:

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a. Each sample collected of a specific media will have a unique sample identifier. For example, if two samples are collected at the same location and time, but are of two different media (e.g. air and solid, or water and tissue), the sample of each specific media will be considered a separate sample. Each sample will be assigned a separate sample number.

b. In-situ samples collected for instantaneous field determinations (e.g. pH, temperature, specific conductance, dissolved oxygen, residual chlorine) in connection with the collection of samples for submission to a laboratory for analysis will be identified by sample identification numbers. Results of field determinations are recorded on field sheets associated with the sample collected for laboratory analysis. The sample identification number of the sample used for the field determination will normally be the same as the sample identification number of the sample submitted for analysis.

c. Continuous samples do not require the assignment of sample identification numbers, but do require specific written documentation to record sampling locations, and times of sampling and readings. Since many continuous monitors provide strip charts and/or printouts of readings, this documentation should be kept to supplement other written documentation.

d. Even though samples for some analyses, such as those for volatile organics, are always collected in two or more containers, they are considered to be a single sample. Additionally, if multiple analyses are to be analyzed for (such as metals, pesticides and VOAs), separate containers will be needed for each analysis. These containers are collectively considered to be one sample and will have the same unique sample identifier.

e. Sample extracts are labeled by the person performing the extraction of the sample. The sample extract container is labeled by hand-copying the sample label's information onto a smaller sample extract label. The sample extract label must identify the extraction solvent. Transcription errors are prevented by double checking the sample extract label prior to affixing the sample extract label to the sample extract container. The sample extract label is then affixed to the sample extract container.

f. Digestates are labeled by the person performing the digestion of the sample. The sample digestate container is labeled by hand-copying the sample label's information onto a blank label. The sample digestate label must identify the requested analysis. Transcription errors are prevented by double checking the sample digestate label prior to affixing the sample

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digestate label to the sample digestate container. The sample digestate label is then affixed to the sample digestate container.

g. As a general rule-of-thumb, Field Blanks that are associated with a group of samples will have their own Sample Number. Field Blanks that are associated with just one Field Sample (e.g. a separate Field Blank for each Field Sample) may have, but are not required to have, the same Sample Number as the Field Sample that it is associated with.

h. It is common practice for some laboratory QC samples (MB, LCS, LFB) to be assigned a Sample Number in the "900" range. This is not a requirement for these samples (any number may be used), however, it is a desirable practice as it helps avoid confusion by keeping these QC samples "numerically segregated" from Field Samples. For sampling events involving a large number of Field Samples, running into the 900 range, it may be desirable to number these QC samples in the 1500, 2000, or other appropriate range.

6. All samples submitted for analysis will have a sample label affixed to each sample container.

a. Sample labels currently in use are computer generated, therefore, minimal or no entries are required. Any entries made on the sample labels will be accomplished using indelible ink.

b. With the exception of volatile samples and samples packed inside a paint can for shipping, only one sample label is needed for each sample container. Since volatile and over-packed samples consist of more than one container, multiple labels are required so that each container (including the outside container) can be labeled.

NOTE: Since some of the computer-generated sample labels are susceptible to deterioration from water, clear plastic tape should be placed over these sample labels if they will come into contact with water (including ice) during storage, transport and/or shipment. Some computer-generated sample labels are water resistant; these labels will not require tape protection.

c. Each sample container must be uniquely identified by the sample label. Where there is only one container for an analysis (such as Metals in Water by ICP), the container is uniquely identified by the unique sample identifier (ASR Number, Sample Number, and QC Code) and the analysis abbreviation (such as Met W). Where there is more than one container for an analysis (such as VOCs in Water by GC/MS), the containers are

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uniquely identified by the unique sample identifier (ASR Number, Sample Number, and QC Code), the analysis abbreviation (such as VOA W), and a sequential container number (1, 2, 3, etc.). "Specific" sample container labels generated by the laboratory's LIMS are uniquely identified as described above. When samples are received by the laboratory bearing LIMS "Generic" labels, labels generated by the sampler, or hand-made labels, the necessary additional information should be added to the label or a second label should be placed on the container to uniquely identify it. It is the responsibility of the laboratory person receiving the samples (RSCC or their alternate) to ensure that each container is uniquely identified.

F. SAMPLE DOCUMENTATION

1. A field sheet is used to document the field sample collection process and contains pertinent information relative to the sample collected. (Laboratory QC samples are documented on the sample prep and/or analysis log as described in SOP 2410.10, "Analytical Data Submission Package Contents and Review". This section deals primarily with field collected samples.)

2. A field sheet will be completed for each sample collected and will be the official document that provides a permanent record of each sample collected. Since this document is the essential written component required to establish the relationship between the sample collected and the analytical results obtained, it will be controlled and will become a part of the official file on a sampling event.

3. Field sheets can be generated by the laboratory's LIMS, or alternate forms may be used. A field sheet should contain, at a minimum, the following information:

   a. Unique Sample Identifier - This may be recorded as three separate pieces of information (ASR Number, Sample Number and QC Code) or written as one entry (separated by hyphens).

   b. Matrix Sampled - The RLAB matrix as defined in section C.7.a.

   c. Project Information - This should include such things as the Project Manager, Project ID and description, city, state and other pertinent information.

   d. Location/Description - This short description should identify, to the satisfaction of the Project Manager, where the sample was collected. This is typically done by describing or naming the sample collection location.

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e. Sample Collection Date/Time - For time-composited samples, the start date and time and end date and time are required. For grab samples only the start date and time are needed. Times should be recorded in the 24-hour format.

f. Analyses - An unambiguous list of the required laboratory analyses.

g. Field Measurements - Recorded along with the measurement units.

h. Comments - As appropriate.

i. Sampler - The name of the person(s) collecting the sample.

4. The Project Manager is responsible for ensuring that all field sheets are properly and accurately completed, and are safeguarded until they are delivered to RLAB.

5. The original completed field sheets for each sampling activity will be delivered to RLAB along with the samples to be analyzed. They will be maintained in the RLAB analytical support file for the specific ASR.

6. All entries on the field sheets will be legible and completed in indelible ink. Corrections to entries on field sheets should be accomplished by drawing a single line through the entry to be corrected, entering the correction above or adjacent to the lined-through entry and dating and initialing the correction.

7. In addition to the field sheet, another essential component of sample documentation is chain-of-custody. SOP 2420.4 describes the procedures for chain-of-custody of field collected samples being delivered to RLAB. SOP 2420.2, "Storage and Security of Environmental Samples" describes chain-of-custody procedures for within-lab sample transfers of routine samples. For samples that are connected with a criminal investigation, SOP 2420.10, "RLAB Procedures for Custody and Tracking of Samples and Analytical Data Files to be used as Evidence in Criminal Investigations," describes chain-of-custody documentation procedures for within-lab sample transfers.

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G. SAMPLE TRACKING

1. The LIMS database system is used for tracking the status of samples and sample analyses through the analytical process and for tracking and reporting the results of sample analysis. Numerous reports are available from the LIMS and provide a variety of information pertaining to the samples and sample analyses. SOP 2410.20 and the LIMS online help provides more information on this.

2. Information relating to the status of samples submitted for analysis and the status of sample analyses may be obtained by the Project Manager from the LIMS or the RLAB Data Coordinator.

3. It is recognized that changes frequently occur in the field which result in changes to planned sampling activities. Since the LIMS system is used for logging in samples upon receipt, tracking, and ultimately reporting the results, it is essential that Project Managers ensure the entries contained in LIMS for specific sampling activities are accurate and complete (especially any field data and measurements). Discrepancies relating to numbers and types of samples and parameters requested for analysis must be corrected at the time of sample receipt by RLAB in accordance with SOP 2420.1.

4. SOP 2420.2 describes, for routine samples, the procedures for tracking the location of samples and sample containers within the laboratory. For samples that are connected with a criminal investigation, SOP 2420.10 describes the procedures used for tracking the location of samples and sample containers within the laboratory.

5. Unless otherwise requested, environmental samples will be properly disposed of in accordance with SOP 2420.9, "Sample Disposal", upon completion of the analysis and finalization of the analytical results.

H. QUALITY ASSURANCE AND QUALITY CONTROL

It is incumbent on all parties involved with sample collection, analysis, and management that these procedures be followed. Conformance with these procedures shall be evaluated during scheduled audits of RLAB operations as described in SOP 2430.5, "Quality Control Spot Checks of Regional Laboratory Data Packages", and SOP 2430.6, "Periodic Internal Program Review of the Region 7 Laboratory".

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I. REFERENCES

1. Region 7 SOP 2410.10, Analytical Data Submission Package Contents and Review
2. Region 7 SOP 2410.15, Estimating and Documenting Data Quality
3. Region 7 SOP 2410.20, R7LIMS Functions and Security
4. Region 7 SOP 2420.1, Sample Receipt and Log-in
5. Region 7 SOP 2420.2, Storage and Security of Environmental Samples
6. Region 7 SOP 2420.4, Field Chain-of-Custody for Environmental Samples
7. Region 7 SOP 2420.6, Sample Container Selection, Preservation and Holding Times
8. Region 7 SOP 2420.9, Sample Disposal
9. Region 7 SOP 2420.10, RLAB Procedures for Custody and Tracking of Samples and Analytical Data Files to be used as Evidence in Criminal Investigations
10. Region 7 SOP 2420.13, RLAB Procedures for Preparation of Field Sheets and Tags
11. Region 7 SOP 2430.5, Quality Control Spot Checks of Regional Laboratory Data Packages
12. Region 7 SOP 2430.6, Periodic Internal Program Review of the Region 7 Laboratory

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EPA SOP 2420.4C –
Field Chain of Custody for Environmental Samples,
December 2, 2003

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STANDARD OPERATING PROCEDURE

No. 2420.4C

FIELD CHAIN OF CUSTODY FOR ENVIRONMENTAL SAMPLES

December 2, 2003

by Nicole Roblez

ENSV/RLAB/CATS

APPROVED:

Peer Reviewer — Date: 12/3/03

Manager, Regional Laboratory — Date: 4 Dec 03

Harold D. Brown — Independent QA Reviewer — Date: 12/08/03

Recertified

Reviewer					
Date					

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Attachments

1. RLAB Custody Seal;
   Total number of pages: 1.

2. Chain of Custody Record (COC);
   Total number of pages: 1.

3. Instructions for Completing a Chain of Custody Record (COC);
   Total number of pages: 3.

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A. Purpose

The purpose of this Standard Operating Procedure (SOP) is to establish uniform policies and procedures for use by field personnel to maintain an accurate written record of environmental samples from the time of collection through their acceptance by a laboratory for analysis. The custody procedures utilized within the laboratory for receiving samples and maintaining custody through the analytical processes are not covered in this SOP. See "Storage and Security of Environmental Samples", SOP 2420.2 for custody procedures utilized within the Regional Laboratory (RLAB).

B. Applicability

The policies and procedures outlined in this SOP are applicable to all Environmental Services Division (ENSV) personnel, Environmental Protection Agency (EPA), state/local agencies, and/or EPA contractors who collect environmental field samples for analyses by the RLAB or contract laboratories.

C. Summary of Procedures

As a requirement of any activity which may be used to support litigation proceedings, the validity of any data introduced into evidence must be clearly demonstrated. In the case of samples collected in support of an enforcement case, it must be clearly documented that the sample introduced into evidence is, in fact, the same sample collected and/or that the analytical data offered into evidence accurately represent the environmental conditions at the time of sample collection. It is imperative that there is adequate proof to demonstrate that transfer, storage or analysis, and that the analytical results were obtained from the same sample collected. Therefore, an accurate written record must be maintained to track the possession and handling Chain Of Custody Record (COC) (see Attachment 2) of each sample from the moment of collection through analysis and its introduction into evidence.

By definition, a sample is in "custody" if:

1. It is in one's actual physical possession; or
2. It is in one's view, after being in one's physical possession; or
3. It is locked up so no one can tamper with it, after being in one's physical possession; or
4. It is placed in a designated secured area

D. Definitions/Acronyms

ASR	Analytical Services Request
CLP	Contract Laboratory Program
COC	Chain of Custody Record

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ENSV	Environmental Services Division
EPA	Environmental Protection Agency
LIMS	Laboratory Information Management System
PM	Project Manager
PO	Project Officer
QC	Quality Control
RECAP	Region 7 Environmental Collection and Analysis Program
ESAT	Environmental Services Assistance Team
RLAB	Regional Laboratory
RSCC	Regional Sample Control Coordinator
SOP	Standard Operating Procedure
SRN	Sample Receipt Notice
Tags	Sample container labels
UPS	United Parcel Service
VOA	Volatiles

E. Personnel Qualifications

Personnel performing this task should have a basic knowledge of the RLAB sample and records management procedures.

F. Responsibilities

1. Project Manager

a. The Project Manager submits a completed Analytical Services Request (ASR) to the RLAB 30 days before initiation of the sampling activity.

b. The Project Manager or designee (i.e., field contractor) ships and/or delivers properly collected, preserved, labeled, and packaged samples to the RLAB.

c. The Project Manager or designee (i.e., field contractor) is responsible for the accuracy and completeness of all accompanying paperwork. If any changes are required as a result of the sampling (e.g., sample number changes, additional analyses, samples not collected, quality control (QC) code additions), the Project Manager or designee (i.e., field contractor) must see that these corrections are made on all paperwork.

All changes made to the paperwork (COC, sample tags, or field sheets) must also be made to the information contained in the LIMS. It is the responsibility of the Project Manager or designee to supply correct information so that the Regional Sample Control Coordinator (RSCC) can

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properly process the samples into the LIMS. Whenever possible, any changes are made prior to the delivery of the samples. If necessary, the RSCC will assist the Project Manager when changes are noted prior to sample collection/delivery, concurrent to sample delivery or after.

d. The Project Manager must be available to help resolve any problems with the samples or must designate someone to do this for them in their absence. This requires that when delivering samples, the Project Manager or designee stays with the RSCC to answer any questions. Samples must not be just dropped off (unless after normal business hours).

The Project Manager or designee calls the RSCC close to the anticipated delivery date and/or time that samples are sent by courier (i.e., Federal Express) to confirm that samples have arrived and to answer any questions the RSCC may have.

2. RSCC

a. The RSCC opens the ice chest (cooler) and utilizing the Infrared Digital Thermometer, checks the cooler temperature and records the temperature (in degrees Celsius) in the last row of the "Receiving Laboratory Remarks/Other Information" column on the COC (see Attachment 2).

b. The RSCC verifies the presence of all samples, checks all documentation and signs the COC after all paperwork is complete and accurate.

c. The RSCC works with the Project Manager to obtain correct information and puts the amended information into the LIMS.

d. The RSCC notifies the Project Manager of problems which prevent acceptance of the samples by ENSV. RLAB maintains all samples received in a secure location including those pending reconciliation of problems.

e. The RSCC logs samples into the LIMS and is responsible for the proper storage, tracking and/or distribution of the samples to the appropriate contract laboratories (this includes while the sample is in transit to the contract laboratory facility). The RSCC prepares an electronic Sample Receipt Notice (SRN) message for each activity received by the RLAB and routes it appropriately to the Environmental Services Assistance Team (ESAT), the Contract Laboratory Program (CLP) PO, or the Region 7 Environmental Collection and Analysis Program (RECAP) PO, CATS PM, ANOP PM, and appropriate back-up personnel.

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G. Procedures

1. In order to ensure adequate control and documentation of collected samples, the number of personnel handling the samples from the time of collection through delivery to RLAB should be limited.

2. The following actions must be accomplished in order to ensure that the relationship between the physical sample and the description of the sample is clearly, completely and accurately established, and that the custody of the sample is initiated from the time of actual sample collection.

   a. A unique number is assigned to each sample (see "Identification, Documentation, and Tracking of Samples", SOP No. 2420.5) in order to relate the descriptive information to a physical sample. If a sample consists of several containers for analysis of different parameters from the same physical sample, the same number is used for each portion of the original sample.

   b. A sample tag (sample container label) is securely attached to each container at the time of collection for specific instructions for filling out the sample tag (see "Identification, Documentation and Tracking of Samples", SOP No. 2420.5).

   c. Custody of the sample is initiated at the time of collection by ensuring that the sample is in the sample collector's physical possession or view at all times, or is stored in a locked place where no one can tamper with it.

   The sample collector is responsible for the collected samples until they are delivered to the RLAB.

3. Samples may be delivered to RLAB by the sampler or EPA contractor via courier or commercial carrier.

   a. Sampler or EPA contractor-conveyed samples are those transported and delivered to RLAB. The coolers may be sealed or unsealed, but the sampler or EPA contractor must ensure that they are secured in the transport vehicle when he/she is not physically with the vehicle.

   b. Samples may be delivered via courier (e.g., Greyhound). The cooler and sample containers must be transported with the lids secured. The transfer of possession of the samples must be recorded from the sampler or EPA contractor to RLAB.

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c. Samples may be shipped via commercial carrier (e.g., Federal Express, Airborne, United Parcel Service (UPS)) from the field to RLAB. The cooler and sample containers must be sealed at the time of shipment.

4. Samples are considered to be sealed when they are packaged in such a manner that would prohibit tampering or readily reveal any tampering, if it occurred.

a. A custody seal (see Attachment 1) may be used to secure the individual sample container, as appropriate to meet specific regulatory program requirements. These custody seals must be signed and dated by the sampler or EPA contractor when used to seal individual sample containers.

b. The use of a custody seal must be used to secure the openings of boxes, plastic bags, ice chests or coolers containing samples. These custody seals must be signed and dated by the sampler or EPA contractor when used to seal the shipping containers.

5. The COC (see Attachment 2) is initiated at the time of sample collection and must accompany all samples. The COC is utilized to document the transfer of a sample from the sampler or EPA contractor through receipt by the RSCC or designated back-up at RLAB.

RLAB instructions for the completion of the COC are outlined in Attachment 3.

a. The transfer of possession of the samples would occur when the sampler or EPA contractor delivers the samples to RLAB, gives them to the courier who will deliver the samples to RLAB, or packs the samples in a sealed shipping container for shipment to RLAB via commercial carrier.

b. The original and yellow copy of the COC will accompany the samples to RLAB. When the samples are conveyed by the sampler or EPA contractor, the COC may be hand carried. When the samples are delivered via courier or commercial carrier, the COC must be placed in a plastic document enclosure which is enclosed in the shipping container.

6. When samples are delivered to RLAB after duty hours, the samples and the COC will be placed in the refrigerator located on the back dock until acceptance by the RSCC or designated backup in accordance with the procedures outlined in "Storage and Security of Environmental Samples", SOP No. 2420.2.

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7. Once RLAB has accepted the samples, the responsibility for custody of the samples transfers to the RLAB personnel. Custody of the samples is maintained through analysis in accordance with the laboratory's internal control procedures.

8. The original of the completed COC is obtained by RLAB for inclusion with the permanent site activity files, and included with the final data transmittal sent to the Project Manager.

9. The yellow copy of the completed COC is returned to the Project Manager for inclusion in their appropriate activity files after all samples, for a given activity, have been accepted.

10. The custody seals or evidence tape associated with the specific samples or sample shipments are not retained.

H. Quality Assurance/Quality Control

A written tracking record (COC) is maintained from the time that the sample is collected to its transfer from the collection site to its laboratory destination. This record is used to demonstrate that sample possession has been secured and limited. Signed and dated custody seals placed over the access points of the sample shipment demonstrate that the contents of the samples have not been tampered with or compromised.

I. References

1. US EPA, Region 7,"RLAB Procedures for Sample Receipt and Log-In", Environmental Services Division Operations and Quality Assurance Manual, SOP 2420.1

2. US EPA, Region 7, "Identification, Documentation, and Tracking of Samples", Environmental Services Division Operations and Quality Assurance Manual, SOP 2420.5

3. US EPA, Region 7, "Storage and Security of Environmental Samples", Environmental Services Division Operations and Quality Assurance Manual, SOP 2420.2

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Attachment 1

RLAB Custody Seal

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Attachment 2

CHAIN OF CUSTODY RECORD
ENVIRONMENTAL PROTECTION AGENCY REGION VII

ACTIVITY LEADER(Print)	NAME OF SURVEY OR ACTIVITY	DATE OF COLLECTION DAY MONTH YEAR	SHEET of

CONTENTS OF SHIPMENT

SAMPLE NUMBER	TYPE OF CONTAINERS CUBITAINER	BOTTLE	BOTTLE	BOTTLE	VOA SET (2 VIALS EA)	SAMPLED MEDIA water	soil	sediment	dust	other	RECEIVING LABORATORY REMARKS/OTHER INFORMATION (condition of samples upon receipt, other sample numbers, etc.)
	NUMBERS OF CONTAINERS PER SAMPLE NUMBER										

DESCRIPTION OF SHIPMENT

_____ PIECE(S) CONSISTING OF _____ BOX(ES)

_____ ICE CHEST(S): OTHER _____

MODE OF SHIPMENT

_____ COMMERCIAL CARRIER: _____

_____ COURIER

_____ SAMPLER CONVEYED _____ (SHIPPING DOCUMENT NUMBER)

PERSONNEL CUSTODY RECORD

RELINQUISHED BY (SAMPLER)	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	
RELINQUISHED BY	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	
RELINQUISHED BY	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	

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Attachment 3

Instructions For Completing A Chain Of Custody Record

(Note: Each numbered item explains what is to be entered into that particular block moving from left to right, top to bottom of the document.)

1. Activity Leader. Enter the first initial and last name of the EPA Project Manager.

2. Name of Survey or Activity. Enter the activity number and/or Analytical Services Request (ASR) number (e.g., ERN07/900) for which the samples were collected.

3. Date of Collection. Enter the day, month, and year the samples were collected.

4. Sheet. Enter 1 of 1 unless there are more than one total sheets describing the shipment. If multiple sheets, enter the consecutive number of each sheet of the total number of sheets (e.g., 1 of 3, 2 of 3, 3 of 3).

5. Contents of the Shipment.

   a. Enter the specific sample numbers, number of sample type containers per sample number and sample media in the appropriate column

      (1) The ASR number and the individual sample numbers composing the shipment are entered in the "Sample Number" column (e.g., 2222-2). If more than one sheet is required, continue on additional sheets. For shipments of a large group of samples, it would be more appropriate and efficient to complete a separate sheet for each shipping container.

      (2) The types of containers for each sample number are entered in the columns provided. The size should be entered above the container type, as appropriate. For Volatiles, the "VOA Set" refers to two=40 ml vials contained in the cubitainer which are collected for volatile organics analyses. The container types are modified, as necessary or appropriate, to describe sample containers.

      (3) The sampled media for each sample number will be indicated by placing an "X" in the appropriate column. If the sample media is not listed, the actual media sampled should be entered in the "Other" column (e.g., wipe, sludge, air, biota, fish, etc.).

      (4) The "Receiving Laboratory Remarks/Other Information" is to be used by the RLAB to indicate any problems with the shipment or condition of the samples upon receipt; e.g., custody seal on sample container or shipping container broken, a sample container broken in transit, a sample lost due to leakage during shipment, etc. The temperature of the shipping coolers(s) are to be recorded in the lower area of this column. This column may also be used to record other sample numbers for cross-referencing purposes (e.g., external sample number).

b. After entering all of the above information, the total contents of the shipment should be indicated by marking out any remaining lines in this section. This can be accomplished either by drawing a line across the next line after the last entry and entering "None to Follow" or "Activity/ASR Complete," or by drawing a line across the next blank line or diagonally across the remaining lines in the section and entering "None to Follow" or "Activity/ASR Complete."

6. Description of Shipment. Enter the total number of pieces (e.g., samples or sample containers) packed in the total number of shipping containers (e.g., ice chests, boxes or other, which comprise the total shipment)(e.g., 12 pieces in 2 ice chests or 24 pieces in 2 boxes).

7. Mode of Shipment. Indicate the mode by which the samples are shipped to the RLAB by placing an "X" in the appropriate line preceding the specific mode in this block. If the shipment is via commercial carrier, the name of the carrier and the shipping document number (e.g., airbill) should be entered in the appropriate lines provided. This information may be entered by the sample shipper (sampler or individual to whom the sampler relinquished the samples), or the shipment receiver (lab sample custodian), as appropriate.

8. Personnel Custody Record. This portion of the form provides the record of changes of custody of the shipment (sample or group of samples)from the sample collector to the laboratory. To provide an adequate written record, all of the blocks should be completed as described below.

a. The sample collector will sign the first "Relinquished By" block when the samples are presented to another individual or commercial carrier.

(1) An "X" should be entered in the appropriate block to indicate whether the shipment is sealed or unsealed with a piece of completed custody seal tape, the date and time when the samples are relinquished should be entered in the appropriate blocks, and the reason for change of custody (e.g., transport to lab, receipt by lab, etc.) should be entered in the appropriate block.

(2) If the sampler is presenting the samples to a commercial carrier for shipment, the name of the carrier should be entered in the next available "Received By" block. The signature of a representative of the carrier is not required.

b. Each individual who received the shipment of samples will sign the next available "Received By" block and enter an "X" in the appropriate block to indicate whether the samples were received sealed or unsealed with a piece of completed custody seal tape. If the samples were shipped via commercial carrier, the individual receiving the samples (e.g., sample custodian at the RLAB) should enter the date and time the samples were received and the reason for change of custody (e.g., receipt by the RLAB) in the appropriate blocks.

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c. Each successive individual who relinquishes custody of the samples will sign the next available "Relinquished By" block, enter an "X" in the appropriate block to indicate whether the sample shipment is sealed or unsealed with a piece of completed custody seal tape, enter the date and time when custody is relinquished and enter the reason for change of custody in the appropriate blocks.

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Packaging and Shipping Environmental Samples

SOP 2-1
Revision: 3
Date: March 2007

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1.0 Objective

The objective of this SOP is to outline the requirements for the packaging and shipment of environmental samples. Additionally, Sections 2.0 through 7.0 outline requirements for the packaging and shipping of regulated environmental samples under the Department of Transportation (DOT) Hazardous Materials Regulations, the International Air Transportation Association (IATA), and International Civil Aviation Organization (ICAO) Dangerous Goods Regulations for shipment by air and applies only to domestic shipments. This SOP does not cover the requirements for packaging and shipment of equipment (including data loggers and self-contained breathing apparatus [SCBAs] or bulk chemicals that are regulated under the DOT, IATA, and ICAO.

1.1 Packaging and Shipping of All Samples

This standard operating procedure (SOP) applies to the packaging and shipping of all environmental samples. If the sample is preserved or radioactive, the following sections may also be applicable.

Section 2.0 - Packaging and Shipping Samples Preserved with Methanol
Section 3.0 - Packaging and Shipping Samples Preserved with Sodium Hydroxide
Section 4.0 - Packaging and Shipping Samples Preserved with Hydrochloric Acid
Section 5.0 - Packaging and Shipping Samples Preserved with Nitric Acid
Section 6.0 - Packaging and Shipping Samples Preserved with Sulfuric Acid
Section 7.0 - Packaging and Shipping Limited-Quantity Radioactive Samples

1.2 Background

1.2.1 Definitions

Environmental Sample - An aliquot of air, water, plant material, sediment, or soil that represents the contaminant levels on a site. Samples of potential contaminant sources, like tanks, lagoons, or non-aqueous phase liquids are normally not "environmental" for this purpose. This procedure applies only to environmental samples that contain less than reportable quantities for any foreseeable hazardous constituents according to DOT regulations promulgated in 49 CFR - Part 172.101 Appendix A.

Custody Seal - A custody seal is a narrow adhesive-backed seal that is applied to individual sample containers and/or the container (i.e., cooler) before offsite shipment. Custody seals are used to demonstrate that sample integrity has not been compromised during transportation from the field to the analytical laboratory.

Inside Container - The container, normally made of glass or plastic, that actually contacts the shipped material. Its purpose is to keep the sample from mixing with the ambient environment.

Outside Container - The container, normally made of metal or plastic, that the transporter contacts. Its purpose is to protect the inside container.

Secondary Containment - The outside container provides secondary containment if the inside container breaks (i.e., plastic overpackaging if liquid sample is collected in glass).

Excepted Quantity - Excepted quantities are limits to the mass or volume of a hazardous material in the inside and outside containers below which DOT, IATA, ICAO regulations do not apply. The excepted quantity limits are very low. Most regulated shipments will be made under limited quantity.

Limited Quantity - Limited quantity is the maximum amount of a hazardous material below which there are specific labeling or packaging exceptions.

Performance Testing - Performance testing is the required testing of outer packaging. These tests include drop and stacking tests.

Qualified Shipper - A qualified shipper is a person who has been adequately trained to perform the functions of shipping hazardous materials.

1.2.2 Associated Procedures

- CDM Federal SOP 1-2, *Sample Custody*

1.2.3 Discussion

Proper packaging and shipping is necessary to ensure the protection of the integrity of environmental samples shipped for analysis. These shipments are potentially subject to regulations published by DOT, IATA, or ICAO. Failure to abide by these rules places both CDM and the individual employee at risk of serious fines. The analytical holding times for the samples must not be exceeded. The samples shall be packed in time to be shipped for overnight delivery. Make arrangements with the laboratory before sending samples for weekend delivery.

1.3 Required Equipment

- Coolers with return address of the appropriate CDM office
- Heavy-duty plastic garbage bags
- Plastic zip-type bags, small and large
- Clear tape
- Nylon reinforced strapping tape
- Duct tape
- Vermiculite (or an equivalent nonflammable material that is inert and absorbent)*
- Bubble wrap (optional)
- Ice
- Custody seals
- Completed chain-of-custody record or contract laboratory program (CLP) custody records, if applicable
- Completed bill of lading
- "This End Up" and directional arrow labels

*Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

1.4 Packaging Environmental Samples

The following steps must be followed when packing sample bottles and jars for shipment:

1. Verify the samples undergoing shipment meet the definition of "environmental sample" and are not a hazardous material as defined by DOT. Professional judgment and/or consultation with qualified persons such as the appropriate health and safety coordinator or the health and safety manager shall be observed.

2. Select a sturdy cooler in good repair. Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler. Line the cooler with a large heavy-duty plastic garbage bag.

3. Be sure the caps on all bottles are tight (will not leak); check to see that labels and chain-of-custody records are completed properly (SOP 1-2, Sample Custody).

4. Place all bottles in separate and appropriately sized plastic zip-top bags and close the bags. Up to three VOA vials may be packed in one bag. Binding the vials together with a rubber band on the outside of the bag, or separating them so that they do not contact each other, will reduce the risk of breakage. Bottles may be wrapped in bubble wrap. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite or equivalent. ***Note***: Trip blanks must be included in coolers containing VOA samples.

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5. Place 2 to 4 inches of vermiculite (or equivalent) into a cooler that has been lined with a garbage bag, and then place the bottles and cans in the bag with sufficient space to allow for the addition of packing material between the bottles and cans. It is preferable to place glass sample bottles and jars into the cooler vertically. Glass containers are less likely to break when packed vertically rather than horizontally.

6. While placing sample containers into the cooler, conduct an inventory of the contents of the shipping cooler against the chain-of-custody record. The chain-of-custody with the cooler shall reflect only those samples within the cooler.

7. Put ice in large plastic zip-top bags (double bagging the zip-tops is preferred) and properly seal. Place the ice bags on top of and/or between the samples. Several bags of ice are required (dependant on outdoor temperature, staging time, etc.) to maintain the cooler temperature at approximately 4° Celsius (C) if the analytical method requires cooling. Fill all remaining space between the bottles or cans with packing material. Securely fasten the top of the large garbage bag with fiber or duct tape.

8. Place the completed chain-of-custody record or the CLP traffic report form (if applicable) for the laboratory into a plastic zip-top bag, seal the bag, tape the bag to the inner side of the cooler lid and close the cooler.

9. The cooler lid shall be secured with nylon reinforced strapping tape by wrapping each end of the cooler a minimum of two times. Attach a completed chain-of-custody seal across the opening of the cooler on opposite sides. The custody seals shall be affixed to the cooler with half of the seal on the strapping tape so that the cooler cannot be opened without breaking the seal. Complete two more wraps around with fiber tape and place clear tape over the custody seals.

10. The shipping container lid must be marked **"THIS END UP"** and arrow labels that indicate the proper upward position of the container shall be affixed to the cooler. A label containing the name and address of the shipper (CDM) shall be placed on the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Air Craft, Flammable Solids, etc.) are not permitted on the outside of containers used to transport environmental samples and shall not be used. The name and address of the laboratory shall be placed on the container, or when shipping by common courier, the bill of lading shall be completed and attached to the lid of the shipping container.

2.0 Packaging and Shipping Samples Preserved with Methanol

2.1 Containers

- The maximum volume of methanol in a sample container is limited to 30 ml.
- The sample container must not be full of methanol.

2.2 Responsibility

It is the responsibility of the qualified shipper to:

- Ensure that the samples undergoing shipment contain no other contaminant that meets the definition of "hazardous material" as defined by DOT
- Determine the amount of preservative in each sample so that accurate determination of quantities can be made

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

2.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Inner packing may consist of glass or plastic jars
- Outer packaging (for limited quantities) insulated cooler that has passed the ICAO drop test
- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
- Class 3 flammable liquid labels
- Orientation labels
- Consignor/consignee labels

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2.4 Packaging Samples Preserved with Methanol

The following steps are to be followed when packaging limited-quantity sample shipments:

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
  - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)
- Wrap each container (40-ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble-wrapped container into a 2.7-mil zip-type bag, removing trapped air.
- Place wrapped containers inside a polyethylene bottle filled with vermiculite; seal the bottle. (Maximum of 4 VOA vials will fit inside a 500-ml wide-mouth polyethylene bottle.)
- Total volume of methanol per shipping container must not exceed 500 ml.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

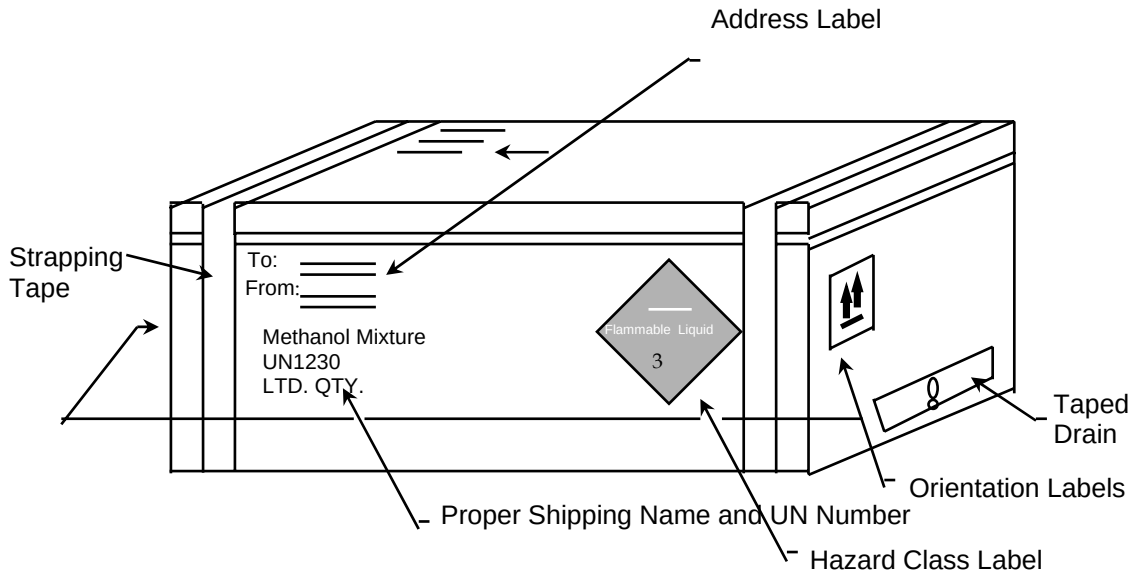
  Methanol Mixture
  UN1230
  LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Flammable Liquid label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marking locations is shown in Figure 1.

Note: No marking or labeling can be obscured by strapping or duct tape.
Note: The inner packaging of dangerous goods must be placed into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

Figure 1
Example of Cooler Label/Marking Locations



3.0 Packaging and Shipping Samples Preserved with Sodium Hydroxide

3.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Sodium Hydroxide Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
NaOH	30%	>12	0.08%		.25	0.5	1	2

5 drops = 1 ml

3.2 Responsibility

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

3.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Outer packaging (for limited quantities) insulated cooler that has passed the ICAO drop test
- Inner packings may consist of glass or plastic jars no larger than 1 pint
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

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3.4 Packaging Samples Preserved with Sodium Hydroxide

Samples containing NaOH as a preservative that exceed the excepted concentration of 0.08 percent (2 ml of a 30 percent NaOH solution per liter) may be shipped as a limited quantity per packing instruction Y819 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited-quantity samples shipments:

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
  - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)
- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble-wrapped container into a 2.7-mil zip-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- The total volume of sample in each cooler must not exceed 1 liter.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

  Sodium Hydroxide Solution
  UN1824
  LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marking locations is shown in Figure 1.

Note: Samples meeting the exception concentration of 0.08 percent NaOH by weight may be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.

Note: No marking or labeling can be obscured by strapping or duct tape.

Note: The inner packaging of dangerous goods must be placed into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

4.0 Packaging and Shipping Samples Preserved with Hydrochloric Acid

4.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Hydrochloric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*		
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**
HCl	2N	<1.96	0.04%	.2	.5	1

5 drops = 1 ml

4.2 Responsibility

It is the responsibility of the qualified shipper to:

- Determine the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT
- Determine the amount of preservative in each sample so that accurate determination of quantities can be made

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

4.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3.

- Inner packing may consist of glass or plastic jars no larger than 1 pint.
- Outer packaging (for limited quantities) insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

4.4 Packaging Samples Preserved with Hydrochloric Acid

The following steps are to be followed when packaging limited-quantity sample shipments:

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
  - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)
- Wrap each container (40-ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble-wrapped container into a 2.7-mil zip-type bag, removing trapped air.
- Place wrapped containers inside a polyethylene bottle filled with vermiculite; seal the bottle. (No more than 4 VOA vials will fit inside a 500-ml wide-mouth polyethylene bottle.)

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- Total volume of sample inside each cooler must not exceed 1 liter.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

  Hydrochloric Acid Solution
  UN1789
  LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marking locations is shown in Figure 1.

Note: Samples containing less than the exception concentration of 0.04 percent HCl by weight will be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.

Note: No marking or labeling can be obscured by strapping or duct tape.

Note: The inner packaging of dangerous goods must be placed into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

5.0 Packaging and Shipping Samples Preserved with Nitric Acid

5.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Nitric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
HNO_3	6N	<1.62	0.15%		2	4	5	8

5 drops = 1 mg/L

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5.2 Responsibility

It is the responsibility of the qualified shipper to:

- Determine the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT
- Determine the amount of preservative in each sample so that accurate determination of quantities can be made

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

5.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Inner packings may consist of glass or plastic jars no larger than 100 ml.
- Outer packaging (for limited quantities) insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

5.4 Packaging Samples Preserved with Nitric Acid

Samples containing HNO_3 as a preservative that exceed the excepted concentration of 0.15 percent HNO_3 will be shipped as a limited quantity per packing instruction Y807 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited-quantity sample shipments:

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
  - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)
- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble-wrapped container into a 2.7-mil zip-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- The maximum volume of preserved solution in the cooler must not exceed 500 ml.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

Nitric Acid Solution (with less than 20 percent)
UN2031
Ltd. Qty.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marking locations is shown in Figure 1.

Note: Samples meeting the exception concentration of 0.15 percent HNO_3 by weight will be shipped as nonregulated or nonhazardous following the procedure in Section 1.4.

Note: No marking or labeling can be obscured by strapping or duct tape.

Note: The inner packaging of dangerous goods must be placed into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

6.0 Packaging and Shipping Samples Preserved with Sulfuric Acid

6.1 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Excepted Quantities of Sulfuric Acid Preservatives

Preservative		*Desired in Final Sample*		*Quantity of Preservative (ml) for Specified Container*				
		pH	**Conc.**	**40 ml**	**125 ml**	**250 ml**	**500 ml**	**1 L**
H_2SO_4	37N	<1.15	0.35%	.1	.25	0.5	1	2

5 drops = 1 ml

6.2 Responsibility

It is the responsibility of the qualified shipper to:

- Determine the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT
- Determine the amount of preservative in each sample so that accurate determination of quantities can be made

Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

6.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

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- Inner packings may consist of glass or plastic jars no larger than 100 ml.
- Outer packaging (for limited quantities) insulated cooler that has passed the ICAO drop test.
- Survey documentation (if shipping from DOE or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

6.4 Packaging of Samples Preserved with Sulfuric Acid

Samples containing H_2SO_4 as a preservative that exceed the excepted concentration of 0.35 percent will be shipped as a limited quantity per packing instruction Y809 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited-quantity samples shipments:

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
  - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody form)
- Wrap each glass container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble-wrapped container into a 2.7-mil zip-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- The maximum volume of preserved solution in the cooler must not exceed 500 ml.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

  Sulfuric Acid Solution
  UN2796
  LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marking locations is shown in Figure 1.

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Note: Samples containing less than the exception concentration of 0.35 percent H_2SO_4 by weight will be shipped as nonregulated or nonhazardous in accordance with the procedure described in Section 1.4.

Note: No marking or labeling can be obscured by strapping or duct tape.

Note: The inner packaging of dangerous goods must be placed into the designated cooler for shipment. Other nonregulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

7.0 Packaging and Shipping Limited-Quantity Radioactive Samples

7.1 Containers

The inner packaging containers that may be used for these shipments include:

- Any size sample container

7.2 Description/Responsibilities

- The qualified shipper will determine that the samples undergoing shipment contain no other contaminant that meets the definition of hazardous material as defined by DOT.
- The qualified shipper will ship all samples that meet the Class 7 definition of radioactive materials and meet the activity requirements specified in Table 7 of 49 CFR 173.425, as Radioactive Materials in Limited Quantity. The qualified shipper will verify that all packages and their contents meet the requirements of 49 CFR 173.421, *Limited Quantities of Radioactive Materials*.
- The packaging used for shipping will meet the general requirements for packaging and packages specified in 49 CFR 173.24 and the general design requirements provided in 173.410. These standards state that a package must be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal condition of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use.
- If the shipment is from a DOE facility, radiological screenings will be completed on all samples taken. The qualified shipper will review the results of each screening (alpha, beta, and gamma speciation). Samples will not be shipped offsite until the radiological screening has been performed.
- The total activity for each package will not exceed the relevant limits listed in Table 7 of 49 CFR 173.425. The A_2 value of the material will be calculated based on all radionuclides found during previous investigations (if any) in the area from which the samples are derived. The A_2 values to be used will be the most restrictive of all potential radionuclides as listed in 49 CFR 173.435.
- The radiation level at any point on the external surface of the package bearing the sample(s) will not exceed 0.005 mSv/hour (0.5 mrem/hour). These will be verified by dose and activity monitoring before shipment of the package.
- The removable radioactive surface contamination on the external surface of the package will not exceed the limits specified in 49 CFR 173.443(a). CDM will apply the DOE-established free release criteria for removable surface contamination of less than 20 dpm/100 cm^2 (alpha) and 1,000 dpm/100 cm^2 (beta/gamma). It shall be noted that these values are more conservative than the DOT requirements for removable surface contamination.
- The qualified shipper will verify that the outside of the inner packaging is marked “Radioactive.”
- The qualified shipper will verify that the excepted packages prepared for shipment under the provisions of 49 CFR 173.421 have a notice enclosed, or shown on the outside of the package, that reads, **“This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910.”**

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Note: Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site-/project-specific quality assurance project plan (QAPP).

7.3 Additional Required Equipment

The following equipment is needed in addition to the required equipment listed in Section 1.3:

- Survey documentation/radiation screening results (if shipping from DOE or radiological sites)
- Orientation labels
- Excepted quantities label
- Consignor/consignee labels

7.4 Packaging of Limited-Quantity Radioactive Samples

The following steps are to be followed when packaging limited-quantity sample shipments:

- The cooler is to be surveyed by a qualified radiation control technician to ensure that radiation flux on exterior surfaces does not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape before sampling.
- At a minimum the label must contain:
  - Project name
  - Project number
  - Date and time of sample collection
  - Sample location
  - Sample identification number
  - Collector's initials
- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place sufficient amount of vermiculite, or approved packaging material, in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- If required, place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tieing or taping.
- Place a label marked Radioactive on the outside of the sealed bag.
- Enclose a notice that includes the name of the consignor or consignee and the following statement: ***"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910."***
- Note that both DOT and IATA apply different limits to the quantity in the inside packing and in the outside packing.
- The maximum weight of the package shall not exceed 30 kg (66 lbs) for any limited-quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a zip-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- If a cooler is used, wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix package orientation labels on two opposite sides of the cooler/package.
- Affix a completed Excepted Quantities label to the side of the cooler/package.
- Secure any marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of the cooler labeling/marking is shown in Figure 2.

Note: No marking or labeling can be obscured by strapping or duct tape.

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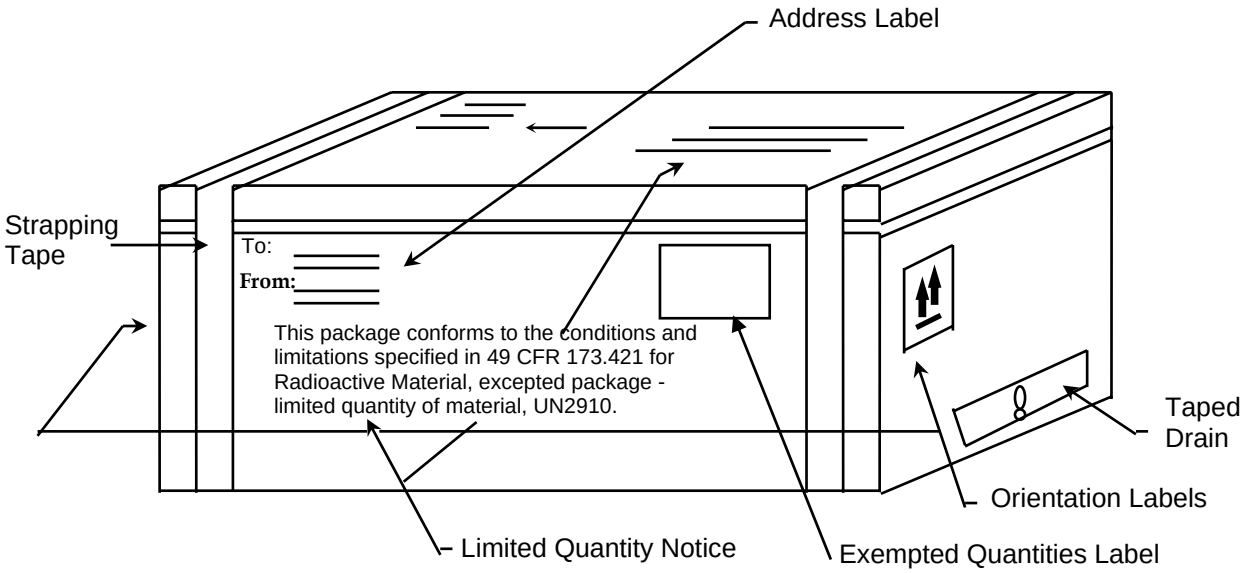
- Complete the Shipment Quality Assurance Checklist (Appendix B).

Note: Except as provided in 49 CFR 173.426, the package will not contain more than 15 grams of ^{235}U.
Note: A declaration of dangerous goods is not required.

Figure 2
Radioactive Material – Limited-Quantity Cooler Marking Example



8.0 References

U. S. Environmental Protection Agency. Region IV. February 1991 or current. *Standard Operating Procedures and Quality Assurance Manual*.

_____. 1996 or current. *Sampler's Guide to the Contract Laboratory Program*, EPA/540/R-96/032.

Title 49 Code of Federal Regulations, Department of Transportation. 2005 or current revision. *Hazardous Materials Table, Special Provisions, Hazardous, Materials Communications, Emergency Response Information, and Training Requirements*, 49 CFR 172.

Title 49 Code of Federal Regulations, Department of Transportation. 2005 or current revision. *Shippers General Requirements for Shipments and Packagings*, 49 CFR 173.

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Appendix A

Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited-Quantity

Sample Packaging

Yes	No	N/A	
❑	❑	❑	The VOA vials are wrapped in bubble wrap and placed inside a zip-type bag.
❑	❑	❑	The VOA vials are placed into a polyethylene bottle, filled with vermiculite, and tightly sealed.
❑	❑	❑	The drain plug is taped inside and outside to ensure control of interior contents.
❑	❑	❑	The samples have been placed inside garbage bags with sufficient bags of ice to preserve samples at 4°C.
❑	❑	❑	The cooler weighs less than the 66-pound limit for limited-quantity shipment.
❑	❑	❑	The garbage bag has been sealed with tape (or tied) to prevent movement during shipment.
❑	❑	❑	The chain-of-custody has been secured to the interior of the cooler lid.
❑	❑	❑	The cooler lid and sides have been taped to ensure a seal.
❑	❑	❑	The custody seals have been placed on both the front and back hinges of the cooler, using waterproof tape.

Air Waybill Completion

Yes	No	N/A	
❑	❑	❑	Section 1 has the shipper's name, company, and address; the account number, date, internal billing reference number; and the telephone number where the shipper can be reached.
❑	❑	❑	Section 2 has the recipient's name and company along with a telephone number where they can be reached.
❑	❑	❑	Section 3 has the **Bill Sender** box checked.
❑	❑	❑	Section 4 has the **Standard Overnight** box checked.
❑	❑	❑	Section 5 has the **Deliver Weekday** box checked.
❑	❑	❑	Section 6 has the number of packages and their weights filled out. Was the total of all packages and their weights figured up and added at the bottom of Section 6?
❑	❑	❑	Under the **Transport Details** box, the **Cargo Aircraft Only** box is obliterated, leaving only the **Passenger and Cargo Aircraft** box.
❑	❑	❑	Under the **Shipment Type**, the **Radioactive** box is obliterated, leaving only the **Non-Radioactive** box.
❑	❑	❑	Under the **Nature and Quantity of Dangerous Goods** box, the **Proper Shipping Name, Class or Division, UN or ID No., Packing Group, Subsidiary Risk, Quantity and Type of Packing, Packing Instructions, and Authorization** have been filled out for the type of chemical being sent.
❑	❑	❑	The **Name, Place and Date, Signature, and Emergency Telephone Number** appears at the bottom of the FedEx Airbill.
❑	❑	❑	The statement "In accordance with IATA/ICAO" appears in the **Additional Handling Information** box.
❑	❑	❑	The E**mergency Contact Information** at the bottom of the FedEx Airbill is truly someone who can respond any time of the day or night.

Proper Shipping Name	*Class or Division*	*UN or ID No.*	*Packing Group*	*Sub Risk*	*Quantity*	*Packing Instruction*	*Authorization*
Hydrochloric Acid Solution	8	UN1789	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Nitric Acid Solution (with less than 20%)	8	UN2031	II		1 plastic box × 0.5 L	Y807	Ltd. Qty.
Sodium Hydroxide Solution	8	UN1824	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Sulfuric Acid Solution	8	UN2796	II		1 plastic box × 0.5 L	Y809	Ltd. Qty.
Methanol	3	UN1230	II		1 plastic box × 1 L	Y305	Ltd. Qty.

Sample Cooler Labeling

Yes	No	N/A	
❑	❑	❑	The proper shipping name, UN number, and Ltd. Qty. appears on the shipping container.
❑	❑	❑	The corresponding hazard labels are affixed on the shipping container; the labels are not obscured by tape.
❑	❑	❑	The name and address of the shipper and receiver appear on the top and side of the shipping container.
❑	❑	❑	The air waybill is attached to the top of the shipping container.
❑	❑	❑	**Up Arrows** have been attached to opposite sides of the shipping container.
❑	❑	❑	Packaging tape does not obscure markings or labeling.

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Appendix B
Shipment Quality Assurance Checklist

Date: _____ Shipper: _____ Destination: _____

Item(s) Description: _____

Radionuclide(s): _____

Radiological Survey Results: surface _____mrem/hr 1 meter _____

Instrument Used: Mfgr: _____ Model: _____

S/N: _____ Cal Date: _____

Limited-Quantity or Instrument and Article

Yes	No		
___	___	1.	Strong tight package (package that will not leak material during conditions normally incidental to transportation).
___	___	2.	Radiation levels at any point on the external surface of package less than or equal to 0.5 mrem/hr.
___	___	3.	Removable surface contamination less than 20 dpm/100 cm^2 (alpha) and 1,000 dpm/100 cm^2 (beta/gamma).
___	___	4.	Outside inner package bears the marking "Radioactive."
___	___	5.	Package contains less than 15 grams of ^{235}U (check yes if ^{235}U not present).
___	___	6.	Notice enclosed in or on the package that includes the consignor or consignee and the statement, **"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910."**
___	___	7.	Activity less than that specified in 49 CFR 173.425. Permissible package limit: Package Quantity:
___	___	8.	On all air shipments, the statement **Radioactive Material, excepted package-limited quantity of material** shall be noted on the air waybill.

Qualified Shipper: _____ Signature: _____

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Field Logbook Content and Control

Prepared: Del Baird
Technical Review: Sharon Budney
QA Review: Douglas J. Updike
Approved: _____ Signature/Date
Issued: _____ Signature/Date

1.0 Objective

The objective of this standard operating procedure (SOP) is to set CDM Federal (CDM) criteria for content entry and form of field logbooks. Field logbooks are an essential tool to document field activities for historical and legal purposes.

2.0 Background

2.1 Definitions

Biota - The flora and fauna of a region.

Magnetic Declination Corrections - Compass adjustments to correct for the angle between magnetic north and geographical meridians.

2.2 Discussion

Information recorded in field logbooks includes field team names, observations, data, calculations, date/time, weather, and description of the data collection activity, methods, instruments, and results. Additionally, the logbook may contain deviations from plans and descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

3.0 Responsibilities

Field Team Leader (FTL) - The FTL is responsible for ensuring that the format and content of data entries are in accordance with this procedure.

Site Personnel - All CDM employees who make entries in field logbooks during onsite activities are required to read this procedure prior to engaging in this activity. The FTL will assign field logbooks to site personnel who will be responsible for their care and maintenance. Site personnel will return field logbooks to the records file at the end of the assignment.

4.0 Required Equipment

- Site-specific plans
- Field notebook
- Indelible black or blue ink pen
- Ruler or similar scale

5.0 Procedures

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks must be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation. These procedures should be located at the field office.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. Prior to use in the field, each logbook will be marked with a specific document control number issued by the document control administrator, if required by the contract quality implementation plan (QIP). Not all contracts require document control numbers. The following information shall be recorded on the cover of the logbook:

- Field logbook document control number.
- Activity (if the logbook is to be activity-specific) and location.
- Name of CDM contact and phone number(s).
- Start date.
- In specific cases, special logbooks may be required (e.g., waterproof paper for stormwater monitoring).

The first few (approximately five) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading and enter the following:

Table of Contents

Date/Description	Page
(Start Date)/Reserved for TOC	1-5

The remaining pages of the table of contents will be designated as such with "TOC" written on the top center of each page.

5.2 Operation

Requirements that must be followed when using a logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information need not be duplicated in the logbook. However, any forms used to record site information must be referenced in the logbook.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.

Specific requirements for field logbook entries include:

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- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- Multiple authors must sign out the logbook by inserting the following:
  Above notes authored by:
  - (Sign name)
  - (Print name)
  - (Date)
- A new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:
  - Date and time
  - Name of individual making entry
  - Names of field team and other persons onsite
  - Description of activity being conducted including station or location (i.e., well, boring, sampling location number) if appropriate
  - Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data
  - Level of personal protection to be used
  - Serial numbers of instruments
  - Required calibration information
  - Serial/tracking numbers on documentation (e.g., carrier air bills)

Entries into the field logbook shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In these cases, the logbook must reference the automatic data record or form.

At each station where a sample is collected or an observation or measurement made, a detailed description of the location of the station is required. Use a compass (include a reference to magnetic declination corrections), scale, or nearby survey markers, as appropriate. A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator. It is preferred that maps and sketches be oriented so that north is toward the top of the page. Maps, sketches, figures, or data that will not fit on a logbook page should be referenced and attached to the logbook to prevent separation.

Other events and observations that should be recorded include:

- Changes in weather that impact field activities.
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protection equipment.

5.3 Post-Operation

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Field Logbook Content and Control

To guard against loss of data due to damage or disappearance of logbooks, completed pages shall be periodically photocopied (weekly, at a minimum) and forwarded to the field or project office. Other field records shall be photocopied and submitted regularly and as promptly as possible to the office. When possible, electronic media such as disks and tapes should be copied and forwarded to the project office.

At the conclusion of each activity or phase of site work, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated, and that corrections were made properly (single lines drawn through incorrect information, then initialed and dated). The completed logbook shall be submitted to the records file.

6.0 Restrictions/Limitations

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM personnel and their subcontractors. They are documents that may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these logbooks should be factual, clear, precise, and non-subjective. Field logbooks, and entries within, are not to be used for personal use.

7.0 References

Sandia National Laboratories, *Procedure for Preparing Sampling and Analysis Plan, Site-Specific Sampling Plan, and Field Operating Procedures*, QA-02-03, Albuquerque Environmental Program Department 3220, Albuquerque, New Mexico, 1991.

Sandia National Laboratories, Division 7723, *Field Operation Procedure for Field Logbook Content and Control, Environmental Restoration Department*, Albuquerque, New Mexico, 1992.

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Lithologic Logging

SOP 3-5
Revision: 7
Date: March 2007

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1.0 Objective

This standard operating procedure (SOP) governs lithologic logging of core, cuttings, split-spoon samples, and subsurface samples collected during field operations at sites where environmental investigations are performed by CDM Federal Programs Corporation (CDM). The purpose of this SOP is to present a set of descriptive protocols and standardized reporting formats to be used by all investigators in making lithologic observations. It prescribes protocols for recording basic lithologic data including, but not limited to, lithologic names, texture, composition, color, sedimentary structures, bedding, lateral and vertical contacts, and secondary features such as fractures and bioturbation.

The goal of this SOP is to provide a set of instructions to produce uniform lithologic descriptions and to present a list of references to help in this task.

2.0 Background

2.1 Definitions

The following list of definitions corresponds to the description sequences outlined in Section 5.2.1. They are provided to aid the geologist in what to look for when following the sequences. Example lithologic logs are given in Attachment A.

Name of Sediment or Rock - In naming unconsolidated sediments, the logger shall use field equipment and reference charts to help identify the grain-size distribution and shall name the material according to the procedure in Section 5.2.1. In naming sedimentary, igneous, and metamorphic rocks, the logger shall examine the specimen for mineralogy and use the appropriate classification chart in the attachments.

Texture - In examining unconsolidated sediments, the texture shall refer to the grain-size distribution, particle angularity, sorting, and packing. The logger shall provide estimates of the grain sizes present using Attachment B and C. When larger particles such as cobbles are present, determine the size of the particles and give a percentage estimate. The sediment particles shall be examined for angularity by comparing with Attachment B and the sorting shall be determined by percentage estimation. The logger shall note that the Unified Soil Classification System (USCS) uses the term grading to describe how the materials are sorted. (A poorly sorted unconsolidated material is well graded.) In examining igneous rocks, texture refers to whether the specimen is aphanitic, phaneritic, glassy, fragmental, porphyritic, or pegmatitic. Attachment D has more specific definitions of these terms. For metamorphic rocks, texture refers to whether the specimen has a foliated structure (slaty, phyllitic, schistose, or gneissic) or nonfoliated structure (granular).

Color - Color may be determined using the appropriate Munsell color chart (soil or rock) and listing the Munsell number that corresponds to the color. If an unconsolidated material is mottled in color, the ranges in color shall be described. When describing core samples with several individual colors such as in phaneritic textures, individual color names shall be listed, and an overall best color name shall be given.

Sedimentary Structures - This term refers primarily to unconsolidated sediments and sedimentary rocks. There are several different sedimentary structures, and the logger is referred to Compton's *Manual of Field Geology* (1962) book for more details. Among the more common structures are bedding, cross-bedding, laminations, and burrows. These structures shall only be included in the description if found in the samples.

Degree of Consolidation - The degree of consolidation is applicable to sedimentary rocks and unconsolidated sediments and refers to how well the material has been indurated. Unconsolidated sediments may be compacted somewhat and shall

be described as loose, moderately compacted, or strongly compacted. In some cases they may be slightly cemented by caliche and shall be described as slightly cemented, moderately cemented, or strongly cemented. Sedimentary rocks are typically indurated but may vary in the degree of cementation. These materials shall be described as friable, moderately friable, or well indurated. When describing the cementing material, a test for reaction to hydrochloric acid (HCl) shall be done and results recorded under the description. If the logger believes he/she can identify the cementing material, then it shall be included in the description.

Moisture Content - Moisture content refers to the amount of water within the sediment or the matrix. Typically sedimentary rocks and unconsolidated sediments may have water within and shall be described as dry, moist, wet (not flowing), or saturated (flowing water). Igneous and metamorphic rocks may have water within fractures and cavities. The presence of water and pertinent observations that may help in site evaluation in these rocks shall be noted.

Presence of Fractures, Cavities, and Secondary Mineralization - The rock that may be encountered during drilling may have fractures or joints present within them. Should fractures be observed, they shall be noted and a description as to the density of fractures shall be given. Cavities or vugs may be present, and the density of voids, as well as size estimation, shall be given. If fractures or cavities contain evidence of secondary minerals such as zeolites, clays, or iron oxides, then a description of the mineral fill shall be added.

Evidence of Contamination - The logger shall examine the core and note any obvious signs of contamination such as streaking, free product, odor, or discoloration. These observations shall be noted in the field book as shall any readings from the photoionization or flame ionization detector (PID/FID). PID/FID hits shall be recorded on the Lithologic Log Form also.

Description of Contacts - The logger shall note any significant change in lithology. These changes may be gradational contacts within sediments or may be sharp contacts such as sediments over rocks. The contacts shall be noted as to whether they are erosional, gradational, or sharp, and the depth below the surface shall be noted.

Composition - The composition of the rock refers to the mineralogy of the material encountered. For sedimentary rocks, it is important to note the matrix composition and use Attachment E in naming. In igneous and metamorphic rocks, the minerals that make up the rock shall be stated and an estimation of their percentage shall be noted. The classification charts listed in Attachments D and F provide a description of common compositions.

2.2 Associated Procedures

- CDM Federal SOP 4-1, *Field Logbook Content and Control*

2.3 Discussion

The installation of monitoring wells, piezometers, and boreholes is a standard practice at many sites requiring environmental investigations. The installation of these devices requires that a trained geologist, or other earth scientist under a geologist's supervision, provide lithologic descriptions as they encounter subsurface material during auguring or drilling. In evaluating these lithologic descriptions from different boreholes, monitoring wells, or piezometers, it is sometimes possible to correlate similar units. To help in this task, it is important to provide uniform and consistent descriptions.

In describing lithologies, it is helpful to have a set of references covering items such as the classification of igneous, metamorphic, and sedimentary rocks; grain-size percentage estimation; particle shape; grain-size charts; and lithologic symbols. To make lithologic descriptions produced by CDM staff as uniform and consistent as possible, this SOP provides a list of references to be used in the field. This SOP also provides a sequence for recording information on a standardized log form to make descriptions as uniform and consistent as possible.

3.0 General Responsibilities

Geologist - The field person performing lithologic logging is responsible for making a consistent and uniform log and for turning in field forms and logbooks to the field team leader (FTL).

Field Team Leader - The FTL is responsible for maintaining logbooks and forms and for approving techniques of lithologic logging not specifically described in this SOP.

***Note*:** Responsibilities may vary from site to site. Therefore, all field team member responsibilities shall be defined in the field plan or site/project specific quality assurance plan.

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4.0 Required Equipment

The description of subsurface lithologies requires a minor amount of field equipment for the geologist. This section provides a list of equipment to be used by the lithologic logger but does not include equipment such as drill rigs, PID/FID, sampling equipment, and personal protection equipment. The following is a general list of equipment that may be used:

- Field logbook and Lithologic Log Form
- Clipboard
- Dilute (10 percent) HCl
- Plastic sheeting
- PVC sampling trays
- Waterproof pens
- No. 2 sieve
- 10x magnifying hand lens
- Reference field charts
- Engineers tape measure or folding stick

5.0 Procedures

5.1 Office

- Obtain field logbook and Lithologic Log Forms
- Coordinate schedules/actions with FTL
- Obtain necessary field equipment (i.e., hand lens, 10 percent HCl)
- Obtain CDM reference field charts
- Review field support documents (i.e., sampling plan, health and safety plan)
- Review applicable geologic references such as U.S. Department of Agriculture (USDA) Soil Conservation Survey Soil Surveys and/or geologic maps

5.1.1 Documentation

Individuals performing lithologic logging will record their observations in a commercially available, bound field logbook (e.g., Lietz books) and/or on individual Lithologic Log Forms. Lithologic loggers will follow the general procedures for keeping a field logbook (SOP 4-1). When using a bound field logbook, record the same data required on the Lithologic Log Form. Data from the field logbook must be transcribed to the Lithologic Log Form if filling in the form in the field is not feasible. However, the data must be the same as that recorded in the field logbook. Editing of field logbook data is not allowed. In addition, if data are transcribed to the Lithologic Log Form, it shall be done within 1 day of the original data recording. All blanks in the Lithologic Log Form must be filled out. If an item is not applicable, an “NA” shall be entered. Note that the Lithologic Log may be modified based on the type of drilling (i.e., changing the blow count column to rock quality designation (RQD) for rock coring).

The Lithologic Log Form shall be filled out according to the following instructions:

The front page of the form contains general information:

- The project name, location, and description
- Borehole number
- Date that the drilling activity was started and completed
- Name of the person logging the well shall be recorded along with the total depth drilled
- Borehole diameter(s) and drilling methods shall be recorded
- Name and company of the driller and the type of drill rig and bits used

A map showing the drilling location may be attached.

The continuation page(s) shall be completed according to the instructions provided within this section and according to the sequence provided in Section 5.2.1. The depth column refers to the depth below ground surface and shall be provided in feet. The tick marks can be arbitrarily set to any depth interval depending on the scale needed except where client requirements dictate the spacing. The lithology column shall contain a schematic representation of the subsurface according to the symbols found in Attachment G. Use a single X to mark the area where no core was recovered, and notes shall be recorded as to why the section was not recovered. The X shall be marked from the top to the bottom of the section so that the entire interval is marked. If the geologist can interpret the probable lithology of the missing section with reasonable confidence, they may fill in the symbols behind the X. Sharp or abrupt contacts between lithologies will be indicated by a

solid horizontal line. Gradational changes in lithologic composition will be shown by a gradual change of lithologic symbol in the appropriate zone. PID/FID hits shall be recorded within the PID/FID column at the appropriate depth, if applicable. Blow counts specifically refer to the number of hammer blows it takes to drive a split-spoon into the ground. Usually this is recorded as the number of blows per 6 inches but may vary. The recording of blow counts provides a relative feel for the cohesiveness of the formation. The individual recording lithologic logs shall ask the FTL whether it is required information. The description column is the most important part of the Lithologic Log Form and is where the lithology is described. In completing this section, use the applicable reference charts and complete according to the sequence in Section 5.2.1. The sample interval column is reserved for noting any samples taken and processed for the laboratory. The sample number shall be filled in at the appropriate depth. The last column refers to the percent core recovery. The individual performing lithologic logging shall determine the amount recovered and write the percentage at the appropriate depth.

In addition to the information on the lithologic form, the logger shall record the appropriate information into the logbook when there is a rig shutdown, rig problems, failures to recover cores, or other issues.

5.2 General Guidelines for Using and Supplementing Lithologic Descriptive Protocols

This SOP is intended to serve as a guide for recording basic lithologic information with emphasis on those sediment or rock properties that affect groundwater flow and contaminant transport. The fields of specialization of geologists using this SOP will vary. If the user has expertise in a particular field of petrology or soil science that allows for descriptions of certain geologic sections beyond the basic level required by this SOP, they may expand their descriptions. This shall be done only with approval of the FTL. The descriptive protocol presented here must be followed in making basic observations. Any further descriptions must follow a protocol that is published and generally recognized by the geologic community as a standard reference.

General lithologic description will not include collecting detailed information such as can be obtained from sieve analysis or petrographic analysis. This SOP is a guide for recording visual observations of samples in the field aided by a 10x hand lens and the other simple tools. Field descriptions shall be supplemented by petrographic analysis and sieve analysis when the FTL needs data on numerical grain-size distributions, secondary porosity development, or other data that can be collected by these methods.

Description detail will also be dependent on the drilling and sampling methods used. Descriptions of drill cuttings will generally be very basic verses detailed descriptions of soil split-spoon or rock core samples.

This SOP includes protocols for describing igneous, metamorphic, bedrock, sedimentary rocks, and unconsolidated materials. Common abbreviations used for lithologic logging purposes are given in Attachment H. This SOP includes charts to be used for classification and naming of rocks, sediments, and soils and descriptions of texture, sedimentary structures, and percentage composition of grains. There is also a chart of lithologic symbols to be used and a list of abbreviations. For charts covering other observations or field procedures not specified by this SOP, the user is referred to the following for more information:

- *Compton's Manual of Field Geology and American Geological Society (AGI) Data Sheets for Geology in the Field, Laboratory, and Office* contain other reference charts applicable to descriptions. The source of the chart used must be recorded on the Lithologic Log Form or in the field logbook.
- The Munsell soil color chart may be used for descriptions of color.
- The *Dictionary of Geological Terms* (AGI) is to be used for definitions of geological terms.

Some observations will be common to all rock and soil descriptions. All descriptions shall include as appropriate: name of sediment or rock, color, sedimentary structures, texture, moisture content, composition, fabric, significant inclusions, and degree of consolidation or induration. The description of each category shall be separated by a semicolon. Each section that discusses descriptions of a particular lithology provides a sequence for recording observations. Follow these sequences for all descriptions. All interpretive comments shall be segregated from lithologic descriptions by recording them in the remarks column.

Secondary features affecting porosity and permeability such as fractures (joints or faults), cavities, and/or bioturbation shall be described if observed. Exact measurement of apparent bed thicknesses shall be made when logging core and shall supplement terminology such as "thin" or "thick." Particular attention is to be given to recording exact locations of water tables, perched saturated zones, and description of contaminants that may be visible.

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In some cases individuals logging may wish to describe materials such as unconsolidated sediments and soils according to different systems such as the USCS or USDA Soil Taxonomy System. These descriptions can provide additional information from what is required by this SOP. If an individual is competent in using other description methods, then they shall do so with permission from the FTL.

It is often more practical to use abbreviations for often repeated terminology when recording lithologic descriptions. For the terms given in this SOP, its attachments, or the associated charts to be used for description in the field, use only the designated abbreviations. Other abbreviations are allowed; however, the abbreviation and its meaning shall be recorded on the lithologic log the first time it is used and shall be recorded at least once for every well or boring log. Loggers are cautioned to limit the use of abbreviations to avoid producing a lithologic log that is excessively cryptic.

5.2.1 Protocols for Lithologic Description of Discrete Soil or Rock Cores

This section describes the protocols for completing a lithologic description based on discrete soil or rock core samples. The logger shall use the appropriate portion of this section when describing cores. In recording descriptions of sedimentary sections from a whole core, it is possible to reduce the amount of description being written by at least two strategies. One is to look at as long of a section of core as possible, looking for the "big" picture. For instance, in a 20-foot-thick zone, the dominant lithology may be siltstone that is interrupted by several thin beds of another lithology such as gravel. This section description can be simplified by writing: 35-55 below ground surface (bgs) = siltstone (with other descriptors) except as noted; 37.5-38.5 gravel zone (with descriptors); 40-42 pebble zone (with descriptors); etc. This also aids in "seeing" the thickest unit designations possible for use in modeling. Another acceptable way to describe the same interval would be: 35-37.5 siltstone; 37.5-38.5 gravel zone (with descriptors); 38-40 same as 35-37.5; 40-42 pebble zone (with descriptors); etc.

Description of Unconsolidated Material

Unconsolidated material comprises a significant portion of the sections of interest at CDM sites. The shallow subsurface is very important to the hydrologic investigation, as this is the portion of the geologic section where infiltration first occurs. Much of the contamination at sites being investigated is surface contamination and therefore lies on, or within, the upper portion of the surficial material.

For the purpose of this SOP, soil refers to the upper biochemically weathered portion of the regolith and not the entire regolith itself. Soils are to be described as unconsolidated material and shall use the same description format. The scientist shall use the USCS classification if consistent with project objectives (Attachment K). More detailed soil descriptions shall only be made in addition to descriptions outlined below.

Descriptions of unconsolidated sediments shall follow the following sequence:

- Name of sediment (sand, silt, clay, etc.)
- Texture
- Composition of larger-grained sediments
- Color
- Structure
- Degree of consolidation and cementation
- Moisture content
- Evidence of bioturbation
- Description of contacts

In naming unconsolidated material (refer to Attachment I - Naming of Unconsolidated Materials), the particle size with the highest percentage is the root name. When additional grains are present in excess of 15 percent, the root name is modified by adding a term in front of the root name. For instance, if a material is 80 percent sand and 20 percent gravel, then it is gravelly sand. If the subordinate grains comprise less than 15 percent but greater than 5 percent, the name is written: _____(dominant grain) with _____(subordinate grain). For example, a sediment with 90 percent sand and 10 percent silt would be named a sand with silt. If a sediment contains greater than 15 percent of four particle sizes, then the name is comprised of the dominant grain size as the root name and modifiers as added before. For example, if a material is 60 percent sand, 20 percent silt, and 20 percent clay the name would be a silty clayey sand. If a material is 70 percent sand, 20 percent silt, and 10 percent clay, it would be a silty sand with clay. When large cobbles or boulders are present, their percentage shall be estimated and their mineralogy recorded. Use AGI Data Sheet 29.1 (Attachment B) for grain terms. Refer to Attachment J for an example sorting chart.

Description of Bedrock Material

Descriptions of rock core can vary in detail depending on the experience of the geologist and the scope of the project. However, features that shall be noted while logging rock core include depth of major fractures, mineralization in fractures and cavities, degree of weathering, hardness, and RQD. The RQD is a ratio of the total length of intact rock 4 inches in length or longer to the length of the core run. The RQD provides a numeric indication of the degree of fracturing and weathering, and thereby, and indication of conductive zones and preferential contaminant migration pathways.

Description of Sedimentary Rocks
Sedimentary rocks consist of lithified detrital sediments such as sand and clay, chemically precipitated sediments such as limestone and gypsum, and biogenic material such as coal and coquina. The classification scheme for naming these rocks is found in Attachment E - Classification of Sedimentary Rocks.

Descriptions for sedimentary rocks shall be given in the lithologic log in the following sequence:
- Name of rock
- Texture
- Color
- Bedding
- Sedimentary structures
- Degree of composition
- Presence of fractures or vugs
- Bioturbation
- Description of contacts

Description of Igneous and Metamorphic Rocks
Igneous and metamorphic rocks are not as commonly observed at work sites, but they may be found interspersed in the sedimentary section as ash layers and as bedrock. Where they form bedrock, the development of fractures and vugs is important to their hydrologic properties. If the logger is unsure of the name of the rock because of difficulty in determining mineralogy, the name shall be accompanied by a question mark. Attachments D and F provide a classification system for these materials.

Igneous and metamorphic rock descriptions shall follow the general format:
- Name of rock
- Texture
- Color
- Degree of induration for volcaniclastics
- Composition
- Presence of fractures or vugs
- Presence of secondary mineralization
- Foliation

5.2.2 Protocols for Lithologic Description from Drill Cuttings
The majority of boreholes drilled in bedrock are drilled without sampling or coring. This section describes the protocols that may be used for completing lithologic logs when discrete soil samples or rock cores are not collected. Lithologic logging of boreholes drilled without sampling generally requires a higher level of experience from the geologist as interpretations need to be made based on a number of factors that are usually not taken into account when logging from discrete samples. Certain details recorded on lithologic logs based on discrete sampling will not be seen (such as sedimentary structures) and therefore cannot be recorded from drill cuttings. Below are general guidelines that shall be used while filling out boring logs based on drill cuttings:

Auger Drilling
The following are general guidelines that can be used to describe cuttings from auger drilling:

- Collect cuttings for descriptions at least every 5 feet or if a change in the cuttings is noticed.
- Keep in mind travel time for cuttings to reach the surface when estimating the depth from which the cuttings originated.
- Pay attention to the reaction of the drill rig as different lithologies are encountered such as chattering versus smooth drilling, rapid easy auger advancement versus slow hard drilling, and auger refusal.
- Watch for the occurrence of water.

Bedrock Rotary Drilling (including air hammer, air rotary, and mud rotary)
The following are general guidelines that shall be used during rotary drilling:

- Use a strainer to collect cuttings at intervals of at least 10 feet or changes in lithology.
- Wash the cuttings in the strainer with potable water and examine for lithology.
- Note size of rock chips.
- Note changes in drill rig responses such as increasing or slowing drilling rate, sudden drop of the drill stem, increase in chatter and record in the remarks column of the lithologic log. These are usually good indicators of changes in lithology and/or fractures.
- If drilling with air, look for changes in color and reduction or disappearance of dust as an indicator of a lithology change and/or presence of water.
- If drilling with mud/fluid rotary, watch for gain or loss of water as an indicator of conductive zones.
- Record drilling rates as feet/minute, or as start and end times of each drill rod, in the remarks column of the boring log.

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6.0 Restrictions/Limitations

Only geologists, or similarly qualified persons trained in lithologic description, are qualified to perform the duties described in this SOP. The FTL for a project will have the authority to decide whether or not an individual is qualified.

7.0 References

American Geological Society. 1989. *American Geological Society Data Sheets for Geology in the Field*, Laboratory, and Office, 3rd Ed.

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Soil Test Inc. 1975. *Munsell Color Chart*. Evanston, Illinois.

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U. S. Department of Agriculture Soil Conservation Service. 1972. *Soil Taxonomy*, U. S. Government Printing Office, Washington, D.C.

Woodward, L.A. 1988. *Laboratory Manual Physical Geology*, University of New Mexico Printing. Albuquerque, New Mexico.

8.0 Attachments

Note: These Attachments are for informational purposes. Other equivalent charts such as USCS or logs may be used.

Attachment A - CDM Federal Programs Corporation Lithologic Logs
Attachment B - Grain-Size Scale; Graph determining size of sedimentary particles, particle degree of roundness charts
Attachment C - Comparison Chart for Estimating Percentage Composition
Attachment D - Classification of Igneous Rocks
Attachment E - Classification of Sedimentary Rocks
Attachment F - Classification of Metamorphic Rocks
Attachment G - Lithologic Symbol Chart
Attachment H - Common Abbreviations for Lithologic Logging
Attachment I - Naming of Unconsolidated Materials
Attachment J - Sorting Chart
Attachment K - Example of Unified Soil Classification System (USCS)

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Attachment A

CDM Federal Programs Lithologic Logs

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Attachment B

Grain-Size Scale; Graph determining size of particles, particle degree of roundness charts

AGI DATA SHEET 29.1

Grain-size Scales

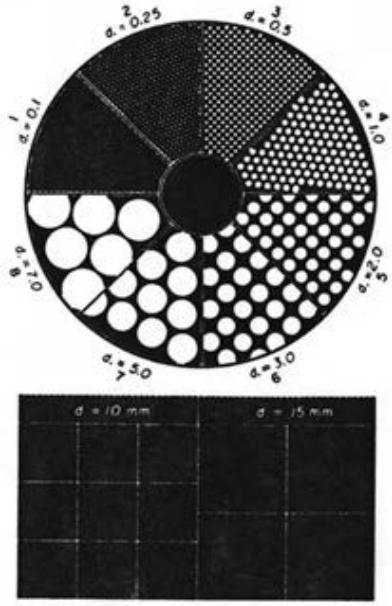
By Roy L. Ingram, University of North Carolina

GRAIN-SIZE SCALE USED BY AMERICAN GEOLOGISTS
Modified Wentworth Scale — after Lane, et al., 1947, Trans. American Geophysical Union, v. 28, p. 936-938

GRADE LIMITS phi	mm	mm	inches	U.S. Standard Sieve Series	GRADE NAME		
−12	4096		161.3		very large		
−11	2048		80.6		large	Boulders	
−10	1024		40.3		medium		
−9	512		20.2		small		
−8	256		10.1		large		
−7	128		5.0		small	Cobbles	GRAVEL
−6	64		2.52	63 mm	very coarse		
−5	32		1.26	31.5 mm	coarse		
−4	16		0.63	16 mm	medium	Pebbles	
−3	8		0.32	8 mm	fine		
−2	4		0.16	No. 5	very fine		
−1	2		0.08	No. 10	very coarse		
0	1		0.04	No. 18	coarse		
+1	1/2	0.500		No. 35	medium	Sand	SAND
+2	1/4	0.250		No. 60	fine		
+3	1/8	0.125		No. 120	very fine		
+4	1/16	0.062		No. 230	coarse		
+5	1/32	0.031			medium		
+6	1/64	0.016			fine	Silt	
+7	1/128	0.008			very fine		
+8	1/256	0.004			coarse		MUD
+9	1/512	0.002			medium		
+10	1/1024	0.001			fine	Clay size	
+11	1/2048	0.0005			very fine		
+12	1/4096	0.00025					

AGI DATA SHEET 28.2

LIGHT PARTICLES



References: (1) George V. Chilingar, 1956, Soviet classification of sedimentary particles and Vasil'evskiy graph: AAPG Bull., v. 40, no. 7, p. 1714. (2) M.S. Shvetsov, 1948, Petrography of sedimentary rocks, 2nd ed., 387 p. Gosgeoltdat, Moscow-Leningrad

American Geological Institute, Data Sheets, Third Edition, 1989.

Compton, R.R., Manual of Field Geology, 1962.

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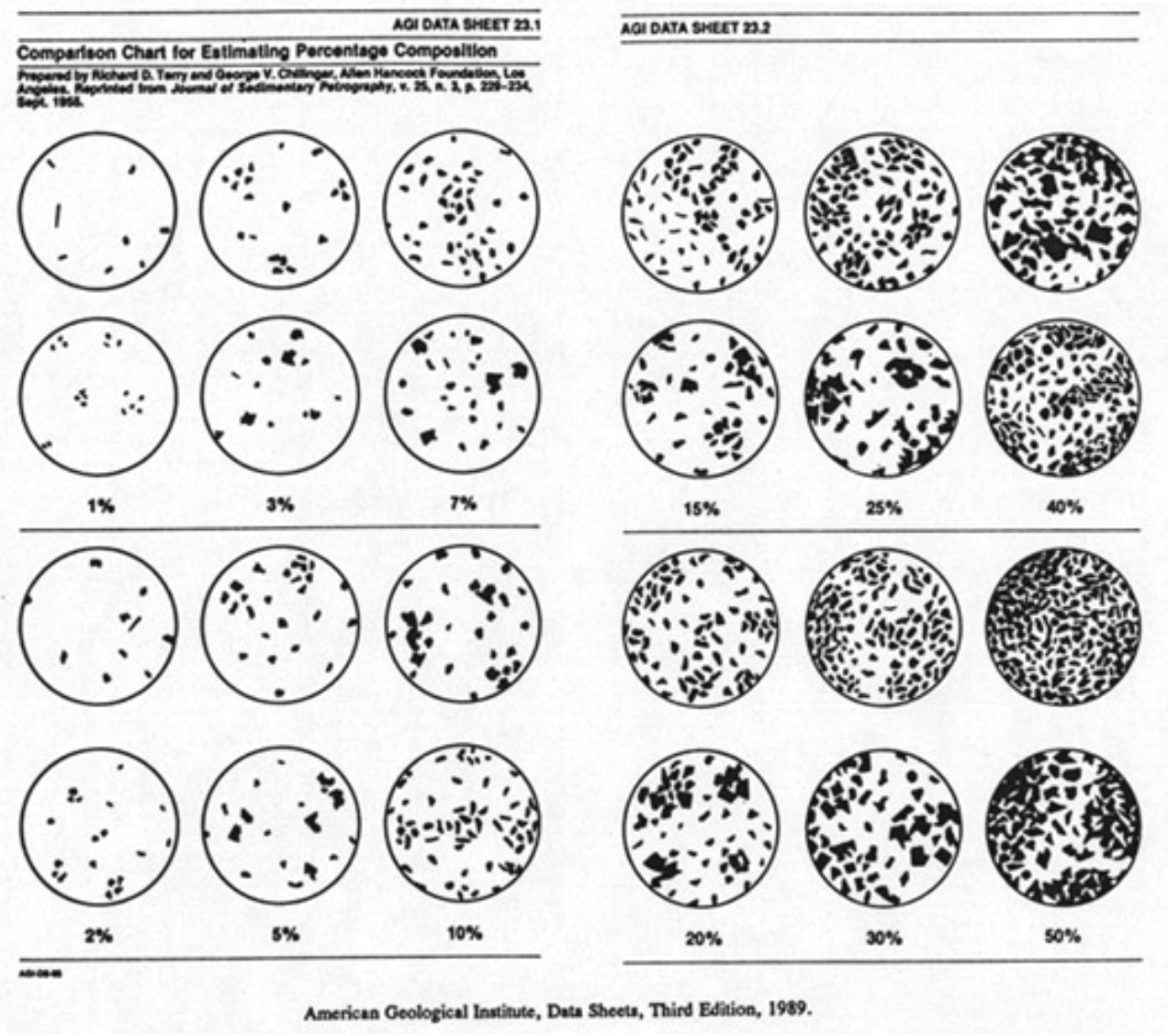
Attachment C

Comparison Chart for Estimating Percentage Composition



American Geological Institute, Data Sheets, Third Edition, 1989.

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Attachment D

Classification of Igneous Rocks

Classification of Igneous Rocks					
Mineral Composition					
		Quartz >10% Abundant feldspar Mafic minerals minor	Quartz <10% Abundant feldspar Mafic minerals moderate	Feldspar abundant Mafic Minerals 40-70%; Quartz minor or absent	Mafic minerals >70%
Color Index		Light Color	Intermediate color	Dark	Dark
Chemistry		SiO_2 70%	SiO_2 60%	SiO_2 50%	SiO_2 40%
	Phaneritic (visible with naked eye)	Granite (Gr)	Diorite (Dr)	Gabbro (Gb)	Peridotite (Pr) (mostly olivine)
TEXTURE	Aphanitic (microscopic)	Rhyolite (Ry) (quartz phenocrysts)	Andesite (An) (feldspar or mafic phenocrysts; no quartz)	Basalt (Ba)	Komatiite (Km) (very rare)
		Felsite (Fl) (no phenocrysts)			
	Glassy	Obsidian (ob) Pumice (Pu)		Rare	
	Glassy-Fragmental (Pyroclastic)	Tuff <4mm (Tf) Breccia >4mm (Br)		Rare	

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Attachment E

Classification of Sedimentary Rocks

Classification of Sedimentary Rocks				
Detrital	***Detrital Classification***	***Principal Composition***	***Additional Identifying Characteristics***	***Name of Rock***
	Rudaceous (clast diameter > 2 mm)	Gravel	Rounded Clasts	Conglomerate (Cg)
			Angular Clasts	Breccia (Br)
	Arenaceous (clast diameter between 0.0625 mm [1/16 mm] and 2 mm)	Sand	Mineral composition and detrital matrix content varies. Additional detrital matrix qualifiers (arenite or wacke) and mineral composition qualifiers (quartz, arkose, feldspathic, etc.) may be necessary.	Sandstone (Sa)
	Argillaceous (clast diameter <0.0625 mm)	Mud	Non-fissile along bedding planes, silt predominant over clay	Siltstone (Sls)
			Non-fissile along bedding planes, clay predominant over silt	Claystone
			Non-fissile along bedding planes, silt and clay fraction approximately equal or unknown	Mudstone (Ms)
			Fissile along bedding planes	Shale (Shl)
Chemical	***Chemical Classification***	***Principal Composition***	***Additional Identifying Characteristics***	***Name of Rock***
	Calcareous	Calcite (Calcium Carbonate)	Effervesces on contact with dilute HCl	Limestone (La)
		Dolomite (Calcium Magnesium Carbonate)	Pulverized sample effervesces on contact with dilute HCL	Dolomite (Dl), Dolostone
	Siliceous	Quartz (Silicon Dioxide)	Hard, dense, fractures conchoidally	Chert (Ch)
	Evaporites	Hydrated Calcium Sulfate	Earthy and crumbly	Gypsum (Gy)
		Calcium Sulfate	Usually exhibits indistinct stratification	Anhydrite
		Halite (Sodium Chloride)	Cubic cleavage	Rock Salt (Na)
Organic (Organogenetic or Biochemical)	***Chemical Classification***	***Principal Composition***	***Additional Identifying Characteristics***	***Name of Rock***
	Calcareous	Fossil shells and fragments	Loosely cemented fragmental limestone	Coquina (Cq)
		Foraminiferal shells	Soft, micritic limestone	Chalk (Chk)
		Calcite or aragonite	Derived from evaporation of spring water	Travertine (Tvr)
	Siliceous	Diatom shells (saltwater or freshwater organisms)	Light-colored, soft, friable, and porous siliceous deposit	Diatomite (Dm)
	Carbonaceous	Plant Remains	Degree of lithification varies-additional qualifiers such as peat, lignite, bituminous and anthracite may be necessary.	Coal (Cl)

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Attachment F

Classification of Metamorphic Rocks

Classification of Metamorphic Rocks			
Structure	**Texture**	**Chief Minerals**	**Name**
Non foliate	granular; breaks across grains	quartz	Quartzite (Qzt)
	granular; grains clearly visible	calcite	Marble (Mbl)
	granular; grains altered and indistinct	plagioclase, chlorite, epidote hornblende	Greenstone (Grs)
	very fine-grained	indistinguishable; mostly submicroscopic micas and clays	Hornfels (Hnf)
Foliate	slaty	submicroscopic mica, quartz	Slate (Slt)
	phyllitic	microscopic mica, quartz	Phyllite (Pyl)
	schistose	microscopic mica, quartz, amphibole	Blueschist
		chlorite, mica plagioclase	chlorite schist (CL-Sch)
		muscovite, quartz	Muscovite (Ms) Schist (Sch)
		garnet, muscovite	Garnet (G) Muscovite (Ms) Schist (Sch)
		hornblende, plagioclase	Amphibolite (Amp)
		staurolite, garnet, muscovite	Garnet (G) Staurolite (S) Muscovite (Ms) Schist (Sch)
	gneissose	plagioclase, hornblende	Amphibolite (Amp) Gneiss (Gns)
		feldspar, quartz	Granitie (Gr) Gneiss (Gns)
		eye-shaped feldspar, mica	Augen (Au) Gneiss (Gns)

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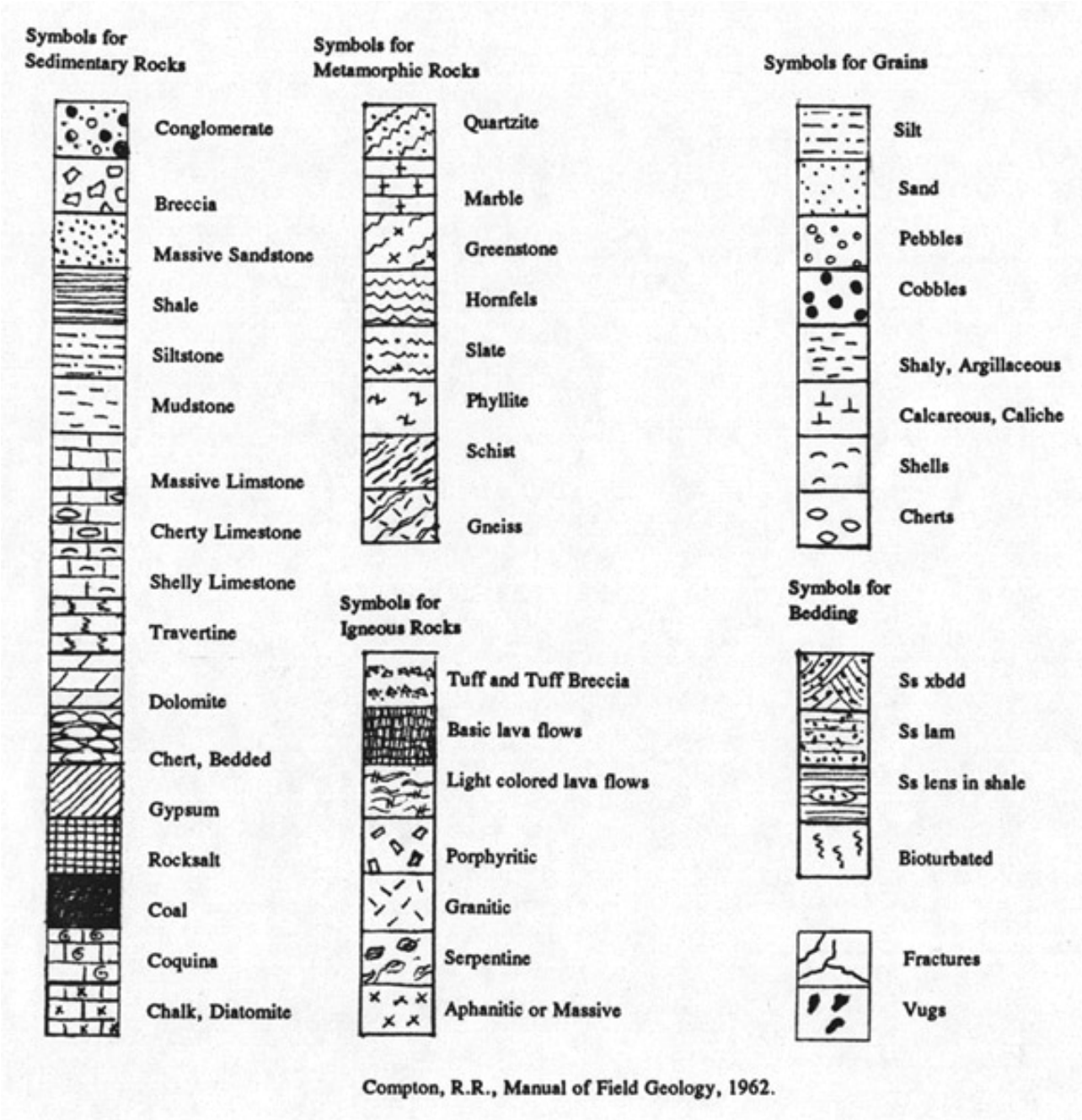
Attachment G

Lithologic Symbol Chart



Compton, R.R., Manual of Field Geology, 1962.

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Attachment H

Common Abbreviations for Lithologic Logging

Common Abbreviations		
Abundant – abnt	Diameter – dia	Laminated – lam
Amount – amt	Different – diff	Maximum – max
Approximate – approx	Disseminated – dissem	Pebble – pbl
Arenaceous – aren	Elevation – elev	Phenocryst – phen
Argillaceous – arg	Equivalent – equiv	Porphyritic – proph
Average – ave	foliated – fol	Probable – prob
Bedded – bdd	Formation frm	Quartz – qrz
Bedding – bdg	Fracture – frac	Regular – reg
Calcareous – calc	Fragmental – frag	Rocks – rx
Cemented – cmt	Granular – Gran	Rounded – rnd
Cobble – cbl	Gypsiferous – Gyp	Saturated – sat
Contact – ctc	Horizontal – hriz	Secondary – sec
Cross-bedded - xbdd	Igneous – ign	Siliceous – sil
Cross-bedding – xbdg	Inclusion – incl	Structure – struc
Cross-laminated – xlam	Interbedded – intbdd	Unconformity – uncnf
Crystal – xl	Irregular – ireg	Variegated – vrgt
Crystalline – xln	Joint – jnt	Vein – vn
Grain Size	**Contacts**	**Sorting**
grain – gn	gradational – grad	poor – pr
fine – f	erosional – er	moderate – mod
very fine – vf	abrupt – ab	well – well
medium – med		
coarse – crs	**Fabric**	
large – lg	grain supported – gs	
very large – vlg	matrix supported – ms	
small – sm	imbricate – im	

Adapted from, Compton, R.R., *Manual of Field Geology*, 1962.

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Attachment I

Naming of Unconsolidated Materials

Main Particle	Gravel	Sand	Silt	Clay
> 15 % gravel	Gravel	Gravelly Sand	Gravelly Silt	Gravelly Clay
> 15 % sand	Sandy Gravel	Sand	Sandy Silt	Sandy clay
> 15 % silt	Silty Gravel	Silty Sand	Silt	Silty Clay
> 15 % clay	Clayey Gravel	Clayey Sand	Clayey Silt	Clay
5-15 % gravel	Not Applicable	Sand with Gravel	Silt with Gravel	Clay with Gravel
5-15 % sand	Gravel with sand	Not applicable	Silt with Sand	Clay with sand
5-15 % silt	Gravel with silt	Sand with silt	Not applicable	Clay with silt
5-15 % clay	Gravel with clay	Sand with clay	Silt with clay	Not applicable
> 15% gravel plus 15% sand	Sandy Gravel	Gravelly Sand	Gravelly Sandy Silt	Gravelly Sandy Clay
> 15% gravel plus 15% silt	Silty Gravel	Gravelly Silty Sand	Gravelly Silt	Gravelly Silty Clay
> 15% gravel plus 15% clay	Clayey Gravel	Gravelly Clayey Sand	Gravelly Sandy Silt	Gravelly Clay
> 15% sand plus 15% silt	Silty Sand Gravel	Silty Sand	Sandy Silt	Sandy Silty Clay
> 15% sand plus 15% clay	Sandy Clayey Gravel	Clayey Sand	Sandy Clayey Silt	Sandy Clay
> 15% silt plus 15% clay	Silty Clayey Gravel	Silty Clayey Sand	Clayey Silt	Silty Clay
Note: Other combinations are possible when all particle sizes are present in greater than 15%. For example, a Silty Clayey Gravelly Sand. Other possible combinations exist such as a Gravelly Sand with silt.				

Compton, R.R., *Manual of Field Geology*, 1962.

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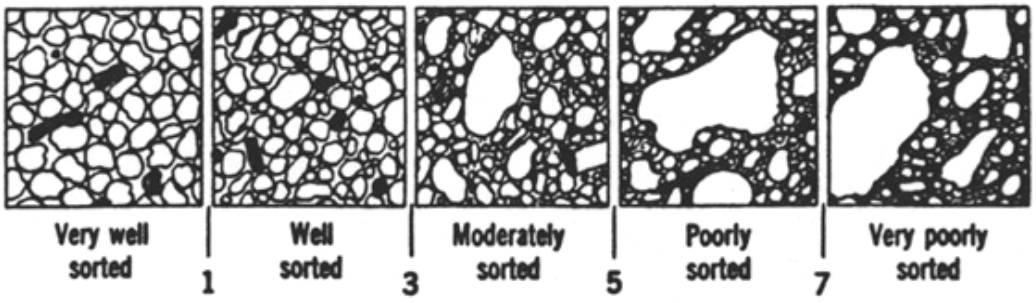
Attachment J

Sorting Chart



Compton, R.R., Manual of Field Geology, 1962.

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Attachment K

Example of Unified Soil Classification System (USCS)

Unified Soil Classification System (USCS)

	MILLIMETERS	INCHES	SIEVE SIZES
BOULDERS	> 300	> 11.8	-
COBBLES	75 - 300	2.9 - 11.8	-
GRAVEL:			
COARSE	75 - 19	2.9 - .75	-
FINE	19 - 4.8	.75 - .19	3/4" - No. 4
SAND:			
COARSE	4.8 - 2.0	.19 - .08	No. 4 - No. 10
MEDIUM	2.0 - .43	.08 - .02	No. 10 - No. 40
FINE	.43 - .08	.02 - .003	No. 40 - No. 200
FINES:			
SILTS	< .08	< .003	< No. 200
CLAYS	< .08	< .003	< No. 200

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Attachment K

Example of Unified Soil Classification System (USCS) (Continued)

CLAY

CLAY CONSISTENCY	THUMB PENETRATION	SPT, N BLOWS/ FT.	Undrained Shear Strength c (PSF) TORVANE	Unconfined Compressive Strength q_u Pocket Penetrometer
VERY SOFT	Easily penetrated several inches by thumb. Exudes between thumb and finger's when squeezed in hand.	< 2	250	500
SOFT	Easily penetrated one inch by thumb. Molded by light finger pressure.	2 - 4	250 - 500	500 - 1000
MEDIUM STIFF	Can be penetrated over 1/4 " by thumb with moderate effort. Molded by strong finger pressure.	4 - 8	500 - 1000	1000 - 2000
STIFF	Indented about 1/4" by thumb but penetrated only with great effort.	8 - 15	1000 - 2000	2000 - 4000
VERY STIFF	Readily indented by thumbnail.	15 - 30	2000 - 4000	4000 - 8000
HARD	Indented with difficulty by thumbnail.	> 30	> 4000	> 8000

SAND

SOILTYPE	SPT, N Blows/ft.	Relative Density,%	FIELD TEST
VERY LOOSE SAND	4	0 - 15	Easily penetrated with 1/2" reinforcing rod pushed by hand.
LOOSE SAND	4 - 10	15 - 35	Easily penetrated with 1/2" reinforcing rod pushed by hand.
MEDIUM DENSE SAND	10 - 30	35 - 65	Penetrated a foot with 1/2" reinforcing rod driven with 5-lb hammer.
DENSE SAND	30 - 50	65 - 85	Penetrated a foot with 1/2" reinforcing rod driven with 5-lb hammer.
VERY DENSE SAND	50	85 - 100	Penetrated only a few inches with 1/2" reinforcing rod driven with 5-lb hammer.

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Example of Unified Soil Classification System (USCS) (Continued)

Summary of USCS Field Identification Tests

Coarse-Grained Soils **More than half the material (by weight) is individual grains visible to the naked eye**	**Gravelly Soils** More than half of coarse fraction is larger than 4.75 mm		**Clean Gravels** Will not leave a stain on a wet palm	Substantial amounts of all grain particle sizes			GW
				Predominantly one size or range of sizes with some intermediate sizes missing			GP
			Dirty Gravels Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			GM
				Plastic fines (to identify, see CL below)			GC
	Sandy Soils More than half of coarse fraction is smaller than 4.75 mm		**Clean Sands** Will not leave a stain on a wet palm	Wide range in grain size and substantial amounts of all grain particle sizes.			SW
				Predominantly one size or a range of sizes with some intermediate sizes missing			SP
			Dirty Sands Will leave a stain on a wet palm	Non-plastic fines (to identify, see ML below)			SM
				Plastic fines (to identify, see CL below)			SC
Fine-Grained Soils **More than half the material (by weight) is individual grains not visible to the naked eye**	**Ribbon**	**Liquid Limit**	**Dry Crushing Strength**	**Dilatancy Reaction**	**Toughness**	**Stickiness**	
	None	<50	None to Slight	Rapid	Low	None	ML
	Weak	<50	Medium to High	None to Very Slow	Medium to High	Medium	CL
	Strong	>50	Slight to Medium	Slow to None	Medium	Low	MH
(<0.074 mm)	Very Strong	>50	High to Very High	None	High	Very High	CH
Highly Organic Soils	Readily identified by color, odor, spongy feel, and frequently by fibrous texture						OL OH Pt

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Control of Measurement and Test Equipment

SOP 5-1
Revision: 7
Date: December 31, 2004

Prepared: Dave Johnson **Technical Review:** Mike Clark

QA Review: Doug Updike **Approved:** _____
Signature/Date

Issued: _____
Signature/Date

1.0 Objective

The objective of this standard operating procedure (SOP) is to establish the baseline requirements, procedures, and responsibilities inherent to the control and use of all measurement and test equipment (M&TE). Contractual obligations may require more specific or stringent requirements that must also be implemented.

2.0 Background

2.1 Definitions

Traceability - The ability to trace the history, application, or location of an item and like items or activities by means of recorded identification.

2.2 Discussion

M&TE may be government furnished (GF), rented or leased from an outside vendor, or purchased. It is essential that measurements and tests resulting from the use of this equipment be of the highest accountability and integrity. To facilitate that, the equipment shall be used in full understanding and compliance with the instructions and specifications included in the manufacturer's operations and maintenance and calibration procedures and in accordance with any other related project-specific requirements.

2.3 Associated Procedures

- CDM Federal (CDM) Technical SOP 4-1
- CDM Quality Procedures (QPs) 2.1 and 2.3
- Manufacturer's operating and maintenance and calibration procedures

3.0 Responsibilities

All staff with responsibility for the direct control and/or use of M&TE are responsible for being knowledgeable of and understanding and implementing the requirements contained herein as well as any other related project-specific requirements.

The project manager (PM) or designee (equipment coordinator, quality assurance coordinator, field team leader, etc.) is responsible for initiating and tracking the requirements contained herein.

4.0 Required Equipment

- Determine and implement M&TE related project-specific requirements
- The maintenance and calibration procedures must be followed when using M&TE
- Obtain the maintenance and calibration procedures if they are missing or incomplete
- Attach or include the maintenance and calibration procedures with the M&TE
- Prepare and record maintenance and calibration in an Equipment Log or a Field Log as appropriate (Figure 1)
- Maintain M&TE records
- Label M&TE requiring routine or scheduled calibration (when required)
- Perform maintenance and calibration using the appropriate procedure and calibration standards
- Identify and take action on nonconforming M&TE

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5.0 Procedures

5.1 Determine if Other Related Project-Specific Requirements Apply

For All M&TE:
The PM or designee shall determine if M&TE related project-specific requirements apply. If M&TE related project-specific requirements apply, obtain a copy of them and review and implement as appropriate.

5.2 Obtain the Operating and Maintenance and Calibration Documents

For GF M&TE that is to be procured:
Requisitioner - Specify that the maintenance and calibration procedures be included.

For GF M&TE that is acquired as a result of a property transfer:
Receiver - Inspect the M&TE to determine whether maintenance and calibration procedures are included with the item. If missing or incomplete, order the appropriate documentation from the manufacturer.

For M&TE that is to be rented or leased from an outside vendor:
Requisitioner - Specify that the maintenance and calibration procedures, the latest calibration record, and the calibration standards certification be included. If this information is not delivered with the M&TE, ask Procurement to request it from the vendor.

5.3 Prepare and Record Maintenance and Calibration Records

For all M&TE:
PM or Designee - Record all maintenance and calibration events in a Field Log unless other project-specific requirements apply.

For GF M&TE only (does not apply to rented or leased M&TE):
If an Equipment Log is a project specific requirement, perform the following:

Receiver - Notify the PM or designee for the overall property control of the equipment of the receipt of an item of M&TE.

PM or Designee - Prepare a sequentially page numbered Equipment Log for the item using the maintenance and calibration form (or equivalent) from the CDM *Property Control Manual* (Figure 1).

PM or Designee and User - Record all maintenance and calibration events in an Equipment Log.

5.4 Label M&TE Requiring Calibration

For GF M&TE only (does not apply to rented or leased M&TE):
If calibration labeling is a project specific requirement, perform the following:

PM or Designee - Read the maintenance and calibration procedures to determine the frequency of calibration required.

PM or Designee - If an M&TE item requires calibration before use, affix a label to the item stating “Calibrate Before Use.”

PM or Designee - If an M&TE item requires calibration at other scheduled intervals, e.g., monthly, annually, etc., affix a label listing the date of the last calibration, the date the item is next due for a calibration, the initials of the person who performed the calibration, and a space for the initials of the person who will perform the next calibration.

5.5 Operating, Maintaining or Calibrating an M&TE Item

For all M&TE:
PM or Designee and User - Operate, maintain, and calibrate M&TE in accordance with the maintenance and calibration procedures. Record maintenance and calibration actions in the Equipment Log or Field Log.

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Figure 1

A subsidiary of Camp Dresser & McKee Inc.

Maintenance and Calibration

Date: Time: (AM/PM)

Employee Name: Equipment Description:

Contract/Project: Equipment ID No.:

Activity: Equipment Serial No.:

Maintenance

Maintenance Performed:

Comments:

Signature: Date:

Calibration/Field Check

Calibration Standard: Concentration of Standard:

Lot No. of Calibration Standard: Expiration Date of Calibration Standard:

Pre-Calibration Reading: Post-Calibration Reading:

Additional Readings: Additional Readings:

Additional Readings: Additional Readings:

Pre-Field Check Reading: Post-Field Check Reading:

Adjustment(s):

Calibration: □ Passed □ Failed

Comments:

Signature: Date:

5.6 Shipment

For GF M&TE:

Shipper - Inspect the item to ensure that the maintenance and calibration procedures are attached to the shipping case, or included, and that a copy of the most recent Equipment Log entry page (if required) is included with the shipment. If the maintenance and calibration procedures and/or the current Equipment Log page (if required) is missing or incomplete, do not ship the item. Immediately contact the PM or designee and request a replacement.

For M&TE that is rented or leased from an outside vendor:

Shipper - Inspect the item to ensure that the maintenance and calibration procedures and latest calibration and standards certification records are included prior to shipment. If any documentation is missing or incomplete, do not ship the item. Immediately contact Procurement and request that they obtain the documentation from the vendor.

5.7 Records Maintenance

For GF M&TE:

PM or Designee - Create a file upon the initial receipt of an item of M&TE or calibration standard. Organize the files by contract origin and by M&TE item and calibration standard. Store all files in a cabinet, file drawer, or other appropriate storage media at the pertinent warehouse or office location.

PM or Designee - Maintain all original documents in the equipment file except for the packing slip and Field Log.

Receiver - Forward the original packing slip to Procurement and a photocopy to the PM or designee.

PM or Designee - File the photocopy of the packing slip in the M&TE file.

PM or Designee and User - Record all maintenance and calibration in an Equipment Log or Field Log (as appropriate.) File the completed Equipment Logs in the M&TE records. Forward completed Field Logs to the PM for inclusion in the project files.

For M&TE rented or leased from an outside vendor:

Receiver - Forward the packing slip to Procurement.

User - Forward the completed Field Log to the PM for inclusion in the project files.

User - Retain the most current maintenance and calibration record and calibration standards certifications with the M&TE item and forward previous versions to the PM for inclusion in the project files.

5.8 Traceability of Calibration Standards

For all items of M&TE:

PM or Designee and User - When ordering calibration standards, request nationally recognized standards as specified or required. Request commercially available standards when not otherwise specified or required. Or, request standards in accordance with other related project-specific requirements.

PM or Designee and User - Require certifications for standards that clearly state the traceability.

PM or Designee and User - Note standards that are perishable and consume or dispose of them on or before the expiration date.

PM or Designee - Require Material Safety Data Sheet to be provided with standards.

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5.9 M&TE That Fails Calibration

For any M&TE item that cannot be calibrated or adjusted to perform accurately:

PM or Designee - Immediately discontinue use and segregate the item from other equipment. Notify the appropriate PM and take appropriate action in accordance with the CDM QP 2.3 for nonconforming items.

PM or Designee - Review the current and previous maintenance and calibration records to determine if the validity of current or previous measurement and test results could have been affected and notify the appropriate PM(s) of the results of the review.

6.0 Restrictions/Limitations

On an item-by-item basis, exemptions from the requirements of this SOP may be granted by the HDQ health and safety manager and/or HDQ quality assurance director. All exemptions shall be documented by the grantor and included in the equipment records as appropriate.

7.0 References

CDM Federal Programs Corporation *Property Control Manual.* 2002. March.

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1.0 INTRODUCTION

This Soil Sampling Standard Operating Procedure (SOP) establishes sampling equipment and collection methods that are technically appropriate for collecting representative surface and subsurface soil samples. The methodologies discussed in this SOP are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by site conditions and equipment limitations. However, if modifications occur, they should be documented in a field logbook and discussed in the appropriate reports. All field personnel are required to read and follow this SOP. The protocols and procedures in this SOP were derived from HGL field experience; guidance contained in *Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies*, U.S. Environmental Protection Agency EPA/600/R-92/128, July 1992; and acceptable industry practice.

2.0 PURPOSE

The methods and equipment use described in this SOP are designed to provide valid collection methods that will:

- Not compromise the integrity of the sample
- Minimize any effects to the chemical and physical properties of the sample
- Minimize the potential for cross contamination
- Assure that site-derived data are of sound quality suitable for use in decision making.

Soil sample integrity is most often compromised by cross contamination and improper sample collection. Improper sample collection (such the use of contaminated equipment, inappropriate sample containers, disturbance of the matrix, and/or incomplete homogenization) can be minimized by following the procedures outlined in this SOP.
Cross contamination can be eliminated by using dedicated sampling equipment or by implementing the appropriate decontamination procedures.

3.0 SOIL SAMPLING PROCEDURES

For the purposes of this SOP, soil is defined as the top layer of the earth's surface, consisting of rock and mineral particles mixed with organic matter. Mention of trade names or commercial products does not constitute endorsement or recommendation for use. It should be noted that the equipment use described in this SOP is not inclusive and that some flexibility exists when implementing this SOP, as different types of projects mandate different data collection efforts. It is the responsibility of the SI GROUP project manager and field team leaders to ensure that the proper collection methods and equipment appropriate to the project site are utilized to fulfill the obligations of the project and contract.

Collection methods and equipment vary depending on depth of desired sample, type of sample required (discrete or composite), and soil type. Surface soil samples may be collected using a scoop, spade, stainless steel spoon, trier, and/or trowel. The collection of subsurface soil samples will require using an auger or other mechanized equipment. Analysis of soil may be chemical or physical in nature and may be used to evaluate the following:

- Lithology (i.e.- soil classification);
- Toxicity;
- Nature, extent, and magnitude of contamination;
- Contaminant source;
- Contaminant migration pathways;
- Fate and transport of contaminants in the soil matrix.

The following subsections discuss sampling strategy selection, pre-sample collection preparation activities, and sample collection procedures.

3.1 SAMPLING STRATEGY SELECTION

Subsections 5.1.1 through 5.1.7 describe the different sampling strategies. Table 1 summarizes the sampling strategies and ranks them from most to least suitable based on the objectives of the sampling event.

Table 1. Sampling Strategy Selection

Sampling Objective	Judgmental	Random	Stratified Random	Systematic Grid	Systematic Random	Biased Search	Transect
Establish Threat	1	4	3	2[a]	3	3	2
Identify Sources	1	4	2	2[a]	3	2	3
Delineate Extent of Contamination	4	3	3	1[b]	1	1	1
Evaluate Treatment and Disposal Options	3	3	1	2	2	4	2
Confirm Cleanup	4	1[c]	3	1[b]	1	1	1[c]

Notes: 1 Preferred Strategy
2 Acceptable Strategy
3 Moderately Acceptable Strategy
4 Least Acceptable Strategy
[a] Use with field analytical screening tools
[b] Preferred only where known trends are present
[c] Allows for statistical support of cleanup verification if sampling over entire site

3.1.1 Judgmental Strategy

This strategy often is used with one of the other methods in unusual situations, when there is historical site information, or when pollution is observed. This strategy may lead to wrong conclusions. The scientist's own bias is built into the sampling effort and the data. Where the data has a potential for litigation this strategy should not be implemented. If it is necessary to use judgmental sampling, a number of co-located samples (i.e. replicate samples) should be taken to have some measure of the precision of the sample data.

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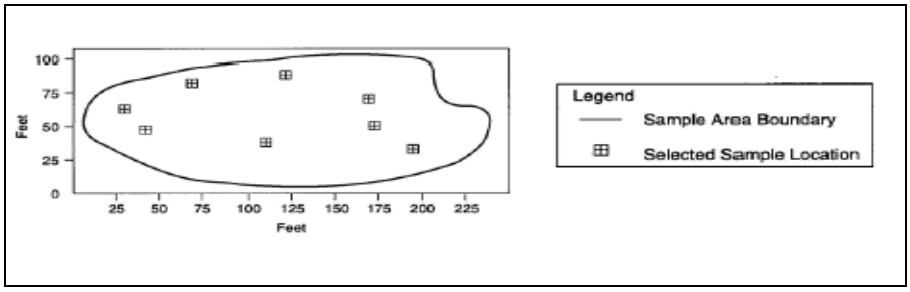
Judgmental sampling also can be used to verify the findings of some other form of pollutant identification such as x-ray fluorescence (XRF), soil-gas analysis, geophysics, or other field methods. In this case, the samples are placed in locations where the field methods indicate the presence of a pollutant. Again, replicate samples should be taken to provide some indication of reliability. If the areal extent of the subject site is large, it is more advisable to develop a detailed sampling plan and conduct a systematic study of the entire area believed to contain pollutants rather than using a strictly judgmental sampling strategy.

3.1.2 Random Strategy

Random sampling involves the arbitrary collection of samples within a defined area. The arbitrary selection of sample locations requires each sample location to be chosen independently so that results in all locations within the area of concern have an equal chance of being selected. To facilitate statistical probabilities of contaminant concentration, the area of concern must be homogeneous with respect to the parameters being monitored. Thus, the higher the degree of heterogeneity, the less the random sampling approach will reflect site conditions. The following figure illustrates the random sampling strategy.



Random Sampling Strategy

3.1.3 Stratified Random Strategy

Prior knowledge of the sampling area and information obtained from background data can be combined with information on pollutant behavior to reduce the number of samples necessary to attain a specified precision. Stratification is based on the premise that environmental factors play a major role in concentrating pollutants in certain locations through leaching, ponding, infiltration and other transport mechanisms. For example, a pesticide that is sorbed to clay particles may accumulate in stream valleys because of soil erosion from surrounding agricultural lands. Conversly, the agricultural land may have lost most of the pesticide because of the same erosion mechanisms. Stratified soil sample locations in this case might be along soil types; along elevation or slope changes; or according to ridge tops, side slopes, and valley floors. Soil types are frequently used as a means of stratification, especially if they are quite different in physical and chemical properties. Sampling of soil horizons is actually a form of stratification. Table 2 summarizes the six common factors that lead to stratified soils.

Table 2. Factors of Stratified Soils

Soil Factor	Potential Sample Location
Soil Type	Properties of the soil
Texture	Sandy loam versus clay loam
Drainage	Stream bottoms, valley slopes, and ridge tops are strata
Uses	eg.- cropland, forest areas, pasture, industrial areas, house lots, factories, etc…
Practices	Untilled cropland versus plowed land, areas of stockpiled drums versus areas of loose material, etc.

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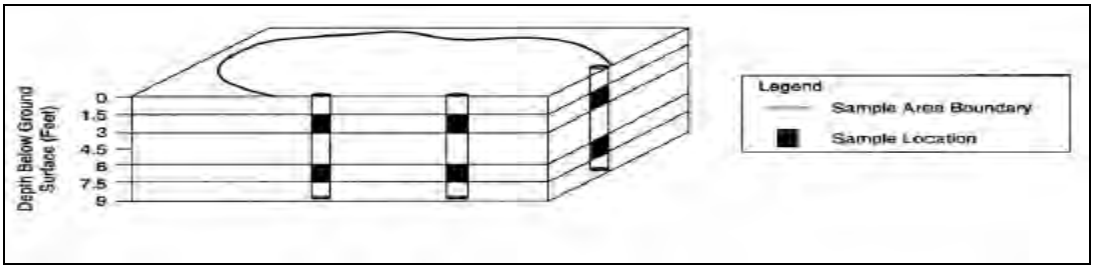
Horizons	A horizon, B horizon, and C horizon (A has more organic matter in the soil)

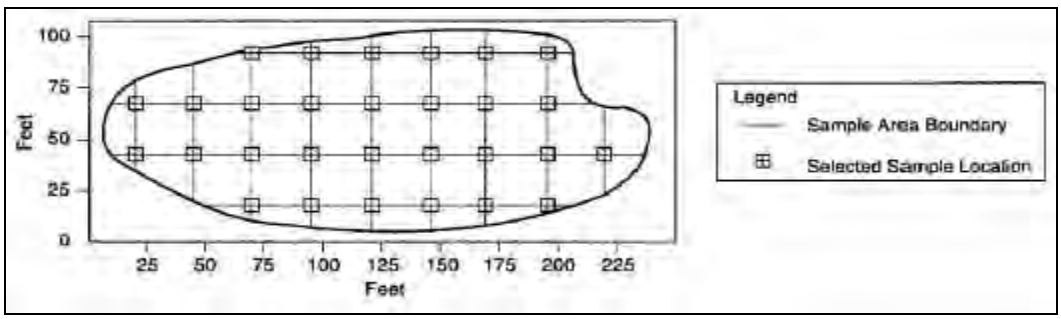
The whole purpose of stratification sampling is to increase the precision of the impacted area estimates and control the sources of variation in the data. The stratified random sampling plan should lead to increased precision if the strata are selected in such a manner that the units within each strata are more homogeneous than the total population. Stratification must remove some of the variation from the sampling error or else there is no benefit from the effort (other than perhaps a better geographic spread of sample points). In general, the more stratification, the greater the increase in precision. At least two samples must be taken from each stratum in order to obtain an estimate of the sampling error. The greater the number of samples in each stratum, the better the estimate will be. The number of sampling units is usually allocated according to a proportion based on the land area covered by each stratum (i.e., if the area of soil in one stratum is 25% of the total study area, then 25% of the samples would be taken from that stratum). Proportional allocation is used in soil sampling work primarily because the variance within a general area tends to be constant over a number of soil types. If the variances are materially different, the allocation must be on the basis of some optimum allocation system. The stratified random strategy is displayed below.



Stratified Random Sampling Strategy

3.1.4 Systematic Grid Strategy

The systematic grid sampling strategy theoretically provides better coverage of the soil study area compared to the random sample or the stratified random sample strategies. The systematic grid sampling design is a stratification based on spatial distribution over the site. Systematic grid sampling collects samples in a regular pattern at a grid line intersect over the area(s) under investigation. The distance between the sample points is dependent upon the acceptable level of error. The systematic grid strategy is illustrated below.



Systematic Grid Sampling Strategy

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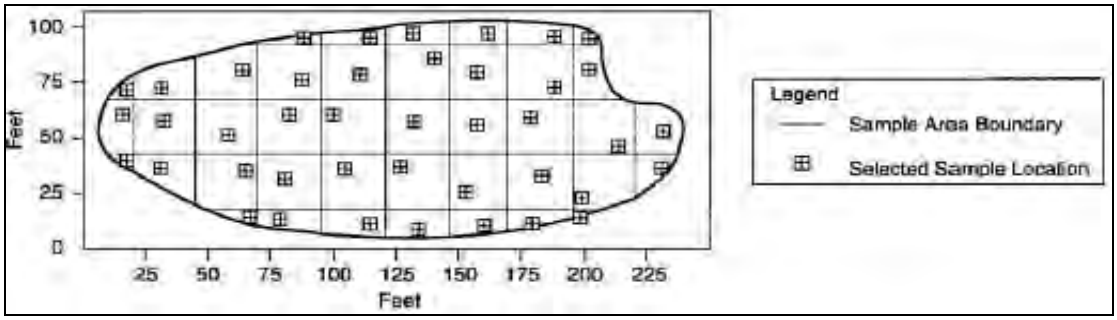
The orientation of the grid lines should be randomly selected unless there is a suspected plume, in which case, the orientation of one axis of the grid should lie parallel to the plume axis. Axes are especially important if geostatistics are implemented to aid in interpreting the data.

Grid spacing is important if regionalized variable theory (the basis of kriging) is used to design the sampling event. The theory is based upon the spacing of data points along the grid lines. The samples must be close enough to provide a measure of the continuity of the location-to-location variation within a soil sampling unit.

The systematic grid sampling strategy also is ideal when a map is the final product of the investigation due to the fact most mapping algorithms use a grid to generate the points for plotting isopleths of concentrations.

3.1.5 Systematic Random Strategy

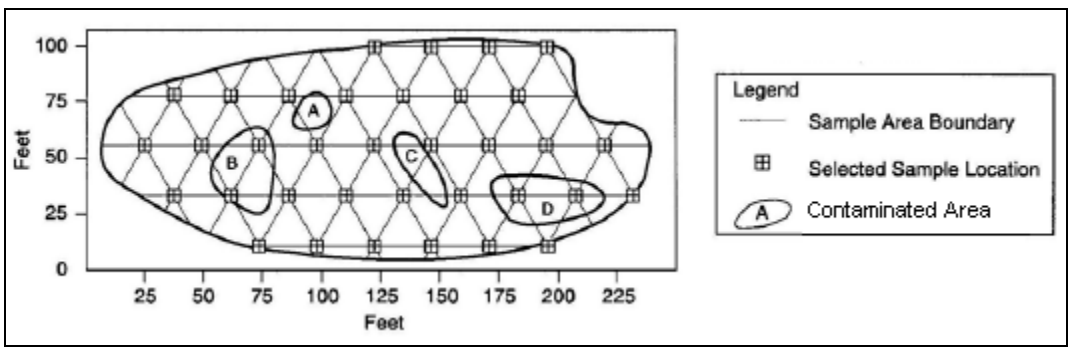
The systematic random sampling strategy is a combination of the systematic grid strategy and the random strategy. Samples are collected from random points within a grid cell. This sampling strategy should be implemented when no trends or natural strata occur in the area of concern. The systematic random strategy is illustrated on the following figure.



Systematic Random Sampling Strategy

3.1.6 Biased Search Strategy

This sampling strategy also utilizes a grid to define areas where contaminant concentrations exceed cleanup standards. As with the systematic grid strategy, the level of error that is determined to be acceptable will define the distance between the sample points for this strategy. When using this strategy assumptions must be made regarding the size of the contaminated area. The illustration below shows the biased search strategy.



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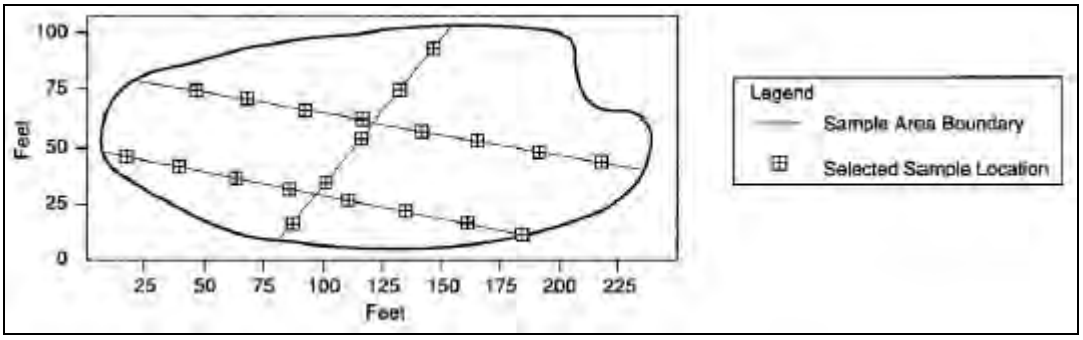
3.1.7 Transect Strategy

This sampling strategy involves one or more transect lines (parallel or intersecting) crossing the area of concern. If the lines are parallel, this strategy is similar to systematic grid sampling. The advantage of the transect strategy compared to the systematic grid strategy is the relative ease of relocating of the transect line as opposed to the entire grid. The samples are collected at regular intervals along the transect line. Again as with the previous strategies, the level of error that is determined to be acceptable will define the distance between the sample points. The transect strategy is displayed on the figure below.



Transect Sampling Strategy

3.2 PRE-SAMPLE COLLECTION PREPARATION ACTIVITIES

This section details preparatory steps that must be taken before collecting samples.

1. A Health and Safety Plan must be prepared and approved by the Health and Safety Officer.

2. A sampling and analysis plan must be prepared and approved. This plan details the samples to be collected and the data quality objectives of the sampling effort. The sampling plan should be approved by all parties involved with the sampling event to assure that data collected are suitable for decision making.

3. Obtain the equipment, supplies, and mechanized devices required to complete the tasks established in the Health and Safety and sampling plans.

4. Inspect the equipment and mechanized devices to verify they are in proper working order and have been decontaminated.

5. Coordinate with field staff, clients, utility companies (if necessary), and regulatory agencies. Utilities companies **must be** contacted if subsurface soil samples are scheduled to be collected. Most states have a one-call system to initiate utility locates.

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3.3 SAMPLE COLLECTION PROCEDURES

For all soil sampling procedures and methods described in the following subsections, several general guidelines and definitions apply. To the extent possible, avoid placing material other than soil in the sample container (i.e. - rocks, roots, sticks, trash, etc.). A sample that is to be submitted for VOC analysis should not be composited, as this may cause a loss of VOCs through volatilization. Instead, VOC samples should be collected directly from the undisturbed soil core to minimize contaminant loss. For the purposes of this discussion, homogenizing is defined as the mixing of a sample to achieve a uniform distribution of the contaminants.

After the soil sample is transferred to its appropriate pre-labeled sample jar, the lid should immediately be secured. The containerized sample should be placed in a cooler, iced to 4^{o}C, and sealed with a custody seal for transport to the analytical laboratory. To the extent practical, excavated material should be returned to the sample point. All disposable sampling equipment should be double-bagged and disposed in accordance with the Field sampling Plan and applicable regulations.

3.3.1 Surface Soil

Stainless steel spoons, spades, shovels, trowels, and scoops can be used to collect samples from surface soils. Plastic utensils should not be used when collecting soil samples that are to be submitted for semivolatile organic compound (SVOC) analysis and chrome-plated utensils should never be used to collect a soil sample. Generally, surface soil sampling does not exceed 2 feet below ground surface (ft bgs). The following procedures describe surface soil sampling methods:

1. Remove the soil to the desired depth with a clean utensil.

2. Collect the sample using a second clean utensil.

3. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the second clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the second clean utensil.

3.3.2 Sub-surface Soil with Trier

A trier is a sampling device that is advanced to depth, then retracted, allowing a soil sample to be collected from the core. Trier sampling procedures are summarized below.

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Trier

1. Trier sample depths should not exceed 2 ft bgs. Force the trier into the sampling area at a 0° to 45° angle. The angle will reduce the amount of soil spilled from the trier.

2. Rotate the trier twice to cut a core of material.

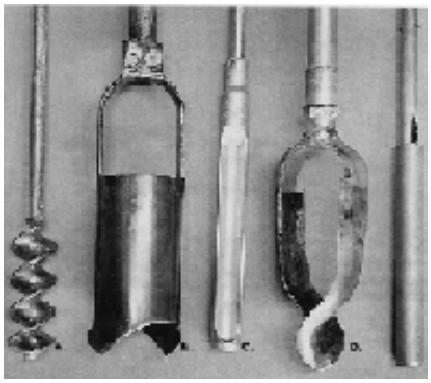
3. Slowly retract the trier, making sure the slot is facing upward.

4. Collect the sample using a clean utensil.

5. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the clean utensil.

3.3.3 Sub-Surface Soil with Augers and Thin-walled Tube Samplers

Several different types of augers can be used to bore to the desired depth including: bucket, power, continuous flight, dutch (rooted soil), and eijkelcamp (rocky soil). In ideal conditions, soil sampling utilizing augers does not exceed 10 ft bgs. Five augers are shown below.



Assorted Augers

1. Assemble bit, extension rod, and "T" handle.

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2. Clear the area to be augured.

3. Place the auger bit on the sample location and begin turning the "T" handle clockwise while pressing down (auguring).

4. Continue auguring to the desired depth.

5. Remove soil cuttings regularly.

6. After reaching the desired depth, remove the auger from the borehole. If the sample is being collected from the auger, extract the auger from the borehole. Place a sleeve inside of the auger. Lower the auger back down the borehole. Auger to the desired depth. When sampling directly from the auger, proceed to step 11.

7. Remove the auger and replace it with a thin-walled tube sampler.

8. Lower the thin-walled tube sampler.

9. Gradually force the thin-walled tube sampler into the bottom of the borehole to obtain soil in tube. Avoid scrapping the side walls of the borehole as much as possible,

10. Remove the sampler from the borehole.

11. Disassemble the sampling apparatus.

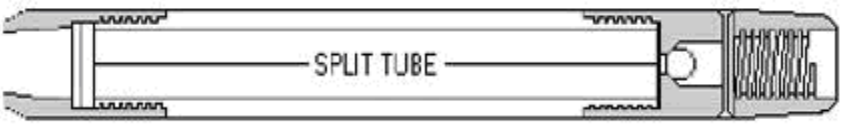
12. Discard the top one inch of the soil core in the tube.

13. Collect the sample using a clean utensil.

14. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the clean utensil.

3.3.4 Sub-surface Soil Sampling with a Split Spoon Sampler

Split spoon sampling provides soil cores that are generally between 18 and 24 inches. A series of cores are strung together to represent the lithological column. Split spoon sampling can extend well beyond 100 ft bgs depending on the drill rig.



Split Tube Sampler

Procedure

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1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit on the bottom and the heavier head piece on top. Install a retaining cap in the head if necessary.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer, slam bar, or well ring, drive the sample apparatus into the sample material. Do not overdrive the sampler. Overdriving will increase the pressure on the split spoon sample apparatus, making it difficult to disassemble the device.

4. Retract and disassemble the sample apparatus.

5. Collect the sample using a clean utensil.

6. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the clean utensil.

3.3.5 Sub-surface Soil Sampling from a Test Pit or Trench

Collection depths are generally less than 10 ft bgs. Occupation Safety and Health Administration (OSHA) guidelines and requirements should be reviewed before excavation begins.

1. Remove the soil to the desired depth with a decontaminated excavator.

2. Collect the sample using a clean utensil.

3. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the clean utensil.

3.3.6 Sub-surface Soil Sampling with Direct Push Technology (Geoprobe™)

Direct-push technology (DPT) sampling provides soil cores that are generally between 12 and 36 inches in length. A series of extension rods can be strung together to collect samples from depths greater than 100 ft bgs depending on the type of Geoprobe™ rig.

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Geoprobe™

1. Assemble the sampler by inserting an acetate sleeve into the barrel and screw the cutting shoe on the bottom and the drive head on top. Install a sand trap in the cutting shoe if necessary.

2. Place the sampler in a perpendicular position on the sample material.

3. Using the Geoprobe™ drive the sample apparatus into the sample material. Do not overdrive the sampler. Overdriving will increase the pressure on the sample apparatus; thus, increasing the difficulty of disassembly.

4. Retract and disassemble the sample apparatus.

5. Remove the acetate liner.

6. Open the acetate liner with a cutting tool.

7. Collect the sample using a clean utensil.

8. Transfer the sample to its appropriate sample container or place the sample in a stainless steel bowl to be homogenized. Homogenize using the clean utensil. If the sample required homogenization, after the homogenization is complete place the sample into its appropriate container using the clean utensil.

3.3.7 Composite Sampling

Compositing is the process of homogenizing several soil sample aliquots to produce one sample. The composite sample will provide an average concentration for all of the aliquots. Composite samples are primarily collected to reduce the number of samples submitted to a laboratory, which consequently decreases the project cost.

3.3.8 Split Sampling

The following steps describe the process of collecting non-VOC split samples. VOC samples should be collected from an undisturbed area of soil in proximity to the parent sample. Replicate split sampling is not appropriate for VOC samples.

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1. Form a cone shape with the sample.
2. Mix by forming a new cone.
3. Flatten the cone.
4. Divide into quarters.
5. Mix opposite quarters.
6. Reform cone.
7. Repeat steps 1 through 6 at least five times.

3.4 SAMPLE PRESERVATION AND HANDLING

Chemical preservation of solids is generally not recommended. Soil samples are typically preserved by cooling to 4 degrees Celsius (°C). Table 3 summarizes the most common soil parameters and their respective holding times, minimum volumes required, container types, and preservatives for soil samples according U.S. Environmental Protection Agency (EPA) method SW-846.

Table 3. Soil Sample Parameter, Holding Time, Minimum Volume Required, Container Type, and Preservative Summary

Parameter	Holding Time		Minimum Volume Required	Container Type	Preservative
	Extraction	Analysis			
Volatile Organic Compounds	Not Applicable	14 days	5 grams	4-oz. jar (no headspace)	Cool to 4 ° C
Semi-volatile Organic Compounds	7 days	40 days	30 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Polychlorinated Biphenyls	7 days	40 days	30 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Pesticides	7 days	40 days	30 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Metals	6 months		2 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Mercury	28 days		0.2 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Hexavalent Chromium	1 day	1 day	2.5 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Cyanide	14 days		25 to 100 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Total Organic Carbon	Not Applicable	2 hours	10 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C
Total Organic Halides	Not Applicable	28 days	100 grams	8-oz. jar (lid:Teflon lined)	Cool to 4 ° C

4.0 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

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Quality Assurance/Quality Control (QA/QC) samples are collected to identify error due to sampling and/or analytical methodologies. The frequency of QA/QC samples collected should be defined in the field sampling plan.

Field Duplicate Samples: Field duplicate samples are collected from one sample location and treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error.

Collocated Samples: Collocated samples are collected from the same general area on site (usually no more than 3 feet apart). These samples are used to determine local soil and contaminant variations on site.

Background Samples: Background samples are collected from distal locations near the site that are not suspected to be contaminated. These samples provide a standard for comparison.

Rinsate Samples: Rinsate samples are collected to define the effectiveness of the decontamination procedures.

Performance Evaluation Samples: Performance evaluation samples are purchased from a certified vendor to determine the accuracy of the laboratory data.

Matrix Spike/Matrix Spike Duplicate Samples: Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples are spiked with known contaminant concentrations by the laboratory to define the matrix effect.
Field Blank Samples: Field blank samples are prepared with certified clean sand. The field blank samples assess contamination error associated with sampling methodology and laboratory procedures.

Trip Blank Samples: Trip blank samples are prepared with certified clean sand by the laboratory to determine if VOC contamination is introduced during the handling of the samples.

5.0 DOCUMENTATION

Documentation of field activities should be conducted in accordance with the SOP Field Activity Logbook Entries and with the protocols in this SOP. This section describes the minimal documentation required for sampling events.

5.1 Sample Label

The following information should be recorded on the sample label.

1. Site name or identification
2. Sample identification
3. Date collected
4. Time (24-hour clock)
5. Preservatives (if any)
6. Analysis requested
7. Name of sampler

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5.1 Field Documentation

All sample information shall be recorded in the field logbook in accordance with the HGL SOP *Field Activity Logbook Entries*.

5.2 Chain-of-Custody

Chain of custody forms must be completed for all samples submitted to the laboratory. Generally, the laboratory will provide these forms.

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ATTACHMENT 1
SOIL SAMPLING EQUIPMENT, SUPPLIES, AND MECHANIZED DEVICES

Sampling

- Aluminum pie pans for homogenizing samples
- Augers
    - Bucket
    - Power
    - Continuous flight
    - Dutch (rooted soil)
    - Eijkelcamp (rocky soil)
- Auger Accessories
    - T-handle
    - Extension rods
- En Core™ samplers
- Laskey sampler
- Sample containers
- Sample labels
- Shelby tube sampler
- Soil Core Sampler
    - Tubes
    - Points
    - Drive head
    - Drop hammer
    - Fuller jack and grip
- Spade or shovel
- Spatula
- Split spoon sampler
- Stainless steel tulip bulb planter
- Stainless steel spoon
- Stainless steel bowls
- Tape (clear)
- Thin walled tube sampler
- Trier
- Trowel

Mechanized Devices

- Backhoe
- Drill rig
- Geoprobe™

Packaging and Shipping

- Coolers
- Custody seals (two per cooler)
- Ice

- Ice bags (leak proof)
- Shipping labels
- Tape (clear)
- Tape (fiber)
- Bubble wrap

Documentation
- Camera
- Chain-of-custody forms
- Compass
- Field sheets
- Global Positioning System (GPS)
- Logbook
- Spray Paint
- Survey stakes or flags
- Tape measure

Support
- Sample location map
- Sampling plan

Health and Safety
- Health and Safety Plan
- Air monitoring instrumentation
    - Photoionization detector
    - Flame Ionization detector
    - Data Respirable Aerosol Monitor (RAM)
    - Single-gas monitor
- Disposable Gloves
- Fire extinguisher
- First aid kit
- Hard hat
- Safety Glasses
- Steel-toed boots
- Hearing protection

Decontamination
- Assorted brushes
- Power washers (heated and unheated water)
- Propane heater

Decontamination
- Soap
- Sprayer
- Tubs
- Tarps or plastic sheeting
- Water

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- Water containers

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SOP 2.29

Collection of Sub-Slab Vapor Samples Using Summa Canisters

1.0 PURPOSE

Soil gas sampling documents volatile organic compounds (VOCs) in a relatively broad subsurface area and in this instance the concentrations available to penetrate foundation flaws. In addition, soil gas sampling can also be used to identify contaminants of concern (COCS), the source of the COC, extent of the area impacted by the COC, and the movement of the COC.

This standard operating procedure (SOP) describes the approach for the collection of sub-slab soil gas samples utilizing Summa canisters. It includes instructions pertaining to following: probe installation, leak checking, gas sampling, and probe abandonment.

The equipment described in this SOP may be purchased or rented at local home center or hardware store and should be sufficient for the installation of a soil gas sampling port in a slab up to 8-inches thick. Equipment can be purchased or rented to drill thru a slab of greater thickness; however this equipment may not be available locally. The thickness of a concrete slab may vary from structure to structure or may even vary within the slab itself.

The standard operating procedures described herein may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. This SOP should be used in conjunction with project data quality objectives. In all instances, the ultimate procedures employed should be documented and associated with the final report.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Summa canister: A Summa canister is a stainless steel vessel which has had the internal surfaces specially passivated using a "Summa" process. This process combines an electropolishing step with chemical deactivation to produce a surface that is chemically inert. Summa canisters range in volume from less than 1 liter to greater than 15 liters. The 6 liter canisters are generally used for ambient air samples and for collecting samples over time. Small, 1 liter, canisters are normally used for taking high level (> 100 ppbv) grab samples although exceptions to these guidelines are common.

2.2 Abbreviations

COC	contaminant of concern
cm	square centimeters
cm^3/min	cubic centimeters per minute
DF	dilution factor
GC	gas chromatograph
ID	inside diameter
kPa	two atmospheres
psia	pounds per square inch absolute
ml/min	milliliters per minute
OD	outside diameter

PID	photoionization detector
ppbv	parts per billion by volume
QA	quality assurance
QC	quality control
SOP	standard operation procedure
VOC	volatile organic compound

3.0 METHOD SUMMARY

Using an electric Hammer Drill or Rotary Hammer, an inner or pilot hole is drilled into the concrete slab to a depth of approximately 2 inches with a 3/8-inch drill bit. Using the pilot hole as a center, drill an outer hole to an approximate depth of 1 3/8 inches using a 1 inch diameter drill bit. Replacing the 1 inch bit with a 3/8 inch diameter drill bit continue to drill the pilot hole thru the slab and several inches into the sub-slab material. Once drilling is completed, the completed hole is monitored with a PID to indicate the presences of VOCs. A stainless steel port is assembled and inserted into the pre-drilled hole. The sampling port is mounted flush with the surrounding slab so it will not interfere with pedestrian or vehicle traffic and cemented into place. After leak testing, sample collection may now begin.

4.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

After the air sample is collected, the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to a laboratory for analysis as soon as possible. Upon receipt at the laboratory, the canister tag data is recorded. Sample holding times and expiration should be determined prior to initiating field activities. Typical, holding times range from 14 to 30 days. Storage requirements are not stipulated in the analytical method; however, it is suggested the canisters are not exposed to extreme conditions. In addition, the samples do not require preservation.

5.0 INTERFERENCE AND POTENTIAL PROBLEMS

Contamination may occur in the sampling system if canisters and sampling equipment are not properly cleaned before use. The determination as to whether the equipment is contaminated will be made after reviewing the field and laboratory quality assurance/ quality control (QA/QC) samples. Section 14 further describes the field QA/QC samples that should be collected.

6.0 EQUIPMENT / APPARATUS

- Hammer Drill or Rotary Hammer
- AC extension cord
- AC generator (if power is not available on site)
- 1” and 3/8” diameter Hammer or Rotary Hammer drill bit
- Vacuum cleaner
- Vacuum pump, sampling manifold
- ¼ Hex head wrench
- Tubing cutter
- (2) 5 gallon buckets
- Trowel or putty knife
- Swagelok® SS-400-7-4 female connecter, ¼” NPT to ¼” Swagelok® connector
- Swagelok® SS-400_1-4 male connector, ¼” NPT to ¼” Swagelok® connector
- Teflon® coated ¼” NPT flush mount hex socket plug
- ¼” OD stainless steel tubing, pre-cleaned instrument grade
- ¼” OD Teflon® tubing
- Teflon® thread tape

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- Anchoring cement
- 1 gallon distilled water or spring water
- Modeling clay
- Leak check enclosure
- Compressed helium tank (balloon grade), helium regulator, flow meter (0-500 ml/min)

- Helium detector, or equal
- Isopropyl alcohol
- 6-liter Summa canister(s) with flow regulator(s)
- Paper towels
- Tools required to cut carpet, and / or tools needed for removal of other floor coverings

7.0 PORT ASSEMBLY AND INSTALLATION

- Locate the sampling locations in accordance with the sampling plan. Check with local utility companies to identify utilities entering the building from the outside. If possible, look for known or suspected utility conduits and note their location on a map or in the field log. Be sure to confirm that the sample locations will not interfere with the known underground utilities. Also note the location of the sampling ports, locations of significant features (walls, cracks, sumps, drains, etc.), and conditions of the slab and / or soil.
- Drill a 3/8" diameter pilot hole to a depth of 2". Be careful not to compromise the integrity of the slab during drilling activities (for example: cracking), although note if this occurs. It is important that the slab and the sampling port remain air tight for sampling and that cracks are noted.
- Using the 3/8" pilot hole as your center, drill a 1" diameter outer hole to a depth of 1 3/8".
- Vacuum out any cuttings from the hole.
- Continue drilling the 3/8" pilot hole thru the slab and a few inches into the sub-slab material. After removing the drilling equipment, quickly monitor the completed hole with a PID. Record the total depth of the slab, the depth drilled into the sub-slab material, and PID reading in the field log. The total depth of the slab and the depth drilled into the sub-slab material are determined by measuring the length on the drill bit where you broke through the slab.
- Vacuum out any cuttings from the hole.
- After vacuuming out the completed hole, monitor for the presence of VOCs using a PID. The hole itself and approximately 3-5 feet above the hole are to be monitored with a PID and the readings recorded in the field log.
- Determine the length of stainless steel tubing required to avoid obstruction of the sampling port tube and insure that it does not contact the sub-slab material. Cut the tubing to the desired length (For a slab that is 9 inches thick, the tubing should be 7 inches).
- Attach the measured length of stainless steel tubing to the female connector with the Swagelok® nut. Tighten the nut.
- Wrap the ¼" hex socket plug with Teflon tape prior to inserting it into the female connector. Tighten the plug. **Do not over tighten**. If excessive forces is required to remove the plug during the sample set-up phase the sampling port may break loose from the anchoring cement.
- Place the completed sampling port into the hole. The sampling port tubing should not contact the sub-slab material and the top of the female connector should be flush with the surface of the slab and centered in the outer hole.
- Wet the walls of the hole using a Q-tip or moistened paper towel. This helps the cement bond to the drilled concrete. Prepare the cement in accordance with manufacture's direction to a stiff consistency. Mix a small amount of the anchoring cement and make sure the consistency is such that the mixture will not run down the sides of the hole and potentially

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clog the port or hole. Using a putty knife or similar tool, apply anchoring cement around the base of the sampling port and fitting union such that it will be sealed once it is in place.

- Fill the space between the sampling port and the outside of the outer hole. In doing so, slightly wiggle the probe to create good 'wetting' contact between the probe and the anchoring cement as well as the anchoring cement and drilled concrete. Allow the cement to cure according to manufactures instructions before sampling.
- Be sure to never leave the sampling port open to the atmosphere for extended periods of time to minimize the effects of surface infiltration.

8.0 SAMPLING PORT LEAK CHECK

Each sampling port will be leak checked and purged before sampling. Two different methods supported by the available literature / guidance are presented. One method uses helium gas as a tracer and allows for the assessment of potential port leak prior to sample collection. The other method uses isopropyl alcohol as a tracer and allows for the assessment of potential sample port leak after sample collection and analysis. Both methods are detailed below.

Helium leak check

- Remove the sampling port hex nut, wrap the sampling fitting threads with Teflon tape and insert into the sampling port. Thread the Teflon sample tubing through the rubber grommet in the leak check enclosure from the outside, and attach the tube to the sample union. Slide the enclosure down so it seals on the slab. Attach the other end of the sample tube to the sampling manifold.
- Attach tubing to the flow meter on the helium tank regulator and the other end to the enclosure. Attach the exhaust tube to the enclosure and position the other end as far away as possible to avoid detection by the helium leak detector.
- Put the helium leak detector on the exhaust line from the sample pump.
- Open the helium tank and set the flow meter for approximately 200 ml/min. Allow it to flow for 1 minute to fill the leak check enclosure before starting the purge. Make sure the detector is not reading any helium before starting the purge.
- Two liters of sub-slab vapor will be purged before sampling. The purge time is approximately 10 minutes at a flow rate of 200 ml/min. During the purge, observe the helium detector for indication of port leakage (for example: infiltration of room air into the sampling port). If a reading of >5% is observed, then the port leak check has failed.
- At the end of the purge time, if at any time during the purge the detector read <5%, then the system is leak free and ready for sampling. If >5% was observed, then check the sampling port and fitting and try again. If <5% cannot be achieved, then this port must be abandoned and a new hole drilled. Record the helium leak check results in the field log.
- Closed the helium tank valve.

Isopropyl alcohol leak check

- Moisten a paper towel with isopropyl alcohol. Wrap the moistened paper towel around the sampling port fittings at the slab surface. It is important to keep the isopropyl alcohol away from the sampling equipment and Summa canister during the sampling phase. The sampler must also change nitrile glove between setting up the sample and conducting the leak test. It is also important to instruct the laboratory to analyze for isopropyl alcohol. If isopropyl alcohol is detected by the laboratory at a concentration greater than 5% than the sample is deemed to be invalid due to a leak.
- Two liters of sub-slab soil gas will be purged before sampling. The purge time is approximately 10 minutes at a flow rate of 200 ml/min.

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- At the end of the time turn the pump off.

9.0 SAMPLING SET-UP

Complete the pre-sampling set-up as follows:

- Wrap one layer of Teflon tape onto the male end of the NPT connector. This connector is attached to the tubing leading to the Summa canister.
- Remove the ¼" hex socket plug from the female connector. Refer to Section 7.0 if the probe breaks loose from the anchoring cement during this step.
- Screw and tighten the male connector into the female connector. **Do not over tighten**. This may cause the probe to beak loose from the anchoring cement during this step or when the male connector is removed upon completion of the sampling event. Refer to Section 7.0 if the probe breaks loose from the anchoring cement during this step.
- Attach a length of ¼" OD Teflon tubing to the male connector with a Swagelok nut. The Teflon tubing is then connected to the sampling container or system to be utilized for sample collection.

Complete the post-sampling set-up as follows:

- After sample collection remove the male connector from the probe and reinstall the hex socket plug. **Do not over tighten the hex socket plug**. If excessive force is required to remove the plug during the next sampling event the sampling port may break loose from the anchoring cement. Refer to Section 7.0 if the probe breaks loose from the anchoring cement during this step.

10.0 REPAIRING A LOOSE PORT

- If the sampling port breaks loose from the anchoring cement while removing or installing the hex head plug, or the male connector, lift the probe slightly above the surface of the concrete slab.
- Hold the female connector with the ¾" open end wrench.
- Complete the step being taken during which the probe broke loose, following the instructions contained in the SOP (i.e. **Do not over tighten** the hex socket nut plug or male connector).
- Push the sampling port back down into place and reapply the anchoring cement.
- Modeling clay may be used as a temporary patch to affect a seal around the probe until the anchoring cement can be reapplied.

11.0 SUB-SLAB SAMPLING

- Inspect the canister for damage. Do not use a canister that has visual damage.
- Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory's evacuation tag. Do not use a canister that has leaked.
- Remove the protective cap from the valve on the canister.
- If using an external gauge, attach the gauge to the canister and open the valve. After taking the reading, close the canister and remove the gauge.
- Verify that the flow controller is set at the desired sampling rate. There are different sample time and flow rate protocols. For a 6-liter Summa canister the flow controller will be set at 3.75 ml/min for a 24-hour sample period.
- In the field log record the canister ID, flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.

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- Connect the flow controller to the canister. The flow controller denoted "LP" or "OUT" is connected to the canister. Tighten the fitting as to be leak free but **do not over tighten** (a ¼ turn past snug is enough).
- Connect a dedicated stainless steel fitting and Teflon tubing to a sub-slab sampling port. Use dedicated fitting and tubing to avoid cross contamination issues.
- Connect the Teflon tubing to ¼" ID Masterflex tubing and a peristaltic pump and 1 liter Tedlar bag. Using a peristaltic pump will ensure that sampled air does not circulate through the pump causing cross contamination and/or leakage.
- Purge sampling area by filling a dedicated 1 liter Tedlar bag. A purge volume of 1 liters was chosen based on the assumption of a ¼" air space beneath a slab and an affected sample diameter of 2 feet. The internal volume of sub-slab sampling port and associated sample tubing is insignificant.
- Use a portable PID to analyze Tedlar bags and record readings in field log.
- To begin sampling, slowly open the Summa canister valve one full turn.
- Collect sub-slab soil gas samples in evacuated 100% certified Summa canisters. Use dedicated in-line particulate filters prior to the inlet port on the canister regulator. Check and record vacuum in canister prior to and after sample collection.
- Sampling will cease when canister pressure reaches between 5" and 2" pressure. Slowly close the canister valve at this point finger tight.
- Submit canisters for analysis by EPA Method TO-15.

12.0 SAMPLING PORT ABANDONMENT

- After sampling, it is critical that the sampling port either be removed or plugged to prevent the creation of a new pathway for vapor intrusion.
- If the sampling port is to be used in the future, wrap the plug with Teflon tape and tighten it into the port until it is tight.
- If the sampling port is to be removed, insert the removal fitting into the probe. Using a crow bar, remove the entire sampling port assembly. If the port cannot be removed in this manner, then over drill the sampling port. Fill the hole with cement to grade.

13.0 CALCULATIONS

A flow control device is chosen to maintain a constant flow into the canister over the desired sample period. This flow rate is determined so the canister is filled to about 88.1 kPa for subatmospheric pressure sampling or to about one atmosphere above ambient pressure for pressurized sampling over the desired sample period. The flow rate can be calculated by:

$$F = \frac{(P)(V)}{(T)(60)}$$

where:

F = flow rate (cm^3/min)
P = final canister pressure, atmospheres absolute
V = volume of the canister (cm^3)
T = sample period (hours)

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For example, if a 6-L canister is to be filled to 202 kPa (two atmospheres) absolute pressure in 24 hours, the flow rate can be calculated by:

$$F = \frac{(2)(6000)}{(24)(60)} = 8.3 \text{ cubic cm per minute}$$

If the canister pressure is increased, a dilution factor (DF) is calculated and recorded on the sampling data sheet.

$$DF = \frac{Ya}{Xa}$$

where:

Xa = canister pressure (kPa, psia) absolute before dilution.
Ya = canister pressure (kPa, psia) absolute after dilution.

After sample analysis, detected VOC concentrations are multiplied by the dilution factor to determine concentration in the sampled air.

14.0 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC samples are collected to identify error due to sampling and/or analytical methodologies. The frequency of QA/QC samples collected should be defined in the field sampling plan.

Collocated Samples: Collocated samples are collected from the same general area on site (usually no more than 3 feet apart). These samples are used to determine local soil and contaminant variations on site.

Background Samples: Background samples are collected from distal locations near the site that are not suspected to be contaminated. These samples provide a standard for comparison.

15.0 REFERENCES

Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, EPA/600/R-05/147, March 2006. US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH 45268.

Standard Operating Procedure Sampling Volatile Organic Compounds Using SUMMA Polished Stainless Steel Canisters, EPA-REG1-EAD/CAN-SAM-SOP, March 1994. US Environmental Protection Agency, New England Regional Laboratory, Environmental Services Division, 60 Westview Street, Lexington, MA 02173.

Summa Canister Sampling, Standard Operating Procedure Number: 1704, July 27, 1995, Revision Number: 0.1, US Environmental Protection Agency, Environmental Response Team.

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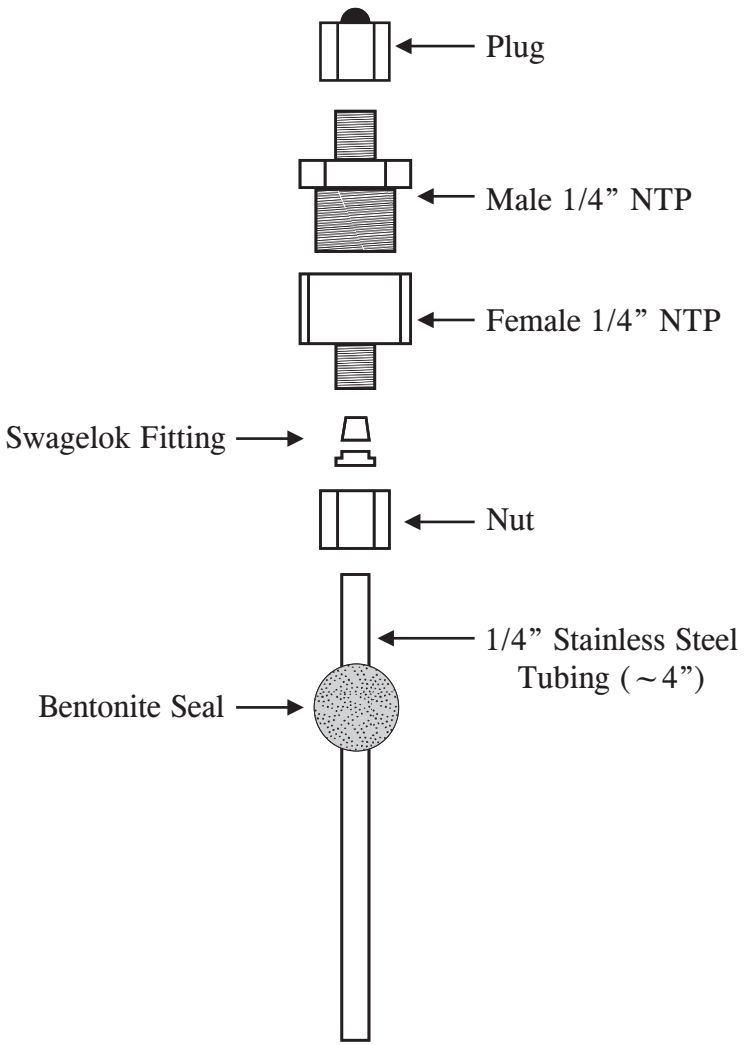
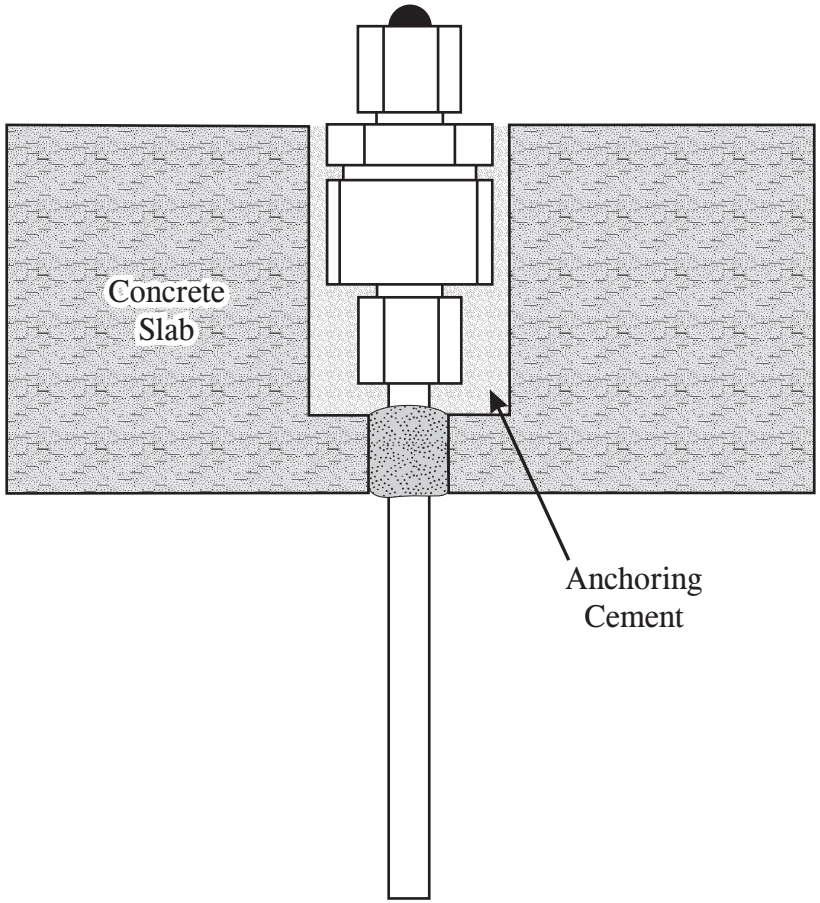
Vapor Port Assembly Parts



Sub-Slab Vapor Port



Filename: X:/EPA009/Garvey/RI_FS/SubSlab_Vapor_Port.cdr
Project: EP9033.01.46.13
Revised: 05/15/09 CV
Source: HGL Database

Figure 1
Subslab Vapor Port

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SUMMA CANISTER SAMPLING

SOP#: 1704
DATE: 07/27/95
REV. #: 0.1

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe a procedure for sampling of volatile organic compounds (VOCs) in ambient air. The method is based on samples collected as whole air samples in Summa passivated stainless steel canisters. The VOCs are subsequently separated by gas chromatography (GC) and measured by mass-selective detector or multidetector techniques. This method presents procedures for sampling into canisters at final pressures both above and below atmospheric pressure (respectively referred to as pressurized and subatmospheric pressure sampling).

This method is applicable to specific VOCs that have been tested and determined to be stable when stored in pressurized and subatmospheric pressure canisters. The organic compounds that have been successfully collected in pressurized canisters by this method are listed in the Volatile Organic Compound Data Sheet (Appendix A). These compounds have been measured at the parts per billion by volume (ppbv) level.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Both subatmospheric pressure and pressurized sampling modes use an initially evacuated canister. Both modes may also use a mass flow controller/vacuum pump arrangement to regulate flow. With the above configuration, a sample of ambient air is drawn through a sampling train comprised of components that regulate the rate and duration of sampling into a pre-evacuated Summa passivated canister. Alternatively, subatmospheric pressure sampling may be performed using a fixed orifice, capillary, or adjustable micrometering valve in lieu of the mass flow controller/vacuum pump arrangement for taking grab samples or short duration time-integrated samples. Usually, the alternative types of flow controllers are appropriate only in situations where screening samples are taken to assess for future sampling activities.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

After the air sample is collected, the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to a laboratory for analysis. Upon receipt at the laboratory, the canister tag data is recorded. Sample holding times and expiration should be determined prior to initiating field activities.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers) should be thoroughly cleaned.

5.0 EQUIPMENT/APPARATUS

The following equipment/apparatus (Figure 1, Appendix B) is required:

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5.1 Subatmospheric Pressure Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100 or equivalent).

2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.

3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).

4. Particulate matter filter - 2-µm sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).

5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.

6. Fixed orifice, capillary, or adjustable micrometering valve - used in lieu of the electronic flow controller/vacuum pump for grab samples or short duration time-integrated samples.

5.2 Pressurized Sampling Equipment

1. VOC canister sampler - whole air sampler capable of filling an initially evacuated canister by action of the flow controlled pump from vacuum to near atmospheric pressure. (Andersen Samplers Inc., Model 87-100).

2. Sampling inlet line - stainless steel tubing to connect the sampler to the sample inlet.

3. Sample canister - leak-free stainless steel pressure vessels of desired volume with valve and Summa passivated interior surfaces (Scientific Instrumentation Specialist, Inc., ID 83843, Andersen Samplers, Inc., or equivalent).

4. Particulate matter filter - 2-µm sintered stainless steel in-line filter (Nupro Co., Model SS-2F-K4-2, or equivalent).

5. Chromatographic grade stainless steel tubing and fittings - for interconnections (Alltech Associates, Cat. #8125, or equivalent). All materials in contact with sample, analyte, and support gases should be chromatographic grade stainless steel.

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURE

7.1 Subatmospheric Pressure Sampling

7.1.1 Sampling Using a Fixed Orifice, Capillary, or Adjustable Micrometering Valve

1. Prior to sample collection, the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).

2. A canister, which is evacuated to 0.05 mm Hg and fitted with a flow restricting device, is opened to the atmosphere containing the VOCs to be sampled.

3. The pressure differential causes the sample to flow into the canister.

4. This technique may be used to collect grab samples (duration of 10 to 30 seconds) or time-integrated samples (duration of 12 to 24 hours). The sampling duration depends on the degree to which the flow is restricted.

5. A critical orifice flow restrictor will have a decrease in the flow rate as the pressure approaches atmospheric.

6. Upon sample completion at the location, the appropriate information is recorded on the

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Canister Sampling Field Data Sheet.

7.1.2 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Andersen Sampler Model 87-100)

1. Prior to sample collection the appropriate information is completed on the Canister Sampling Field Data Sheet (Appendix C).

2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.

3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.

4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.

5. The initially evacuated canister is filled by action of the flow controlled pump to near atmospheric pressure.

6. A digital time-program is used to pre-select sample duration and start and stop times.

7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

7.2 Pressurized Sampling

7.2.1 Sampling Using a Mass Flow Controller/Vacuum Pump Arrangement (Anderson Sampler Model 87-100)

1. Prior to sample commencement at the location, the appropriate information is completed on the Canister Sampling Field Data Sheet.

2. A canister, which is evacuated to 0.05 mm Hg and connected in line with the sampler, is opened to the atmosphere containing the VOCs to be sampled.

3. A whole air sample is drawn into the system through a stainless steel inlet tube by a direct drive blower motor assembly.

4. A small portion of this whole air sample is pulled from the inlet tube by a specially modified inert vacuum pump in conjunction with a mass flow controller.

5. The initially evacuated canister is filled by action of the flow controlled pump to a positive pressure not to exceed 25 psig.

6. A digital time-programmer is used to pre-select sample duration and start and stop times.

7. Upon sample completion at the location, the appropriate information is recorded on the Canister Sampling Field Data Sheet.

8.0 CALCULATIONS

1. A flow control device is chosen to maintain a constant flow into the canister over the desired sample period. This flow rate is determined so the canister is filled to about 88.1 kPa for subatmospheric pressure sampling or to about one atmosphere above ambient pressure for pressurized sampling over the desired sample period. The flow rate can be calculated by:

$$F = \frac{(P)(V)}{(T)(60)}$$

where:

F	=	flow rate (cm^3/min)
P	=	final canister pressure, atmospheres absolute
V	=	volume of the canister (cm^3)
T	=	sample period (hours)

For example, if a 6-L canister is to be filled to 202 kPa (two atmospheres) absolute pressure in 24 hours, the flow rate can be calculated by:

$$F \approx \frac{(2)(6000)}{(24)(60)} \approx 8.3 cm^3/min$$

2. If the canister pressure is increased, a dilution factor (DF) is calculated and recorded on the sampling data sheet.

$$DF \approx \frac{Ya}{Xa}$$

where:

Xa = canister pressure (kPa, psia) absolute before dilution.

Ya = canister pressure (kPa, psia) absolute after dilution.

After sample analysis, detected VOC concentrations are multiplied by the dilution factor to determine concentration in the sampled air.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

1. All data must be documented on standard chain of custody records, field data sheets, or site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices. Specifically, pressurizing of Summa canisters should be performed in a well ventilated room, or preferably under a fume hood. Care must be taken not to exceed 40 psi in the canisters. Canisters are under pressure, albeit only 20-30 psi, and should not be dented or punctured. They should be stored in a cool dry place and always be placed in their plastic shipping boxes during transport and storage.

12.0 REFERENCES

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APPENDIX A

Volatile Organic Compound Data Sheet

TABLE 1. VOLATILE ORGANIC COMPOUND DATA SHEET

COMPOUND (SYNONYM)	FORMULA	MOLECULAR WEIGHT	BOILING POINT (°C)	MELTING POINT (°C)	CAS NUMBER
Freon 12 (Dichlorodifluoromethane)	Cl_2CF_2	120.91	-29.8	-158.0	
Methyl chloride (Chloromethane)	CH_3Cl	50.49	-24.2	-97.1	74-87-3
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	$ClCF_2CClF_2$	170.93	4.1	-94.0	
Vinyl chloride (Chloroethylene)	$CH_2=CHCl$	62.50	-13.4	-1538.0	75-01-4
Methyl bromide (Bromomethane)	CH_3Br	94.94	3.6	-93.6	74-83-9
Ethyl chloride (Chloroethane)	CH_3CH_2Cl	64.52	12.3	-136.4	75-00-3
Freon 11 (Trichlorofluoromethane)	CCl_3F	137.38	23.7	-111.0	
Vinylidene chloride (1,1-Dichloroethene)	$C_2H_2Cl_2$	96.95	31.7	-122.5	75-35-4
Dichloromethane (Methylene chloride)	CH_2Cl_2	84.94	39.8	-95.1	75-09-2
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	CF_2ClCCl_2F	187.38	47.7	-36.4	
1,1-Dichloroethane (Ethylidene chloride)	CH_3CHCl_2	98.96	57.3	-97.0	74-34-3
cis-1,2-Dichloroethylene	$CHCl=CHCl$	96.94	60.3	-80.5	
Chloroform (Trichloromethane)	$CHCl_3$	119.38	61.7	-63.5	67-66-3
1,2-Dichloroethane (Ethylene dichloride)	$ClCH_2CH_2Cl$	98.96	83.5	-35.3	107-06-2
Methyl chloroform (1,1,1-Trichloroethane)	CH_3CCl_3	133.41	74.1	-30.4	71-55-6
Benzene (Cyclohexatriene)	C_6H_6	78.12	80.1	5.5	71-43-2
Carbon tetrachloride (Tetrachloromethane)	CCl_4	153.82	76.5	-23.0	56-23-5
1,2-Dichloropropane (Propylene dichloride)	$CH_3CHClCH_2Cl$	112.99	96.4	-100.4	78-87-5
Trichloroethylene (Trichloroethene)	$ClCH=CCl_2$	131.29	87	-73.0	79-01-6
cis-1,3-Dichloropropene (cis-1,3-dichloropropylene)	$CH_3CCl=CHCl$	110.97	76		
trans-1,3-Dichloropropene (cis-1,3-Dichloropropylene)	$ClCH_2CH=CHCl$	110.97	112.0		
1,1,2-Trichloroethane (Vinyl trichloride)	$CH_2ClCHCl_2$	133.41	113.8	-36.5	79-00-5
Toluene (Methyl benzene)	$C_6H_5CH_3$	92.15	110.6	-95.0	108-88-3
1,2-Dibromoethane (Ethylene dibromide)	$BrCH_2CH_2Br$	187.88	131.3	9.8	106-93-4
Tetrachloroethylene (Perchloroethylene)	$Cl_2C=CCl_2$	165.83	121.1	-19.0	127-18-4
Chlorobenzene (Phenyl chloride)	C_6H_5Cl	112.56	132.0	-45.6	108-90-7
Ethylbenzene	$C_6H_5C_2H_5$	106.17	136.2	-95.0	100-41-4
m-Xylene (1,3-Dimethylbenzene)	$1,3-(CH_3)_2C_6H_4$	106.17	139.1	-47.9	
p-Xylene (1,4-Dimethylxylene)	$1,4-(CH_3)_2C_6H_4$	106.17	138.3	13.3	
Styrene (Vinyl benzene)	$C_6H_5CH=CH_2$	104.16	145.2	-30.6	100-42-5
1,1,2,2-Tetrachloroethane	$CHCl_2CHCl_2$	167.85	146.2	-36.0	79-34-5
o-Xylene (1,2-Dimethylbenzene)	$1,2-(CH_3)_2C_6H_4$	106.17	144.4	-25.2	
1,3,5-Trimethylbenzene (Mesitylene)	$1,3,5-(CH_3)_3C_6H_6$	120.20	164.7	-44.7	108-67-8
1,2,4-Trimethylbenzene (Pseudocumene)	$1,2,4-(CH_3)_3C_6H_6$	120.20	169.3	-43.8	95-63-6
m-Dichlorobenzene (1,3-Dichlorobenzene)	$1,3-Cl_2C_6H_4$	147.01	173.0	-24.7	541-73-1
Benzyl chloride (α-Chlorotoluene)	$C_6H_5CH_2Cl$	126.59	179.3	-39.0	100-44-7
o-Dichlorobenzene (1,2-Dichlorobenzene)	$1,2-Cl_2C_6H_4$	147.01	180.5	-17.0	95-50-1
p-Dichlorobenzene (1,4-Dichlorobenzene)	$1,4-Cl_2C_6H_4$	147.01	174.0	53.1	106-46-7
1,2,4-Trichlorobenzene	$1,2,4-Cl_3C_6H_3$	181.45	213.5	17.0	120-82-1
Hexachlorobutadiene (1,1,2,3,4,4-Hexachloro-1,3-butadiene)					

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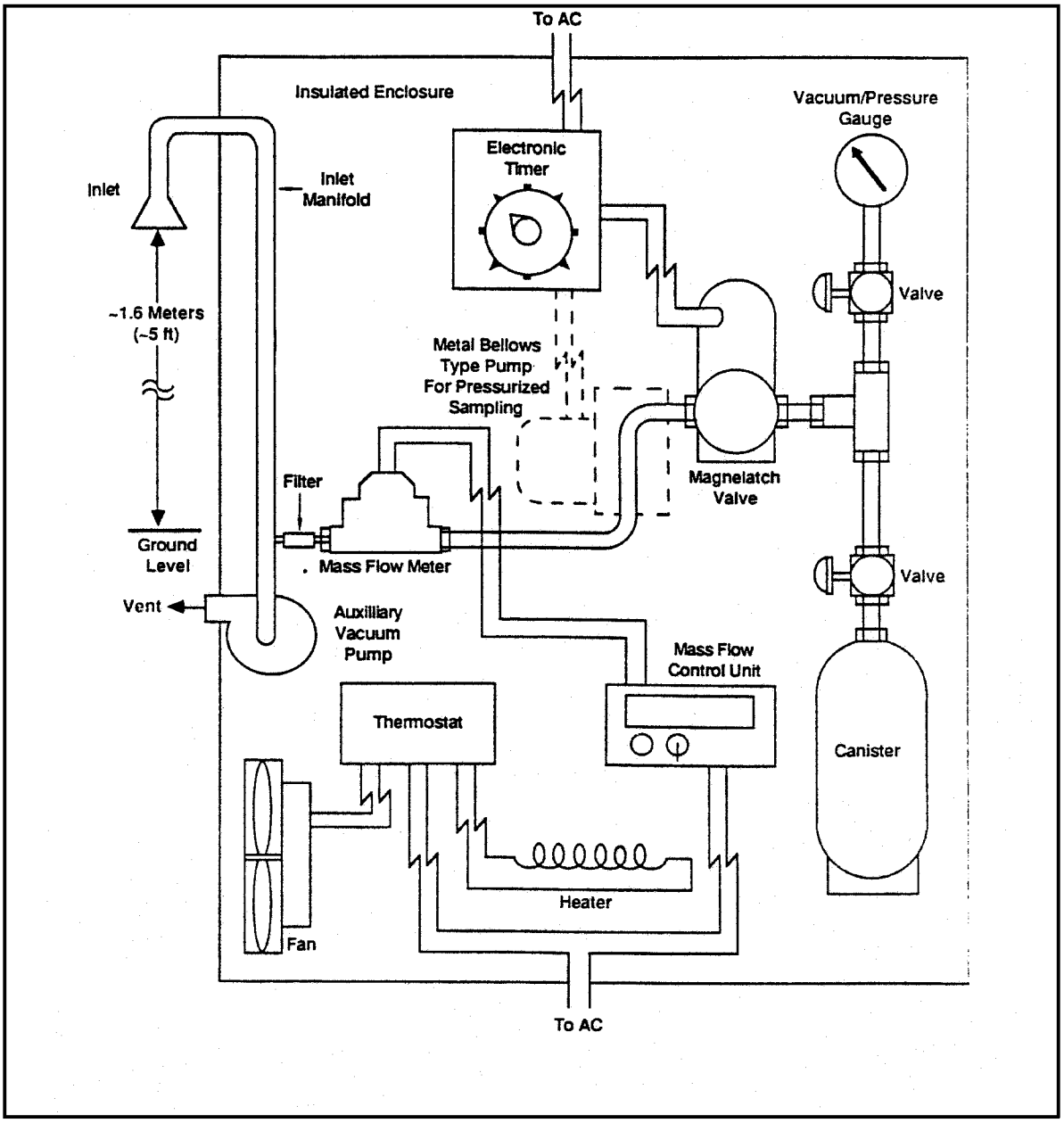
APPENDIX B

FIGURE 1. Subatmospheric/Pressurized Sampling Equipment



APPENDIX C

Canister Sampling Field Data Sheet

Page ___ of ___

SUMMA AIR SAMPLING WORK SHEET

Site: _____ Site#: _____
Samplers: _____ Work Assignment Manager: _____
Date: _____ Project Leader: _____

Sample #					
Location					
SUMMA ID					
Orifice Used					
Analysis/Method					
Time (Start)					
Time (Stop)					
Total Time					
SUMMA WENT TO AMBIENT	YES/NO	YES/NO	YES/NO	YES/NO	YES/NO
Pressure Gauge					
Pressure Gauge					
Flow Rate (Pre)					
Flow Rate (Post)					
Flow Rate (Average)					

MET Station On-site? Y / N

General Comments:

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U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

MANUAL WATER LEVEL MEASUREMENTS

CONTENTS

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- A - Groundwater Level Data Form

SUPERCEDES: SOP #2043; Revision 0.0; 10/03/94; U.S. EPA Contract 68-C4-0022.

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MANUAL WATER LEVEL MEASUREMENTS

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1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water and separate phase chemical product (i.e., gasoline, oil, PCE, TCE) in an open borehole, cased borehole, monitor well, or piezometer. These standard operating procedures may be varied or changed as required, dependent on site conditions , and equipment limitations. In all instances, the actual procedures employed will be documented and described in an appropriate site report. Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

Generally, water-level measurements taken in boreholes, piezometers, or monitor wells are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics. Therefore, all water level measurements at a given site should preferably be collected within a 24 hour period. However, certain situations may produce rapidly changing groundwater levels that necessitate taking measurements as close in time as possible. Large changes in water levels among wells may be indicative of such a condition . Rapid groundwater level changes may occur due to:

- Atmospheric pressure changes
- Tidal influences
- Changes in river stage, impoundments levels, or flow in unlined ditches
- Pumping of nearby wells
- Precipitation

2.0 METHOD SUMMARY

A survey mark should be placed on the top of the riser pipe or casing as a reference point for groundwater level measurements. If the lip of the riser pipe is not flat, the reference point may be located on the grout apron or the top of the outer protective casing (if present). The measurement reference point should be documented in the site logbook and on the groundwater level data form (Appendix A), if used. All field personnel must be made aware of the measurement reference point being used in order to ensure the collection of comparable data.

Before measurements are made, water levels in piezometers and monitor wells should be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to equilibrium may take longer. All measurements should be made to an accuracy of 0.01 feet. Water level measuring equipment must be decontaminated and, in general, measurements should proceed from the least to the most contaminated wells.

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Open the well and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds. For electrical sounders lower the device into the well until the water surface is reached as indicated by a tone or meter deflection. Record the distance from the water surface to the reference point. Measurement with a chalked tape will necessitate lowering the tape below the water level and holding a convenient foot marker at the reference point. Record both the water level as indicated on the chalked tape section and the depth mark held at the reference point The depth to water is the difference between the two readings. Remove measuring device, replace riser pipe cap, and decontaminate equipment as necessary. Note that if a separate phase is present, an oil/water indicator probe is required for measurement of product thickness and water level.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this standard operating procedure (SOP).

4.0 POTENTIAL PROBLEMS

1. Cascading water, particularly in open-hole or rock wells, may interfere with the measurement.

2. Some older types of electric sounders are only marked at five-foot intervals. A surveyor's tape is necessary to extrapolate between the 5-foot marks.

3. Oil or other product floating on the water column can insulate the contacts of the probe on an electric sounder and give false readings. For accurate level measurements in wells containing floating product, a special oil/water level indicator is required.

4. Tapes (electrical or surveyor's) may have damaged or missing sections, or may be spliced inaccurately.

5. An airline may be the only available means to make measurements in sealed production wells but the method is generally accurate only to approximately 0.2 foot.

6. When using a steel tape, it is necessary to lower the tape below the water level in order to make a measurement. This assumes knowledge of the approximate groundwater level.

5.0 EQUIPMENT

The electric water level indicator and the chalked steel tape are the devices commonly used to measure water levels. Both have an accuracy of 0.01 feet. Other field equipment may include:

- Air monitoring instrumentation

- Well depth measurement device
- Chalk
- Ruler
- Site logbook
- Paper towels and trash bags
- Decontamination supplies as outlined in Section 7.2 or the current approved site specific work plan
- Groundwater level data forms

6.0 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required, refer to ERT/REAC SOP #2006 Rev 0.0 08/11/94, *Sampling Equipment Decontamination*, and the current approved site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Determine the number of measurements needed, the methods to be employed, and the equipment and supplies needed.
2. Decontaminate or pre-clean equipment, and ensure that it is in working order.
3. Coordinate schedule with staff, clients, and regulatory agency, if appropriate.
4. If this is an initial visit, perform a general site survey prior to site entry in accordance with the current approved site specific Health and Safety Plan.
5. Identify sampling locations.

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7.2 Procedures

Procedures for determining water levels are as follows:

1. If possible, and when applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated.

2. Clean all the equipment entering the well(s) by the following decontamination procedure:

   - Triple rinse equipment with deionized water.
   - Wash equipment with an Alconox solution which is followed by a deionized water rinse.
   - Rinse with an approved solvent (e.g., methanol, isopropyl alcohol, acetone) as per the work plan, if organic contamination is suspected.
   - Place equipment on clean surface such as a teflon or polyethylene sheet to air dry.

3. Remove locking well cap, note well ID, time of day, and date in site logbook or an appropriate groundwater level data form.

4. Remove well cap.

5. If required by site-specific condition, monitor headspace of well with a photoionization detector (PID) or flame ionization detector (FID) to determine presence of volatile organic compounds, and record results in site logbook.

7. Lower water-level measuring device into the well. Electrical tapes are lowered to the water surface whereas chalked steel tapes are lowered generally a foot or more below the water surface. Steel tapes are generally chalked so that a 1-to 5-foot long section will fall below the expected water level.

8. For electrical tapes record the distance from the water surface, as determined by the audio signal or meter, to the reference measuring point and record in the site logbook. For chalked tapes, an even foot mark is held at the reference point, once the chalked section of the tape is below the water level. Both the water level on the tape and the foot mark held at the reference point is recorded. The depth to the water is then the difference between the two readings. In addition, note the reference point used (top of the outer casing, top of the riser pipe, ground surface, or some other reproducible position

on the well head). Repeat the measurement.

9. Remove all downhole equipment, replace well cap and locking steel caps.

10. Rinse all downhole equipment and store for transport to the next well. Decontaminate all equipment as outlined in Step 2 above.

11. Note any physical changes, such as erosion or cracks in protective concrete pad or variation in total depth of well, in field logbook or on groundwater level data form.

8.0 CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation:

$$E_W = E - D$$

where:

E_W	=	Elevation of water above mean sea level (feet) or local datum
E	=	Elevation above sea level or local datum at point of measurement (feet)
D	=	Depth to water (feet)

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented on field data sheets, groundwater level data forms, or within personal or site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan.

3. Each well should be tested at least twice in order to compare results. If results do not agree to within 0.02 feet, a third measurement should be taken and the readings averaged. Consistent failure of consecutive readings to agree suggests that levels are changing because of one or more conditions as indicated in Section 1.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

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11.0 HEALTH AND SAFETY

The results of monitoring the well head and breathing zone with a FID or PID, as per section 7.2, may indicate the need to upgrade the personal protection level according to the current approved site Health and Safety Plan.

12.0 REFERENCES

Driscoll, F.G. 1986. Groundwater and Wells. Second Edition. Chapter 16. *Collection and Analysis of Pumping Test Data*. pp 534-579. Johnson Filtration Systems Inc. St. Paul, Minnesota.

U.S. Environmental Protection Agency, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document, pp. 207.

U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods. EPA/540/p-87/001 Office of Emergency and Remedial Response Washington, D.C. 20460.

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APPENDIX A
Groundwater Level Data Form
SOP #2043
February 2000

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MANUAL WATER LEVEL MEASUREMENTS

FORM 1. Groundwater Level Data Form

PAGE __ OF __

SITE NAME:_____ LOGGER NAME: _____

LOG DATE: _____ WBS #: RIA _____

Well I.D.	Time	Elevation of well[1] (T.O.C.)	Depth to bottom of well (ft)	Depth to water (ft)	Depth to product (ft)	COMMENTS (pH, temperature, specific conductance)

TOC: top of casing (1) feet above mean sea level

MEASUREMENT REFERENCE POINT FROM __ GROUND SURFACE OR __ TOP OF CASING

Weather Conditions: Temperature(°C):_____ Rain: Heavy Medium Light (Circle one)

Other significant observations:

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) is applicable to the collection of representative sediment samples. Analysis of sediment may be biological, chemical, or physical in nature and may be used to determine the following:

- toxicity;
- biological availability and effects of contaminants;
- benthic biota;
- extent and magnitude of contamination;
- contaminant migration pathways and source;
- fate of contaminants;
- grain size distribution.

The methodologies discussed in this SOP are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by site conditions and equipment limitations. However, if modifications occur, they should be documented in a site or personal logbook and discussed in reports summarizing field activities and analytical results.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static, as in lakes, ponds, and impoundments; or flowing, as in rivers and streams.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Sediment samples may be collected using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface vs. subsurface), the type of sample required (disturbed vs. undisturbed), contaminants present, and sediment type.

Sediment is collected from beneath an aqueous layer either directly, using a hand held device such as a shovel, trowel, or auger; or indirectly, using a remotely activated device such as an Ekman or Ponar dredge. Following collection, sediment is transferred from the sampling device to a sample container of appropriate size and construction for the analyses requested. If composite sampling techniques are employed, multiple grabs are placed into a container constructed of inert material, homogenized, and transferred to sample containers appropriate for the analyses requested. The homogenization procedure should not be used if sample analysis includes volatile organics; in this case, sediment, or multiple grabs of sediment, should be transferred directly from the sample collection device or homogenization container to the sample container.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

1. Chemical preservation of solids is generally not recommended. Cooling to 4ºC is usually the best approach, supplemented by the appropriate holding time for the analyses requested.

2. Wide mouth glass containers with Teflon lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the Work Plan.

3. If analysis of sediment from a discrete depth or location is desired, sediment is transferred directly from the sampling device to a labeled sample container(s) of appropriate size and construction for the analyses

requested. Transfer is accomplished with a stainless steel or plastic lab spoon or equivalent.

4. If composite sampling techniques or multiple grabs are employed, equal portions of sediment from each location are deposited into a stainless steel, plastic, or other appropriate composition (e.g., Teflon) containers. The sediment is homogenized thoroughly to obtain a composite representative of the area sampled. The composite sediment sample is transferred to a labeled container(s) of appropriate size and construction for the analyses requested. Transfer of sediment is accomplished with a stainless steel or plastic lab spoon or equivalent. Samples for volatile organic analysis must be transferred directly from the sample collection device or pooled from multiple areas in the homogenization container prior to mixing. This is done to minimize loss of contaminant due to volatilization during homogenization.

5. All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampling device should remain in this wrapping until it is needed. Each sampling device should be used for only one sample. Disposable sampling devices for sediment are generally impractical due to cost and the large number of sediment samples which may be required. Sampling devices should be cleaned in the field using the decontamination procedure described in the Sampling Equipment Decontamination SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Substrate particle size and organic matter content are a direct consequence of the flow characteristics of a waterbody. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic matter content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic matter content do not typically concentrate pollutants and are generally found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results and should be justified and specified in the Work Plan.

5.0 EQUIPMENT/APPARATUS

Equipment needed for collection of sediment samples may include:

- Maps/plot plan
- Safety equipment
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Camera and film
- Stainless steel, plastic, or other appropriate composition bucket
- 4-oz., 8-oz., and one-quart wide mouth jars w/Teflon lined lids
- Ziploc plastic bags
- Logbook
- Sample jar labels
- Chain of Custody records, field data sheets
- Cooler(s)
- Ice
- Decontamination supplies/equipment
- Spade or shovel
- Spatula
- Scoop
- Trowel
- Bucket auger
- Tube auger
- Extension rods
- "T" handle
- Sediment coring device (tube, drive head, eggshell check value, nosecone, acetate tube, extension rods, "T" handle)
- Ponar dredge
- Ekman dredge
- Nylon rope or steel cable
- Messenger device

6.0 REAGENTS

Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

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7.0 PROCEDURES

7.1 Preparation

1. Determine the objective(s) and extent of the sampling effort. The sampling methods to be employed, and the types and amounts of equipment and supplies required will be a function of site characteristics and objectives of the study.

2. Obtain the necessary sampling and monitoring equipment.

3. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

4. Decontaminate or preclean equipment, and ensure that it is in working order.

5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, contaminant source, and extent and nature of contamination should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

7.2 Sample Collection

Selection of a sampling device is most often contingent upon: (1) the depth of water at the sampling location, and (2) the physical characteristics of the sediment to be sampled. The following procedures may be utilized:

7.2.1 Sampling Surface Sediment with a Trowel or Scoop from Beneath a Shallow Aqueous Layer

For the purpose of this method, surface sediment is considered to range from 0 to six inches in depth and a shallow aqueous layer is considered to range from 0 to 12 inches in depth. Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with tools such as spades, shovels, trowels, and scoops. Although this method can be used to collect both unconsolidated/consolidated sediment, it is limited somewhat by the depth and movement of the aqueous layer. Deep and rapidly flowing water render this method less accurate than others discussed below. However, representative samples can be collected with this procedure in shallow sluggish water provided care is demonstrated by the sample team member. A stainless steel or plastic sampling implement will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials; plating is particularly common with garden trowels.

The following procedure will be used to collect sediment with a scoop, shovel, or trowel:

1. Using a decontaminated sampling implement, remove the desired thickness and volume of sediment from the sampling area.

2. Transfer the sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.

3. Surface water should be decanted from the sample or homogenization container prior to sealing or transfer; care should be taken to retain the fine sediment fraction during this procedure.

7.2.2 Sampling Surface Sediment with a Bucket Auger or Tube Auger from Beneath a Shallow Aqueous Layer

For the purpose of this method, surface sediment is considered to range from 0 to six inches in depth and a shallow aqueous layer is considered to range from 0 to 24 inches in depth. Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of bucket auger or tube auger, a series of extensions, and a "T" handle (Figure 1, Appendix A). The use of additional extensions in conjunction with a bucket auger can increase the depth of water from which sediment can be collected from 24 inches to 10 feet or more. However, sample handling and manipulation increases

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in difficulty with increasing depth of water. The bucket auger or tube auger is driven into the sediment and used to extract a core. The various depths represented by the core are homogenized or a subsample of the core is taken from the appropriate depth.

The following procedure will be used to collect sediment samples with a bucket auger or tube auger:

1. An acetate core may be inserted into the bucket auger or tube auger prior to sampling if characteristics of the sediments or waterbody warrant. By using this technique, an intact core can be extracted.

2. Attach the auger head to the required length of extensions, then attach the "T" handle to the upper extension.

3. Clear the area to be sampled of any surface debris.

4. Insert the bucket auger or tube auger into the sediment at a 0º to 20º angle from vertical. This orientation minimizes spillage of the sample from the sampler upon extraction from the sediment and water.

5. Rotate the auger to cut a core of sediment.

6. Slowly withdraw the auger; if using a tube auger, make sure that the slot is facing upward.

7. Transfer the sample or a specified aliquot of sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.

7.2.3 Sampling Deep Sediment with a Bucket Auger or Tube Auger from Beneath a Shallow Aqueous Layer

For the purpose of this method, deep sediment is considered to range from six to greater than 18 inches in depth and a shallow aqueous layer is considered to range from 0 to 24 inches. Collection of deep sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of a bucket auger, a tube auger, a series of extensions and a "T" handle. The use of additional extensions can increase the depth of water from which sediment can be collected from 24 inches to five feet or more. However, water clarity must be high enough to permit the sampler to directly observe the sampling operation. In addition, sample handling and manipulation increases in difficulty with increasing depth of water. The bucket auger is used to bore a hole to the upper range of the desired sampling depth and then withdrawn. The tube auger is then lowered down the borehole, and driven into the sediment to the lower range of the desired sampling depth. The tube is then withdrawn and the sample recovered from the tube. This method can be used to collect firmly consolidated sediments, but is somewhat limited by the depth of the aqueous layer, and the integrity of the initial borehole.

The following procedure will be used to collect deep sediment samples with a bucket auger and a tube auger:

1. Attach the bucket auger bit to the required lengths of extensions, then attach the "T" handle to the upper extension.

2. Clear the area to be sampled of any surface debris.

3. Begin augering, periodically removing any accumulated sediment (i.e., cuttings) from the auger bucket. Cuttings should be disposed of far enough from the sampling area to minimize cross contamination of various depths.

4. After reaching the upper range of the desired depth, slowly and carefully remove bucket auger from the boring.

5. Attach the tube auger bit to the required lengths of extensions, then attach the "T" handle to the upper extension.

6. Carefully lower tube auger down borehole using care to avoid making contact with the borehole sides and, thus, cross contaminating the sample. Gradually force tube auger into sediment to the lower range of the desired sampling depth. Hammering of the tube auger to facilitate coring should be avoided as the vibrations may cause the boring walls

to collapse.

7. Remove tube auger from the borehole, again taking care to avoid making contact with the borehole sides and, thus, cross contaminating the sample.

8. Discard the top of core (approximately 1 inch); as this represents material collected by the tube auger before penetration to the layer of concern.

9. Transfer sample into an appropriate sample or homogenization container. Ensure that non-dedicated containers have been adequately decontaminated.

7.2.4 Sampling Surface Sediment with an Ekman or Ponar Dredge from Beneath a Shallow or Deep Aqueous Layer

For the purpose of this method, surface sediment is considered to range from 0 to six inches in depth. Collection of surface sediment can be accomplished with a system consisting of a remotely activated device (dredge) and a deployment system. This technique consists of lowering a sampling device (dredge) to the surface of the sediment by use of a rope, cable, or extended handle. The mechanism is activated, and the device entraps sediment in spring loaded or lever operated jaws.

An Ekman dredge is a lightweight sediment sampling device with spring activated jaws. It is used to collect moderately consolidated, fine textured sediment. The following procedure will be used for collecting sediment with an Ekman dredge (Figure 2, Appendix A):

1. Attach a sturdy nylon rope or stainless steel cable through the hole on the top of the bracket, or secure the extension handle to the bracket with machine bolts.

2. Attach springs to both sides of the jaws. Fix the jaws so that they are in open position by placing trip cables over the release studs. Ensure that the hinged doors on the dredge top are free to open.

3. Lower the sampler to a point 4 to 6 inches above the sediment surface.

4. Drop the sampler to the sediment.

5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extension handle.

6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Care should be taken to retain the fine sediment fraction during this procedure.

7. Open the dredge jaws and transfer the sample into a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment grabs until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenize and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

A Ponar dredge is a heavyweight sediment sampling device with weighted jaws that are lever or spring activated. It is used to collect consolidated fine to coarse textured sediment. The following procedure will be used for collecting sediment with a Ponar dredge (Figure 3, Appendix A):

1. Attach a sturdy nylon rope or steel cable to the ring provided on top of the dredge.

2. Arrange the Ponar dredge with the jaws in the open position, setting the trip bar so the sampler remains open when lifted from the top. If the dredge is so equipped, place the spring loaded pin into the aligned holes in the trip bar.

3. Slowly lower the sampler to a point approximately two inches above the sediment.

4. Drop the sampler to the sediment. Slack on

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the line will release the trip bar or spring loaded pin; pull up sharply on the line closing the dredge.

5. Raise the dredge to the surface and slowly decant any free liquid through the screens on top of the dredge. Care should be taken to retain the fine sediment fraction during this operation.

6. Open the dredge and transfer the sediment to a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenized and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

7.2.5 Sampling Subsurface Sediment with a Coring Device from Beneath a Shallow Aqueous Layer

For purposes of this method, subsurface sediment is considered to range from 6 to 24 inches in depth and a shallow aqueous layer is considered to range from 0 to 24 inches in depth. Collection of subsurface sediment from beneath a shallow aqueous layer can be accomplished with a system consisting of a tube sampler, acetate tube, eggshell check valve, nosecone, extensions, and "T" handle, or drivehead. The use of additional extensions can increase the depth of water from which sediment can be collected from 24 inches to 10 feet or more. This sampler may be used with either a drive hammer for firm sediment, or a "T" handle for soft sediment. However, sample handling and manipulation increases in difficulty with increasing depth of water.

The following procedure describes the use of a sample coring device (Figure 4, Appendix A) used to collect subsurface sediments.

1. Assemble the coring device by inserting the acetate core into the sampling tube.

2. Insert the "egg shell" check valve into the lower end of the sampling tube with the convex surface positioned inside the acetate core.

3. Screw the nosecone onto the lower end of the sampling tube, securing the acetate tube and eggshell check valve.

4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.

5. Place the sampler in a perpendicular position on the sediment to be sampled.

6. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. After the desired depth is reached, rotate the sampler to shear off the core at the bottom. Slowly withdraw the sampler from the sediment and proceed to Step 15.

7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.

8. Drive the sampler into the sediment to the desired depth.

9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.

10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.

11. Rotate the sampler to shear off the core at the bottom.

12. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90°.

13. Slowly withdraw the sampler from the sediment. If the drivehead was used, pull the hammer upwards and dislodge the sampler from the sediment.

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14. Carefully remove the coring device from the water.

15. Unscrew the nosecone and remove the eggshell check valve.

16. Slide the acetate core out of the sampler tube. Decant surface water, using care to retain the fine sediment fraction. If head space is present in the upper end, a hacksaw may be used to shear the acetate tube off at the sediment surface. The acetate core may then be capped at both ends. Indicate on the acetate tube the appropriate orientation of the sediment core using a waterproof marker. The sample may be used in this fashion, or the contents transferred to a sample or homogenization container.

17. Open the acetate tube and transfer the sediment to a stainless steel, plastic or other appropriate composition (e.g., Teflon) container. Ensure that non-dedicated containers have been adequately decontaminated. If necessary, continue to collect additional sediment until sufficient material has been secured to fulfill analytical requirements. Thoroughly homogenize and then transfer sediment to sample containers appropriate for the analyses requested. Samples for volatile organic analysis must be collected directly from the bucket before homogenization to minimize volatilization of contaminants.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA/OSHA and Corporate health and safety procedures.

More specifically, when sampling sediment from waterbodies, physical hazards must be identified and adequate precautions must be taken to ensure the safety of the sampling team. The team member collecting the sample should not get too close to the edge of the waterbody, where bank failure may cause loss of balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is determined to be necessary, appropriate protective measures must be implemented.

12.0 REFERENCES

Mason, B.J., Preparation of Soil Sampling Protocol: Technique and Strategies. 1983 EPA-600/4-83-020.

Barth, D.S. and B.J. Mason, Soil Sampling Quality Assurance User's Guide. 1984 EPA-600/4-84-043.

U.S. EPA. Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. 1984 EPA-600/4-84-076.

de Vera, E.R., B.P. Simmons, R.D. Stephen, and D.L. Storm. Samplers and Sampling Procedures for Hazardous Waste Streams. 1980 EPA-600/2-80-018.

US EPA ARCHIVE DOCUMENT

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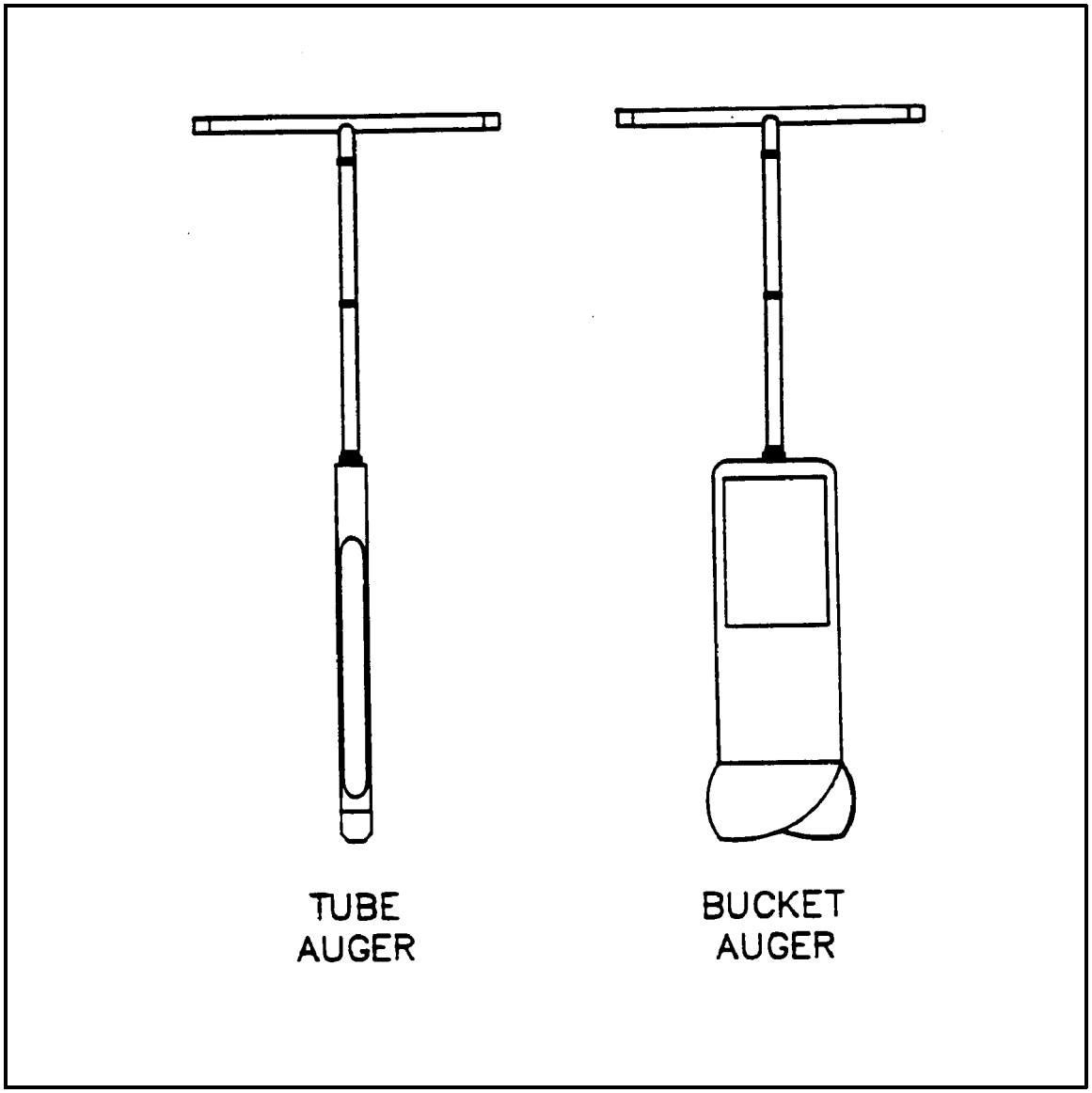
APPENDIX A

Figures

FIGURE 1. Sampling Auger

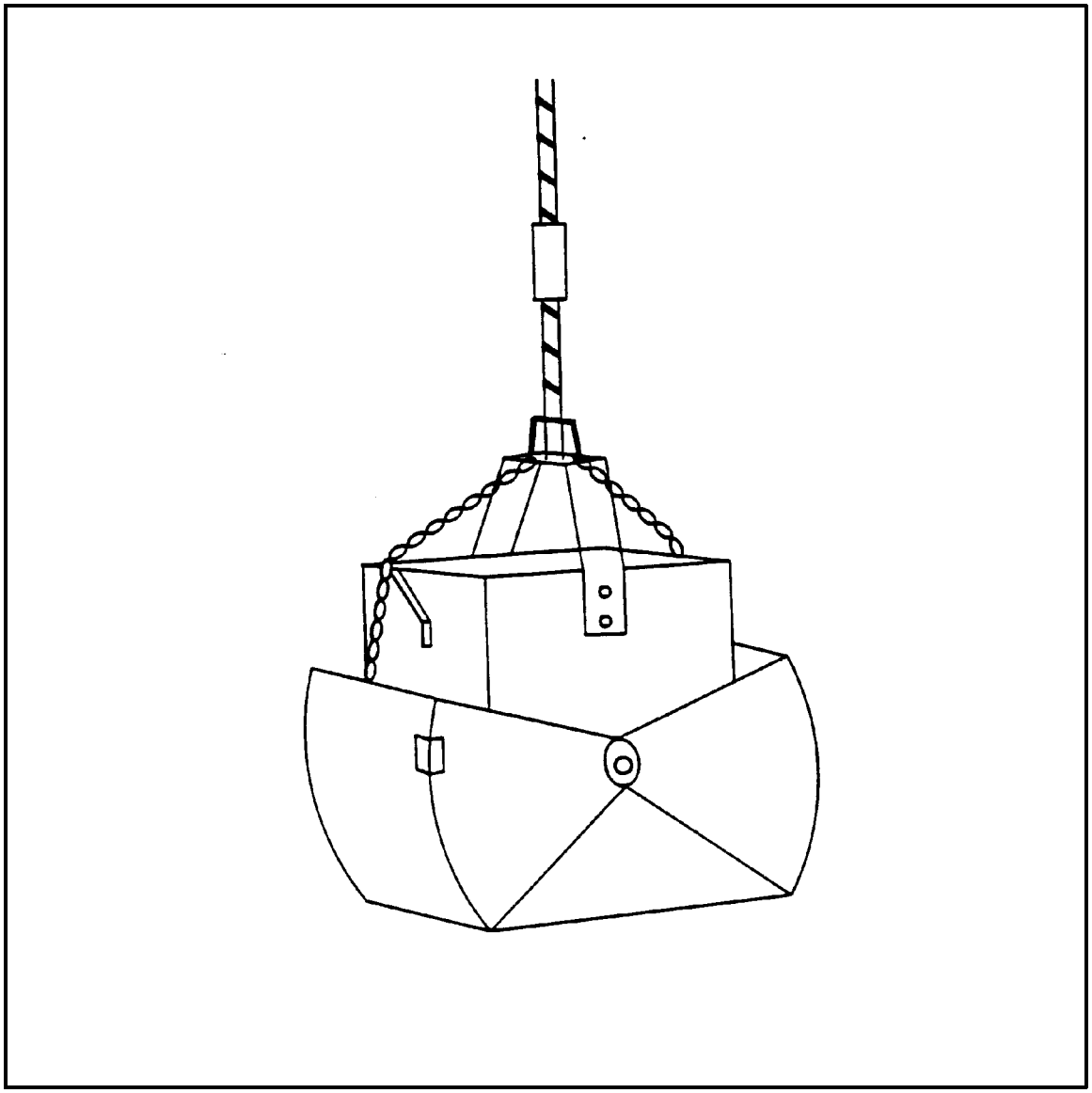


US EPA ARCHIVE DOCUMENT

APPENDIX A (Cont'd)

Figures

FIGURE 2. Ekman Dredge

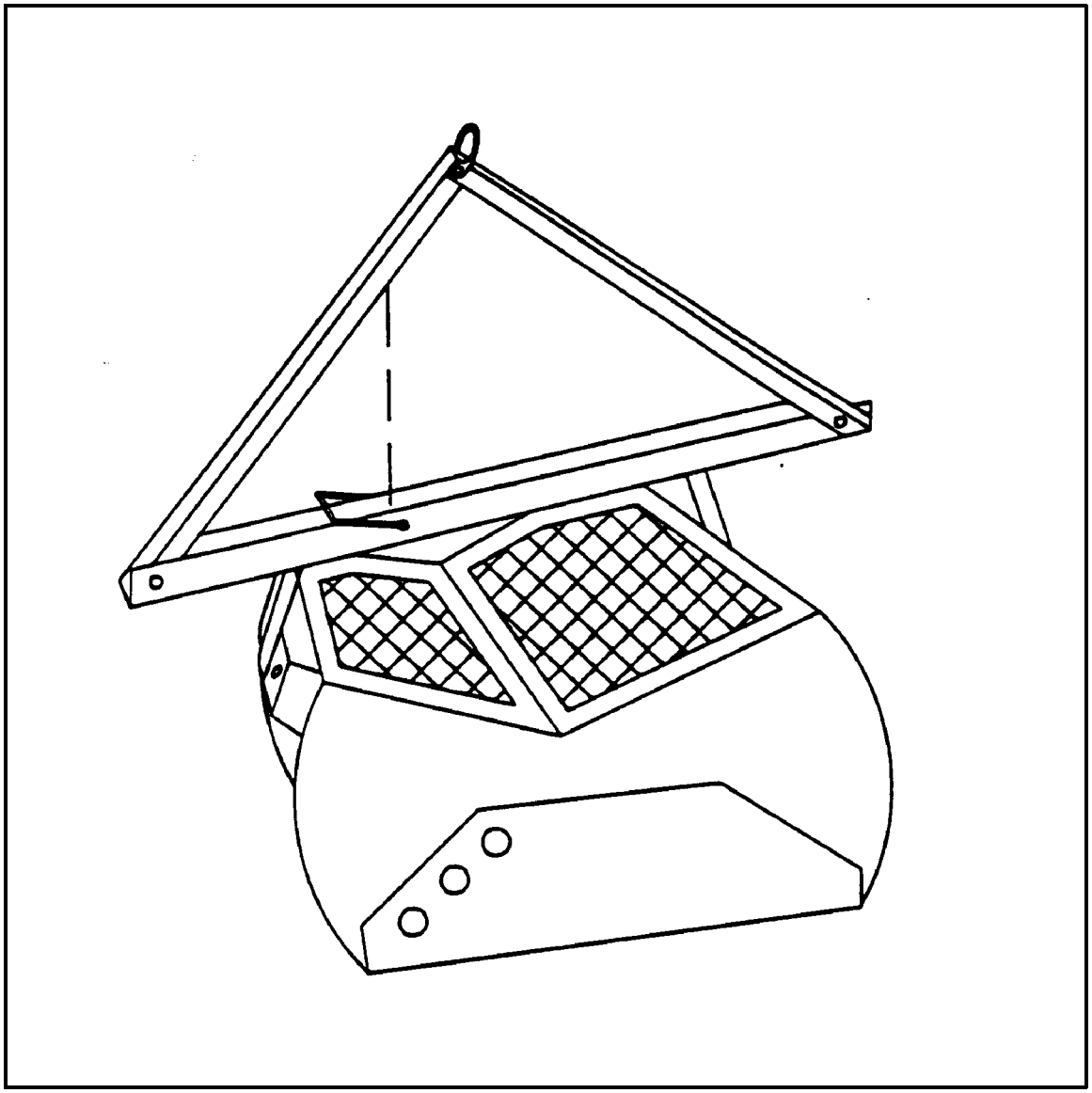


US EPA ARCHIVE DOCUMENT

APPENDIX A (Cont'd)

Figures

FIGURE 3. Ponar Dredge

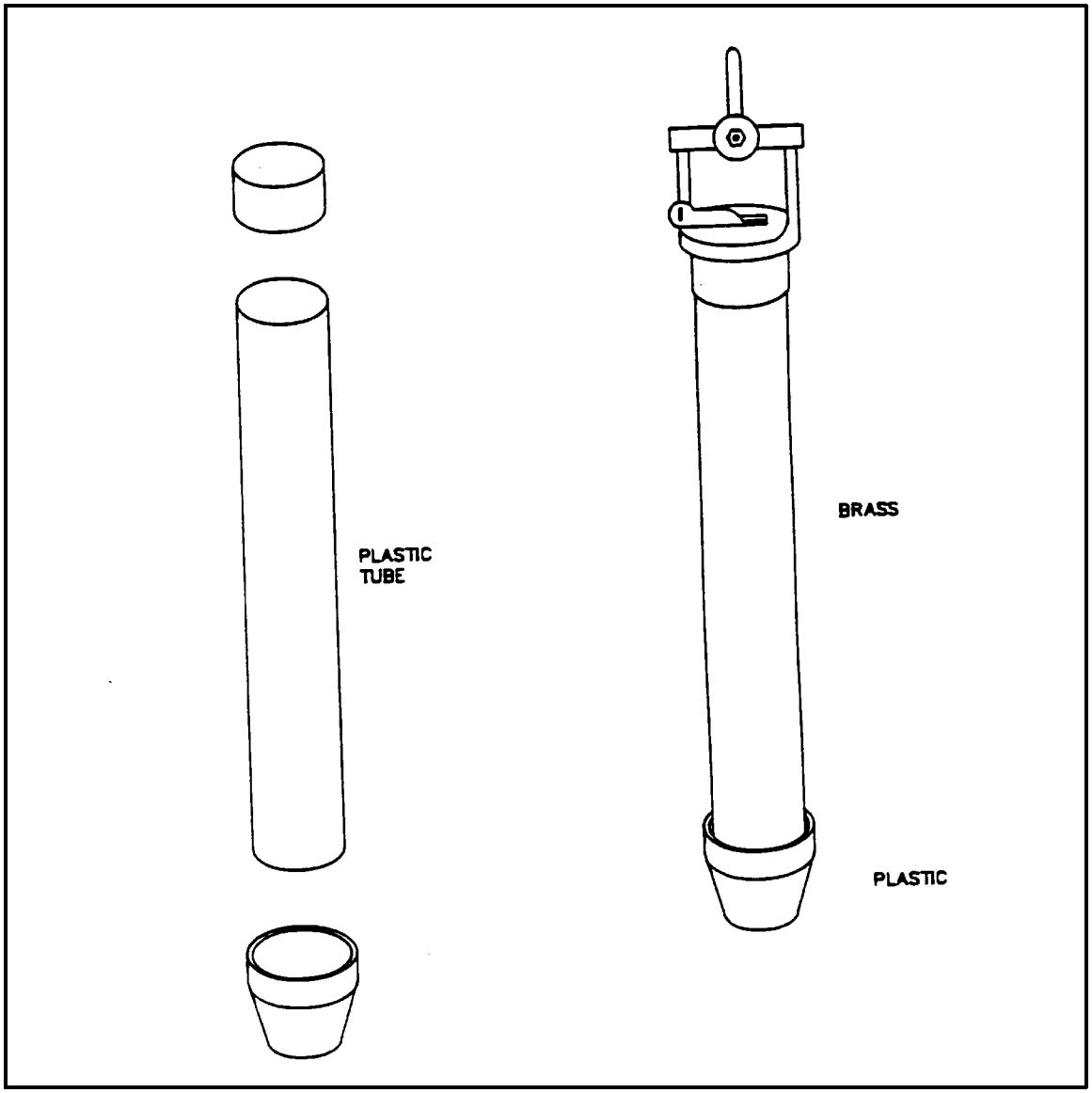


US EPA ARCHIVE DOCUMENT

APPENDIX A (Cont'd)

Figures

FIGURE 4. Sample Coring Device



US EPA ARCHIVE DOCUMENT

SURFACE WATER SAMPLING

SOP#: 2013
DATE: 11/17/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and non-aqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Sampling situations vary widely, therefore, no universal sampling procedure can be recommended. However, sampling of both aqueous and non-aqueous liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- Bacon bomb sampler
- Dip sampler
- Direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, the following procedure should be followed:

1. Transfer the sample(s) into suitable, labeled sample containers.

2. Preserve the sample if appropriate, or use pre-preserved sample bottles. Do not overfill bottles if they are pre-preserved.

3. Cap the container, place in a ziploc plastic bag and cool to 4°C.

4. Record all pertinent data in the site logbook and on field data sheets.

5. Complete the Chain of Custody record.

6. Attach custody seals to cooler prior to shipment.

7. Decontaminate all sampling equipment prior to the collection of additional samples with that sampling device.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross contamination of samples and improper sample collection.

1. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Sampling Equipment Decontamination SOP.

2. Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

5.0 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples may include (depending on technique chosen):

- Kemmerer bottles
- Bacon bomb sampler
- Dip sampler
- Line and messengers
- Sample bottles/preservatives
- Ziploc bags
- Ice
- Coolers
- Chain of Custody records, custody seals
- Field data sheets
- Decontamination equipment
- Maps/plot plan
- Safety equipment
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Camera and film
- Logbook/waterproof pen
- Sample bottle labels

6.0 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain the necessary sampling and monitoring equipment.

3. Decontaminate or pre-clean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. If required the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If collecting sediment samples, this procedure may disturb the bottom.

7.2 Representative Sampling Considerations

In order to collect a representative sample, the hydrology and morphometrics of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons, or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments, and to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist which would effect analytical results. Measurements should be collected at one-meter intervals from the substrate to the surface using the appropriate instrument (i.e., a Hydrolab or equivalent).

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Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths when surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

1. Will the sample be collected from shore or from a boat?

2. What is the desired depth at which you wish to collect the sample?

3. What is the overall depth and flow direction of river or stream?

4. What type of sample will be collected (i.e., water or lagoon liquids)?

7.2.1 Sampler Composition

The appropriate sampling device must be of a proper composition. Selection of samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be based upon the analyses to be performed.

7.3 Sample Collection

7.3.1 Kemmerer Bottle

A Kemmerer bottle (Figure 1, Appendix A) may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the sampling end pieces (upper and lower stoppers) are pulled away from the sampling tube (body), allowing the substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge from the bottom drain the first 10-20 mL to clear any potential contamination of the valve. Transfer the sample to the appropriate sample container.

7.3.2 Bacon Bomb Sampler

A bacon bomb sampler (Figure 2, Appendix A) may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.

2. Release the trigger line and retrieve the sampler.

3. Transfer the sample to the appropriate sample container by pulling up on the trigger.

7.3.3 Dip Sampler

A dip sampler (Figure 3, Appendix A) is useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Extend the device to the sample location and collect the sample by dipping the sampler into the substance.

3. Retrieve the sampler and transfer the sample to the appropriate sample container.

7.3.4 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface directly into the sample bottle. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate precautions must be taken to ensure the safety of sampling personnel. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him/her to lose his/her balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, appropriate boating safety procedures should be followed.

12.0 REFERENCES

U.S. Geological Survey. 1977. National Handbook or Recommended Methods for Water Data Acquisition. Office of Water Data Coordination Reston, Virginia. (Chapter Updates available).

U.S. Environmental Protection Agency. 1984. Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. EPA/600/4-84-076.

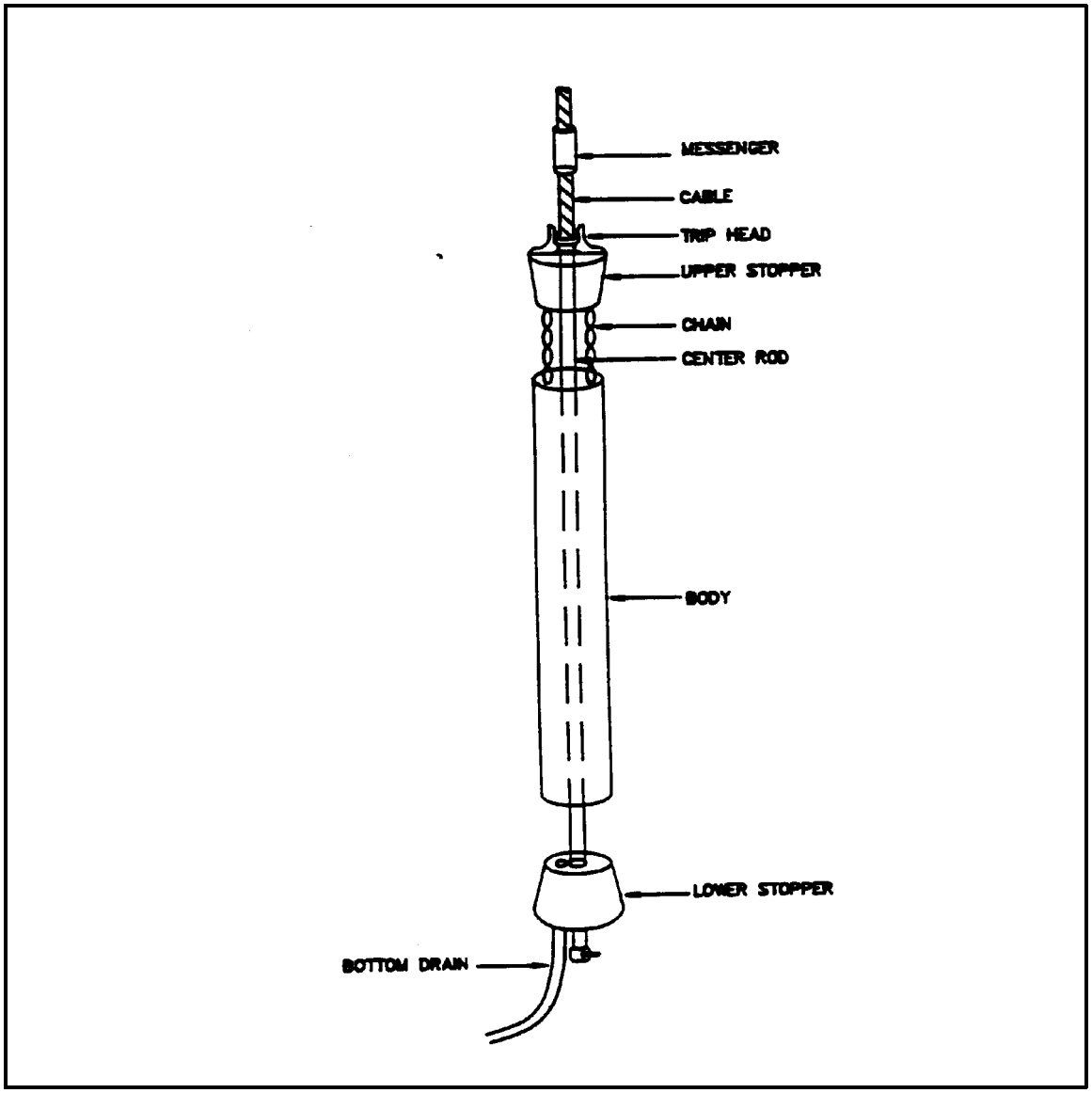
US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

APPENDIX A

Figures

FIGURE 1. Kemmerer Bottle



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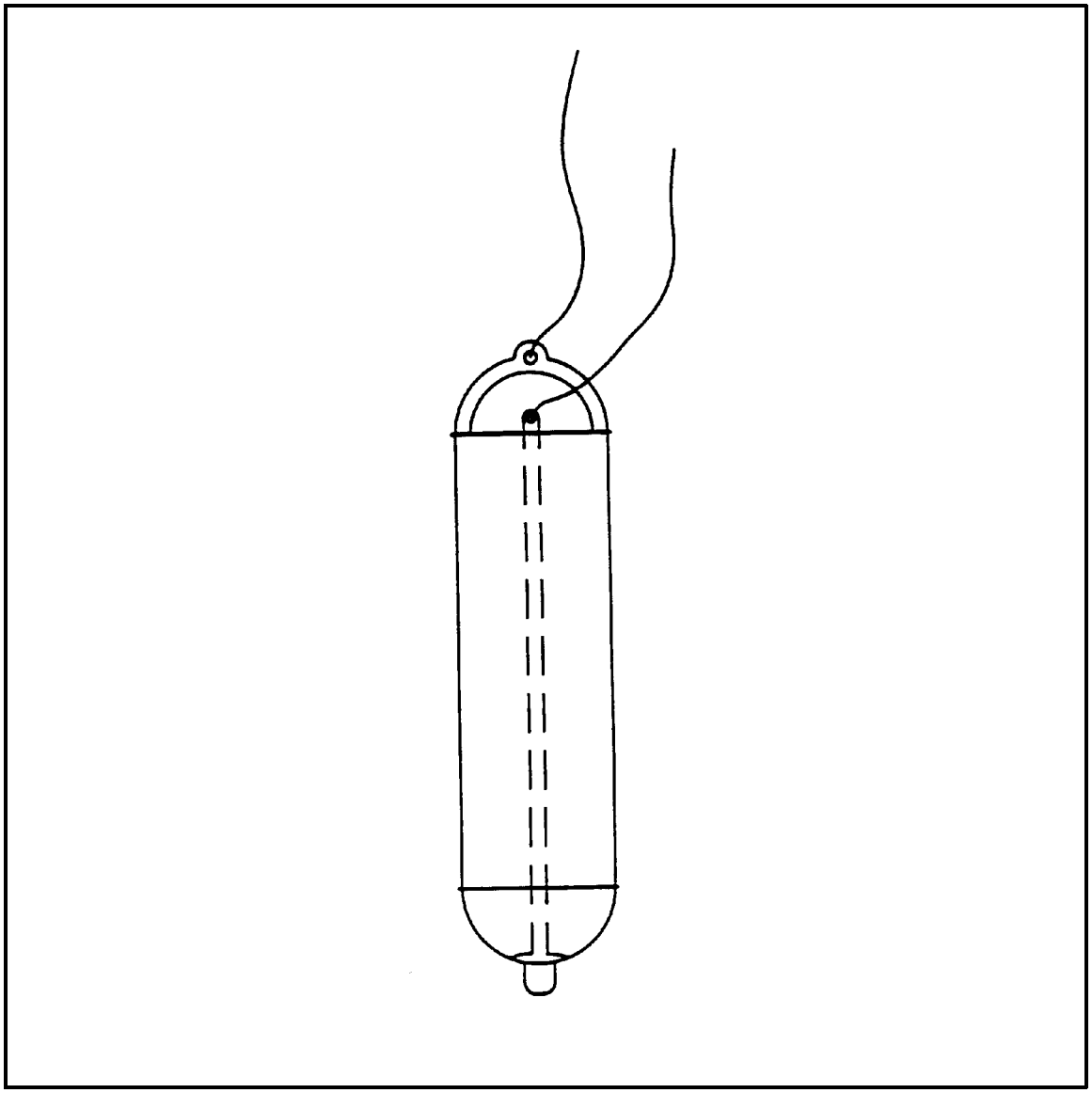
APPENDIX A (Cont'd)

Figures

FIGURE 2. Bacon Bomb Sampler

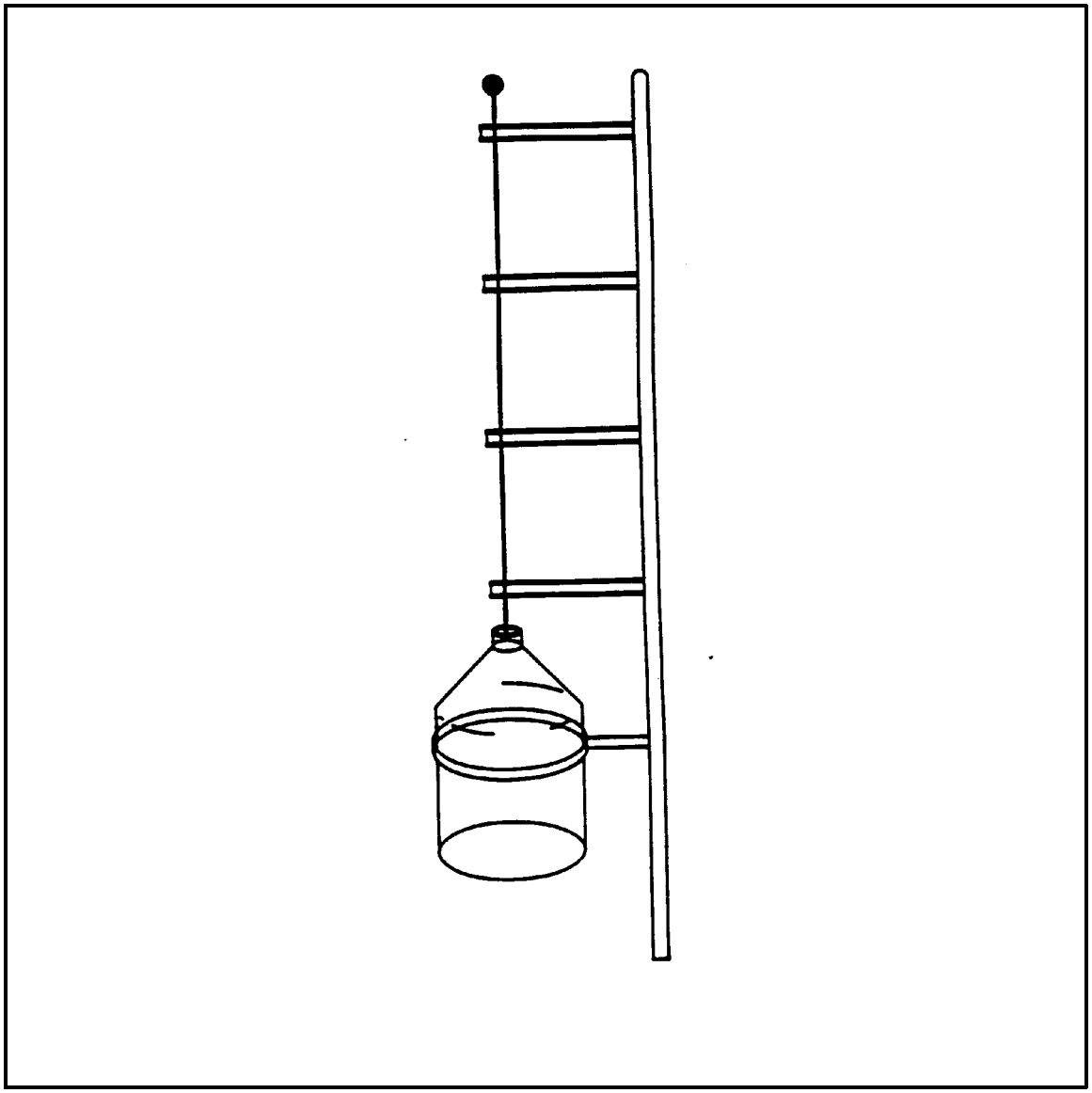


US EPA ARCHIVE DOCUMENT

APPENDIX A (Cont'd)

Figures

FIGURE 3. Dip Sampler



US EPA ARCHIVE DOCUMENT

ATTACHMENT 2

FIELD FORMS

US EPA ARCHIVE DOCUMENT

ATTACHMENT 2

FIELD FORMS

1. Well Development Log
2. Water Level Measurement Form
3. Groundwater Purging and Sampling Form
4. EPA Field Sheet
5. EPA COC
6. Soil Boring Log
7. Daily Health and Safety Meeting Record
8. Equipment Calibration Forms: PID, Horiba, turbidity meter, multi-reading meter, LEL/O2 meter, CO2, decibel meter
9. EQuIS Sample Field Sheet
10. Nonconformance Report
11. Photo Log
12. Slug Test Form
13. HGL COC

WELL DEVELOPMENT LOG	Well ID No.:	
Site: Garvey Elevator Site		Location: Hastings, Nebraska
Client: EPA	Contract/Delivery Order: EP-57-05-05	
A-E Contractor: HGL/CDM		Dev. Start (Date/Time):
Developed by:		Dev. End (Date/Time):
Casing Diameter:_____ (in)	Well Depth:_____ (ft)	Starting SWL:_____ (ft)
Water Column:_____ (ft)	Casing Volume:_____ (gal)	Total Volume to be Purged:_____ (gal)

Purge Volume Calculation:

Water Col. ____ ft (X) Csg. factor* ____ gal/ft (=) ____ gal/Csg. Vol. (X) ____ Csg. Vol to purge (=) ____

Total Volume To Be Purged (gal)

*Casing (Csg.) Factors: 2" Well Dia. = 0.16; 4" Well Dia. = 0.65; 6" Well Dia. = 1.47

Development Method: _____

Equipment: _____

Total quantity of water discharged:_____ (gal); Ending SWL:_____ (ft)**

Disposition of discharge water: _____

Time	Volume Removed (gal)	Water Level (ft)**	Turbidity (NTU)	Clarity/ Color	Temp (°C)	pH	Cond. (µmohs/cm) or (ms/cm)	Remarks (PID/FID Readings, etc.)

** Below top of casing (btoc)

US EPA ARCHIVE DOCUMENT

WELL DEVELOPMENT LOG	Well ID No.:
Site: Garvey Elevator Site	Site Location: Hastings, Nebraska

Time	Volume Water Removed	Water Level (ft)**	Turbidity (NTU)	Clarity/ Color	Temp (°C)	pH	Cond. (ms/cm)	Remarks (PID/FID Readings, etc.)

US EPA ARCHIVE DOCUMENT

HGL/CDM

MONITORING WELL WATER LEVEL DATA

Site: Garvey Elevator Site	Site Location: Hastings, Nebraska
Field Team:	

Measurement Point: ☐ BTOC ☐ BGS ☐ Other (specify) _____

Measurement Device: ☐ Water Level Detector ☐ Weighted Tape

☐ Other (specify) _____

Date	Time	Well ID	PID Reading (ppm)	Well Depth (ft.)	Well SWL (ft.)	Comments/ Weather

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LOW-FLOW GROUNDWATER SAMPLING LOG

Site Name: Garvey Elevator Site **Date:**_____ **OVM:** **FID** G **PID** G **In Casing (ppm):** **(Initial)** _____ **(Vented to)** atmosphere

Well ID: _____ **Purging/Sampling Device:** _____

Initial Static Water Level (feet btoc): _____ **Analytical Parameters:** _____

Final Water Level (feet btoc): _____ **QC Samples Collected:** _____

Purge Start Time: _____ **Sample Number:** _____

Sample Time: _____ **Controller Settings: Recharge:** _____**secs** **Discharge:** _____**secs** **Pressure:** _____**psi**

Samplers= Signatures: _____ **Cycles Per Minute:** _____

Time	Water Level (ft btoc)	Temperature (Degrees C)	pH	Specific Cond. (µs/cm)	Dissolved Oxygen (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (mL/min)	Comments

Casing Volume Calculations:
Water Col. X Casing Factor = Gallons per Casing Volume
Casing Factors: 2" diameter well: 0.16 / 4" diameter well: 0.65 / 6" diameter well: 1.47

PARAMETERS FOR WATER QUALITY STABILIZATION

Temperature	± 1° C	DO / Turbidity	± 10 %
pH	± 0.1 pH unit	ORP	± 10 mV
Conductivity	± 3 %	Water Level	± 0.3 feet

SAMPLE COLLECTION FIELD SHEET
U.S. Environmental Protection Agency Region VII
Kansas City, Kansas

ASR Number: **Sample Number:** ____ **QC Code:** ____ **Matrix:** **TAG ID:** ____ - ___ - ___

Activity Number: **Activity Leader:** Brian Zurbuchen

Activity Desc.: Remedial Investigation

Location: Hastings **State:** Nebraska **Type:** Superfund/Oil

Superfund Name: Garvey Elevator Site **Site ID:** **Site OU:**

Location Desc.:

External Sample Number:

Expected Concentration: Circle One: Low Medium High **Date** **Time (24 Hr)**

Latitude: ____° ____N ____O **Sample Collection:** **Start** ___/___/___ ___:___

Longitude: ____° ____N ____O **End** ___/___/___ ___:___

Laboratory Analyses:

Container	Preservative	Holding Time	Analysis
4-40ml VOA	4 Deg C, HCl to pH<2	14 Days	VOCs in Water by GC/MS for ***Low Detection Limits***

US EPA ARCHIVE DOCUMENT

Sample Comments:

Temperature (°C):_____

pH (SU):_____

Specific Conductivity (µs/cm): _____

ORP (mV): _____

D.O. (mg/L): _____

Turbidity (NTU):_____

Sample Collected By: _____

US EPA ARCHIVE DOCUMENT

CHAIN OF CUSTODY RECORD
ENVIRONMENTAL PROTECTION AGENCY REGION VII

ACTIVITY LEADER(Print)	NAME OF SURVEY OR ACTIVITY	DATE OF COLLECTION DAY MONTH YEAR	SHEET of

CONTENTS OF SHIPMENT

SAMPLE NUMBER	TYPE OF CONTAINERS CUBITAINER	BOTTLE	BOTTLE	BOTTLE	VOA SET (2 VIALS EA)	SAMPLED MEDIA water	soil	sediment	dust	other	RECEIVING LABORATORY REMARKS/OTHER INFORMATION (condition of samples upon receipt, other sample numbers, etc.)
	NUMBERS OF CONTAINERS PER SAMPLE NUMBER										

DESCRIPTION OF SHIPMENT	MODE OF SHIPMENT
_____ PIECE(S) CONSISTING OF _____ BOX(ES)	_____ COMMERCIAL CARRIER: _____
_____ ICE CHEST(S); OTHER _____	_____ COURIER
	_____ SAMPLER CONVEYED (SHIPPING DOCUMENT NUMBER)

PERSONNEL CUSTODY RECORD

RELINQUISHED BY (SAMPLER)	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	
RELINQUISHED BY	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	
RELINQUISHED BY	DATE	TIME	RECEIVED BY	REASON FOR CHANGE OF CUSTODY
☐ SEALED ☐ UNSEALED			☐ SEALED ☐ UNSEALED	

7-EPA-9262(Revised 5/85)

HTW DRILLING LOG

HOLE NO.						
1. COMPANY NAME			2. DRILLING SUBCONTRACTOR			SHEET 1 OF SHEETS
3. PROJECT			4. LOCATION			
5. NAME OF DRILLER			6. MANUFACTURER'S DESIGNATION OF DRILL			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT			8. HOLE LOCATION			
			9. SURFACE ELEVATION			
			10. DATE STARTED		11. DATE COMPLETED	
12. OVERBURDEN THICKNESS			15. DEPTH GROUNDWATER ENCOUNTERED			
13. DEPTH DRILLED INTO ROCK			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED			
14. TOTAL DEPTH OF HOLE			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DEPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

HTW DRILLING LOG

HOLE NO.

PROJECT

INSPECTOR

SHEET
OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

PROJECT

HOLE NO.

HGL HydroGeoLogic, Inc. CDM

Training Conducted By: _____

Day:_____ **Date**:_____ **Time**:_____ **Duration**:_____

$ Field Health & Safety Meeting Record$

Site/Location: Garvey Elevator Site Hastings, Nebraska

Review:

: Health & Safety Plan : Buddy Teams : Hospital Route/Nearest Phone Location

: Weather Concerns : PPE □ Potential Problems:

: Action Levels: _____

□Other: _____

Protective Clothing/Equipment: _____

Special Equipment: Health and Safety; Equipment for particular sampling function

Chemical Hazards: Volatile organic compounds, metals, sample preservatives (HCl, etc)

Physical Hazards: Slips/trips/falls, traffic, inside hazards, outdoor hazards

Emergency Actions: Provide immediate emergency care, transport to hospital if possible without causing further harm to injured person (neck, back injury).

Other Issues: _____

Check:

: H&S Monitoring Equipment/Calibration : Fire Extinguisher

□ Communications/Radio Check : First Aid Kit/Eye Wash Station

: H&S Plan (each team) : Respiratory Protection/Cartridges

□ Other: _____ MSA GMC-H type: _____

	Please Print - Name/Firm/Office	*Signature*
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

Site Health and Safety Officer Signature: _____

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

HGL HydroGeoLogic, Inc Exceeding Expectations

CDM

EQUIPMENT MAINTENANCE AND CALIBRATION RECORD

Contract/Project: Garvey Elevator Site

Activity: _____

Equipment Description: _____

Equipment ID: _____

Equipment Serial No.: _____

Calibration Date/Time	Parameter	Standard Used (Concentration)	Lot Control No./ Expiration Date	Post Calibration Reading	Comments Pass/Fail	Signature

Maintenance Performed: _____

US EPA ARCHIVE DOCUMENT

Field Sheet
EQuIS Sample Information
Garvey Elevator Site, Hastings, Nebraska

Sample Number: _____

Sample Location/Description: _____

General Task Description: _____

Date of Collection: _____ Time of Collection: _____

Sampling Method: _____ Sample Depth (feet bgs): _____

Matrix (*circle one*): soil groundwater water other: _____

Analyses (*circle all applicable*):

EPA R7 Lab: VOCs pH TOC

Alkalinity Chloride Sulfate Total Fe & Mn M/E/E

NO2/NO3 Total phosphorous TSS TDS

Other Analytical Labs: Natural Oxidant Demand (NOD)

Solvent degrading bacteria

Geotech Lab: Permeability Porosity Grain size %Moisture Bulk Density

Test Kits: CO_2 Fe^{2+} DO BART Biofouling Bacteria

Field QC Samples:
Field Duplicate Collected for EPA Lab Y / N
If yes, duplicate sample ID: _____

Trip Blank Collected for EPA Lab Y / N
If yes, trip blank sample ID: _____

MS/MSD Extra Volume Collected for EPA Lab Y / N
If yes, MS/MSD sample ID: _____

Rinsate Blank Collected for EPA Lab Y / N
If yes, rinsate blank sample ID: _____

NONCONFORMANCE REPORT	DATE OF NCR	NCR NUMBER
	LOCATION OF NONCONFORMANCE	PAGE ___ OF ___

INITIATOR (NAME/ORGANIZATION/PHONE)	FOUND BY	DATE FOUND
RESPONSIBLE ORGANIZATION/INDIVIDUAL		PROGRAM
		PROJECT

DESCRIPTION OF NONCONFORMANCE — CATEGORY: H&S Sampling/Analysis

[A] INITIATOR: DATE QA/QC OFFICER DATE CAR REQ'D YES NO

DISPOSITION:

PROBABLE CAUSE:

ACTIONS TAKEN TO PREVENT RECURRENCE:

[B] PROPOSED BY: NAME DATE

JUSTIFICATION FOR ACCEPTANCE

[C] INITIATOR: NAME DATE

VERIFICATION OF DISPOSITION AND CLOSURE APPROVAL

REINSPECTION/RETEST REQUIRED YES NO IF YES;

DATE RESULT

[D] QUALITY ASSURANCE:

NAME DATE

PHOTO LOG

SITE NAME: Garvey Elevator Site

CAMERA # _____

Photograph #	Description	Date/Time	Photographer

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Page ____ of ____

ATTACHMENT 1
SLUG TEST DATA FORM

SLUG TEST DATA

LOCATION _____ SLUG VOLUME (FT^3) _____

LOCATION I.D. _____ LOGGER CODE _____

LOGDATE _____ ACCEPTANCE CODE _____

TEST METHOD: [ ] SLUG INJECTION OR [ ] SLUG WITHDRAWAL

COMMENTS: _____

_____

ELAPSED TIME (MIN)	DEPTH-TO-WATER (FT)
0.00	

ELAPSED TIME (MIN)	DEPTH-TO-WATER (FT)

ACCEPTANCE CODES: A - ACCEPTABLE R - RECONNAISSANCE U - UNACCEPTABLE N - NOT DETERMINED

_____ _____

FORM COMPLETED BY / DATE TECHNICAL REVIEWER / DATE

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CHAIN OF CUSTODY RECORD

HydroGeoLogic, Inc
1155 Herndon Parkway
Suite 900
Herndon, VA 20170

Client:

Project Name/No.:

Project Manager:

Sampler:

Phone: (913) 317-8860 Fax: (913) 317-8868

APPLICABLE REGULATION
- RCRA
- ECRA
- CERCLA
- NPDES
- CWA
- SDWA
- OTHER

SAMPLE IDENTIFICATION	DATE COLL.	TIME COLL.	MATRIX: GRAB	MATRIX: COMPOSITE	MATRIX: SOIL	MATRIX: WATER	MATRIX: OTHER	TOTAL NO. OF CONTAINERS	ANALYSIS REQUIRED	REMARKS OR SAMPLE LOCATION

Special Instructions

Possible Hazard Identification
● Non-Hazard ● Flammable ● Skin Irritant ● Poison B ● Unknown

Sample Disposal
● Return to Client ● Disposal by Lab ● Archive for _____ Months

Turn Around Time Required
● Normal ● Rush

QC Level
● I. ● II. ● III.

Project Specific (specify)

1. Relinquished by	Date	Time	1. Received by	Date	Time
2. Relinquished by	Date	Time	2. Received by	Date	Time
3. Relinquished by	Date	Time	3. Received by	Date	Time

Comments

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APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

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FINAL
QUALITY ASSURANCE PROGRAM PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA

Prepared for:

U.S. Environmental Protection Agency Region 7
901 North 5th Street
Kansas City, KS 66101

Architect and Engineering Services Contract EP-S7-05-05
Task Order: 0033 and 0034

Prepared by:

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CDM Federal Programs Corporation
9200 Ward Parkway, Suite 500
Kansas City, MO 64114

May 2009

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REVISED FINAL
QUALITY ASSURANCE PROJECT PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA

PROJECT: Remedial Investigation/Feasibility Study
Garvey Elevator—OU1 and OU2 Sites, Hastings, Nebraska

TASK ORDER NUMBERS: 0033 and 0034

HYDROGEOLOGIC, INC.
PROGRAM MANAGER: Robert Overfelt, P.G., CHMM
TASK ORDER MANAGER: W. Alan Rittgers, P.G.
REGIONAL QC COORDINATOR: Mary Knowles

U.S. ENVIRONMENTAL PROTECTION AGENCY – REGION 7
TASK ORDER PROJECT OFFICER (TOPO): Brian Zurbuchen, Ph.D.

PREPARATION DATE: June 25, 2009
PLAN PREPARER: HGL/CDM
REVISION: 2

APPROVED BY:

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Quality Assurance Officer

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LIST OF ACRONYMS AND ABBREVIATIONS

AES	Architect and Engineering Services
amsl	above mean sea level
ASR	Analytical Services Request
ASTM	American Society for Testing and Materials
BART	biological activity reaction test
bgs	below ground surface
CCl_4	carbon tetrachloride
CDM	CDM Federal Programs Corporation
CFR	Code of Federal Regulations
COC	chain of custody
COPC	chemical of potential concern
CSM	conceptual site model
DBA	Database Administrator
DFT	dipole flow test
DM	Data Manager
DMP	Data Management Plan
DOT	Department of Transportation
DPT	direct-push technology
DQI	data quality indicators
DQO	data quality objective
EC	electrical conductivity
EDD	electronic data deliverable
EMSL	Environmental Monitoring Systems Laboratory
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
EQuIS	Environmental Quality Information System
ESRI	Environmental System Research Institute
FB	Field Blank
FD	Field Duplicate
FS	Feasibility Study
FSP	Field Sampling Plan
FTL	field team leader
GC/MS	gas chromatography/mass spectrometry
GET	groundwater extraction and treatment
GIS	Geographic Information System

HGL	HydroGeoLogic, Inc.
HHRA	human health risk assessment
HSP	Health and Safety Plan
IDW	investigation-derived waste
L	liter
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MCL	maximum contaminant level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mL	milliliter
MNA	monitored natural attenuation
MQO	measurement quality objective
MS	matrix spike
MSD	matrix spike duplicate
MW	monitoring well
NA	Not Applicable
NDEQ	Nebraska Department of Environmental Quality
NIST	National Institute of Standards and Technology
NOD	natural oxidant demand
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OU	Operational Unit
PCB	polychlorinated biphenyl
PCR	polymerase chain reaction
PID	photoionization detector
PM	Project Manager
PRG	Preliminary Remediation Goals
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QMP	Quality Management Plan

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%R	percent recovery
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
SM	Sample Manager
SMP	Site Management Plan
SOP	standard operating procedure
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TDS	total dissolved solids
TO	task order
TOC	total organic carbon
TOM	Task Order Manager
TOPO	Task Order Project Officer
TSS	total suspended solids
VCP	Voluntary Cleanup Program
VOC	volatile organic compound

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REVISED FINAL
QUALITY ASSURANCE PROJECT PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR–OU1 AND OU2 SITES
HASTINGS, NEBRASKA

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) details the quality assurance/quality control (QA/QC) measures that will be employed for the Remedial Investigation/Feasibility Study (RI/FS) conducted at the Garvey Elevator site to assure that data collected are of acceptable quality and sufficient quantity to support decision making on remedial actions that are needed to protect human health and the environment. HydroGeoLogic, Inc. (HGL) and its team subcontractor CDM Federal Programs (CDM) prepared this QAPP under Region 7 U.S. Environmental Protection Agency (EPA) Architect and Engineering Services (AES) contract EP-S7-05-05, Task Orders (TOs) 0033 and 0034. This QAPP has been developed in accordance with EPA QA/R-5 guidance for preparing QAPPs (EPA, 2001).

The purpose and objectives of the project are discussed in detail in Section 1.1 of the RI/FS Work Plan. The purpose of this QAPP is to provide guidance to ensure that all environmentally related data collection procedures and measurements are conducted in a manner that is scientifically sound, and that the resulting data are of known, acceptable, and documented quality to support decision making. This QAPP establishes the QC methodology, data quality objectives (DQOs), and QC information to be applied during RI/FS activities. This QAPP is a dynamic document that will be updated as needed to reflect the RI activities at the Garvey Elevator Site.

This QAPP is one component of the Work Plan for RI/FS activities at the Garvey Elevator site. The Work Plan consists of the Field Sampling Plan (FSP), this QAPP, the Site Management Plan (SMP) and the site-specific Health and Safety Plan (HSP). Collectively these planning documents present the technical approach, field sampling regime and methodologies, data management policies and procedures, and other measures to be followed to assure that all activities are conducted in a systematic and safe manner.

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2.0 PROJECT DESCRIPTION

2.1 PROJECT BACKGROUND

Site background information for the Garvey Elevator Site is provided in Section 1.2 of the RI/FS Work Plan.

2.2 PROJECT SCOPE AND OBJECTIVES

This QAPP will govern data collection activities performed for the Operable Unit (OU) 1 (TO 0033) and OU2 (TO 0034). These activities are described in detail in the FSP (Appendix A of the RI/FS Work Plan). Data collection activities that will be performed during the RI include the following:

- Collect surface and subsurface soil samples using direct-push technology (DPT)
- Collect surface water and sediment samples from intermittent drainageways
- Collect subslab soil gas samples, and indoor and outdoor air samples
- Collect electrical conductivity (EC) data using DPT
- Collect DPT groundwater grab samples
- Install monitoring wells and one hydraulic test well
- Record manual groundwater level measurements
- Sample new and existing monitoring wells
- Conduct surveying
- Conduct dipole flow testing
- Conduct slug testing

Samples will be analyzed on site for volatile organic compounds (VOCs) by the EPA Region 7 Hapsite mobile laboratory, and for additional parameters by the EPA Region 7 fixed-base laboratory in Kansas City, Kansas. Specialized chemical analysis also will be conducted by an outside analytical laboratory for natural oxidant demand (NOD) of soil.

Geotechnical analysis of soil samples will be conducted by an off-site geotechnical laboratory selected through a competitive procurement process.

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3.0 PROJECT MANAGEMENT

3.1 PROJECT ORGANIZATION

HGL will provide the necessary technical staff to conduct and/or supervise all project activities, including collecting samples, conducting field measurements, condicting slug testing, and conducting data evaluation and preparing reports. HGL will procure subcontractors to provide drilling, DPT, geotechnical sample analysis, surveying, and investigation-derived waste (IDW) handling and disposal services.

Project management and individual organizations and responsibilities specific to this investigation are discussed in the following subsections.

3.1.1 Management Organization

RI/FS activities are being conducted by HGL under Region 7 EPA AES contract EP-S7-05-05, TOs 0033 and 0034. CDM is a team subcontractor to HGL on the AES contract. CDM personnel will have key roles on the Garvey Elevator project.

The HGL Program Manager is Mr. Bob Overfelt, the TO Manager (TOM) for this project is Mr. Alan Rittgers, and the Field Team Leader (FTL) is Mr. Jeff Gadt. Mr. Janardan Patel is the HGL QA Manager. Mr. Doug Updike of CDM is the QA specialist who will oversee project activities assigned to CDM. Ms. Mary Knowles is the regional QC Coordinator at HGL who will oversee day-to-day QA/QC activities for this project.

As the TOM, Mr. Rittgers is responsible for the overall management and coordination of the following activities:

- Coordinating the work of HGL technical and support staff and other team members
- Serving as the primary HGL point of contact and communicating directly with the EPA Region 7 Task Order Project Officer (TOPO) on project concerns, as needed
- Preparing monthly status reports
- Tracking work progress against planned budgets and schedules
- Supervising review and production of deliverables
- Coordinating with the laboratory regarding analytical services, data validation, and QA issues related to sample analysis
- Incorporating and informing EPA of changes in the RI/FS Work Plan, FSP, the HSP, and/or other project documents
- Reviewing analytical results and deliverables from subcontractors
- Reviewing and approving subcontractor invoices
- Notifying the HGL QA Manager, QA Specialist, or Regional QC Coordinator immediately of significant problems affecting the quality of data or the ability to meet project objectives
- Scheduling personnel and material resources
- Implementing field aspects of the investigation, including the RI/FS Work Plan, FSP,

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and other project documents
- Implementing the QC measures specified in the quality management plan (QMP) (HGL, 2005) for this contract, this QAPP, and other project documents
- Implementing corrective actions resulting from staff observations, QA/QC surveillance, and/or QA audits
- Providing oversight of data management.

The FTL, Mr. Jeff Gadt, will be responsible for the following:
- Organizing and conducting a field planning meeting
- Scheduling and conducting field work
- Leading a multidisciplinary field team to implement the RI/FS work plan, FSP, QAPP and HSP as applicable to the investigation
- Notifying the EPA laboratory of scheduled sample shipments and coordinating work activities
- Gathering sampling equipment and supplies and confirming required sample bottles and preservatives are on site, as needed
- Maintaining proper chain-of-custody forms and shipping samples to the off-site analytical laboratory during sampling events
- Ensuring that sampling is conducted in accordance with procedures detailed in the RI/FS work plan including the FSP and QAPP, and that the quantity and location of all samples meet the requirements of these documents
- Identifying problems at the field team level, resolving difficulties in consultation with the QA staff, implementing and documenting corrective action procedures at the field team level, and providing communication between the field teams and HGL management.

The roles and responsibilities of other field team members will be to assist the FTL with sampling activities, sample handling, and overall documentation.

3.1.2 Quality Assurance Organization

The HGL QA Manager, Mr. Janardan Patel, implements the QA program. He is independent of the technical staff and reports directly to the President of HGL on QA matters. The QA Manager has the authority to objectively review projects, identify problems, and use corporate resources, as necessary, to resolve any problems related to quality.

The Regional QC Coordinator for this project, Ms. Mary Knowles, reports to Mr. Patel on QA matters for this project. CDM QA Specialist Mr. Doug Updike reports to Ms. Knowles on QA matters for project tasks assigned to CDM. Under Mr. Patel's oversight, the Regional QC Coordinator is responsible for the following:
- Reviewing and approving all project-specific plans
- Directing the overall project QA program
- Maintaining QA oversight of the project
- Reviewing QA sections in project reports, as applicable
- Reviewing QA/QC procedures applicable to this project

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- Auditing selected activities of this project performed by HGL and subcontractors, as necessary
- Initiating, reviewing, and following up on response actions and corrective actions, as necessary
- Maintaining awareness of active tasks and their QA/QC needs
- Consulting with the HGL QA Manager, as needed, on appropriate QA/QC measures and corrective actions
- Conducting internal system audits to check on the use of appropriate QA/QC measures, if applicable
- Arranging performance audits of measurement activities, as necessary
- Providing written reports on QA/QC activity to the HGL QA Manager

3.1.3 EPA Management

The EPA Region 7 Contract Project Officer, Mr. Jim Seiler, and Contract Officer, Mr. Anthony LaMaster, will be responsible for:

- Participating in TO proposal negotiations
- Tracking the TO budget
- Reviewing TO proposals
- Allocating and authorizing EPA funds to the TOs
- Maintaining communication with the EPA TOPO and HGL contract personnel

The EPA Region 7 TOPO for this site, Dr. Brian Zurbuchen, PhD, is HGL's primary contact for coordinating work at the site. Dr. Zurbuchen will be responsible for:

- Reviewing all project deliverables prepared by HGL
- Maintaining communications with the HGL TOM regarding project status
- Reviewing monthly status reports
- Providing oversight of field efforts as desired
- Conducting the dipole flow testing
- Facilitating and maintaining communication with the stakeholders and others, where applicable
- Tracking work progress against planned budgets and schedules
- Scheduling EPA personnel and material resources, including the laboratory
- Providing oversight of EPA personnel responsible for project tasks
- Coordinating laboratory needs with EPA laboratory and HGL

Other EPA personnel responsible to quality matters at the Agency are the EPA Regional QA manager, Ms. Diane Harris, who is responsible for reviewing and approving the QAPP; Lorenzo Sena, the Hapsite Mobile Laboratory Coordinator; and the EPA Regional Laboratory Coordinator, Ms. Nicole Roblez, who is responsible for coordinating EPA laboratory analysis of samples collected during field work.

3.1.4 NDEQ Management

The Nebraska Department of Environmental Quality (NDEQ) Project Manager (PM), Ms.

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Laurie Brunner, is the point of contact at NDEQ and is responsible for the following:

- Reviewing project deliverables prepared by HGL and providing comments to the EPA TOPO
- Maintaining communications with the EPA TOPO regarding project status and funding requirements
- Providing oversight of field activities, as desired

3.1.5 QAPP Organization

This QAPP is organized in accordance with EPA *Requirements for Quality Assurance Project Plans*, EPA QA/R-5, Interim Final, March 2001 (EPA, 2001). Section 3.0 presents project management and DQO information, Section 4.0 details measurement and data acquisition strategies, Section 5.0 details assessment and oversight aspects of the project, Section 6.0 describes data validation and usability, Section 7.0 describes data management, and Section 8.0 lists the references.

3.2 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT

3.2.1 End Uses of the Data

It is important for any project to identify how the data that are collected in the field will be used and what decisions will result. These end uses must be defined to ensure the appropriate type, amount, and quality of data is collected.

The data collected during the RI will be used to:

- Determine the physical characteristics of the site.
- Determine the nature and extent of contamination in affected media, on site and down gradient of the site, that exceed established Federal or State limits, or in the event such limits have not been promulgated, that pose human health or ecological risks above acceptable limits.
- Update and refine the Conceptual Site Model (CSM) to ensure site characterization is completed in sufficient detail for decision making.
- Assess actual and potential exposure pathways through affected media.
- Prepare a human health risk assessment (HHRA) and an EPA ecological risk assessment (steps 1 through 3a) that presents an assessment of the risks to human health and the environment.
- Identify, develop and evaluate potential remedial alternatives in an FS report.
- Conduct an ecological site survey to identify potential ecological receptors.

The remainder of this section discusses the internal controls and review processes that will be employed to assure environmentally related measurements and data collected by HGL are of known quality and appropriate data can be generated to meet the end uses identified above.

3.2.2 Data Types

Quality of analytical data is defined as either “definitive data” or “screening data with

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definitive confirmation" in USEPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, Publication No. EPA/240/B-06/001, February 2006 (EPA, 2006). Screening data provide analyte identification and quantification, although the quantification may be relatively imprecise and requires definitive-level confirmation. Definitive data are generated using rigorous analytical methods, such as approved EPA methods. Data are analyte-specific with verification of analyte identity and concentration. Methods produce tangible raw data in the form of paper printouts or computer-generated electronic files. Definitive data will be generated by the EPA Region 7 laboratory. Hapsite mobile laboratory data, EC data, and NOD data produced by Carus Chemical Company will be considered screening data.

An additional data category of "other" is also defined in the guidance. This category is used to define data that do not fit exactly into either of the above two categories. Types of data that are included in the other category include photoionization detector (PID) field screening measurements, water quality measurements taken with a field meter, test kit analyses, water level measurements, flowmeter data, slug test data, geotechnical, and surveying data. "Other" data are used to support the field investigation. These data will be used to guide field decisions, such as locating sample locations for "definitive" analyses, but these data will not be directly used to characterize the nature and extent of site contaminants or to evaluate risk. The data types and DQO categories are listed in Table 3.1.

3.2.3 Data Quality Objectives

The DQO process is a series of planning steps based on the scientific methods that are designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended purpose. EPA has issued guidelines to help data users develop site-specific DQOs (EPA, 2006). The DQO process is intended to:

- Clarify the study objective
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the project objectives

The goal of the DQO process is to help ensure that data of sufficient quality and quantity are obtained to support remedial decisions, reduce overall costs of data sampling and analysis activities, and accelerate project planning and implementation.

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The process also ensures that the resources required to generate the data are justified. The DQO process consists of seven steps of which the output from each step influences the choices that will be made later in the process. These steps are:

Step 1: State the problem
Step 2: Identify the goals of the study
Step 3: Identify decision inputs
Step 4: Define the boundaries of the study

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Step 5: Develop the analytical approach
Step 6: Specify performance or acceptance criteria
Step 7: Develop the plan for obtaining data

During the first six steps of the process, the planning team develops decision performance criteria (i.e., DQOs) that will be used to develop the data collection design. The final step of the process involves developing the data collection design based on the DQOs. A brief discussion of these steps and their application to this project are provided below.

STEP 1: STATE THE PROBLEM

The purpose of this step is to describe the problem to be studied so that the focus of the study is unambiguous.

From 1959 to 2005 Garvey Elevators Inc. owned and operated a grain storage facility at the subject property where grain was stored in bins and transported by rail.

The VOC carbon tetrachloride (CCl_4) and its degradation product chloroform have been found in soils and groundwater beneath the facility. The groundwater plume extends approximately three miles downgradient of the facility and has impacted local drinking water wells.

Soil vapor extraction (SVE) and groundwater extraction and treatment (GET) systems were constructed and operated on the subject property by Garvey while participating in the NDEQ's voluntary cleanup program (VCP), but the total extent of contaminants in the subsurface and their impact on the environment have not been fully determined. Operation of the remedial systems and further investigation and cleanup at the site has been turned over to EPA.

Other potential source areas such as the construction debris disposal pit, fumigant applicator wash area, chemical storage shed; former storage shed location; former drum storage area, and electrical transformer area have not been completely characterized. Herbicides (i.e. 2,4-D), pesticides (i.e. Malathion), polychlorinated biphenyls (PCBs), and semivolatile organic compounds (SVOCs) are other chemicals of potential concern (COPCs) for this site.

STEP 2: IDENTIFY THE GOALS OF THE STUDY

This step identifies what questions the investigation will attempt to resolve and what actions may result. The goals of the study are to answer the following principal investigation questions:

- Are CCl_4 and chloroform the only COPCs at the site that pose a potential threat to human health or the environment (i.e. what contaminants are present at and associated with the site at concentrations above Preliminary Remediation Goals [PRGs] in groundwater or soil)?
- What are the concentrations and extent of these contaminants in soil and groundwater? Are they defined horizontally and vertically to risk-based levels?
- Do VOCs in soil gas pose a potential vapor intrusion threat?

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- Are there ecological receptors potentially impacted by site contaminants?
- Is there an ecological risk posed from release of site contaminants to surface water and sediment in on-site and off-site drainage ways?
- Is the use of irrigation wells adjacent to the site posing adverse human health or ecological risk?
- Is the current groundwater extraction system preventing off-site migration of contaminated groundwater?
- Are the current remedial systems in place at the site sufficient to reduce contaminant concentrations to those that are safe for human health and the environment in the most efficient and cost-effective manner?
- Are there other actions that need to be taken to supplement the existing remedial systems?

STEP 3: IDENTIFY DECISION INPUTS

The purpose of this step is to identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statements. Based on the investigation questions, the following information will need to be obtained during this investigation:

- Identify the VOC, SVOC, herbicide, pesticide, and/or PCB COPCs for the site based on source area characterization.
- Identify the COPCs in soil, groundwater, soil gas, surface water and sediment for completion of human health and ecological risk assessments.
- Determine nature and extent of COPCs in soil above risk-based levels and soil to groundwater migration potential to complete human health and ecological risk assessments and to evaluate remedial options in the FS including location/depth, concentration, and volume of contaminated soil.
- Determine the nature and extent of COPCs in groundwater (horizontally and vertically) above PRGs to allow assessment regarding impacts to human health and identification of applicable remedial alternatives.
- Determine the nature and extent of COPCs in soil gas to evaluate the vapor intrusion pathway in the human health risk assessment.
- Determine the nature and extent of COPCs in surface water and sediment to evaluate ecological risk.
- Collect supplemental data regarding soil and hydrogeologic characteristics and the existing SVE and GET systems to allow evaluation of applicable remedial alternatives in the FS.
- Identify potential ecological receptors that may be impacted by site COPCs.

STEP 4: DEFINE THE BOUNDARIES OF THE STUDY

This step defines the temporal and spatial boundaries of the study.

The site is located in Hastings, Nebraska, at 2315 W. Highway 6. The topography of the area is relatively flat with a slope to the east-southeast. Surface soils in the area are primarily silty

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loam, and the elevation of the site is approximately 1,925 feet above mean sea level (amsl).

The onsite investigation of potential source areas and known areas of soil and groundwater contamination will take place on the site property. Soil gas samples will be collected from beneath the building slab, and indoor and outdoor air samples will also be collected on site. Groundwater contamination extends beyond the property boundary for at least 3 miles east-southeast beneath properties owned by the city of Hastings, private landowners, and Adams County. Off-site sampling locations will be situated on property owned by either the city, county, or private parties. City and county properties will be targeted if possible to limit efforts associated with obtaining access to private properties. Soil sampling locations are planned to be limited to the former Garvey property.

Sediment and surface water samples are planned for upstream, on site, and downstream locations within intermittent drainage features and a pond south of the site. Surface water sampling may or may not be possible based on the amount of water present in the drainage features.

The RI field activities are scheduled to occur between July and December 2009.

STEP 5: DEVELOP THE ANALYTICAL APPROACH

The analytical approach consists of a series of if/then statements to determine what decisions will be made based on the principal investigation questions developed under Step 2, and the decision inputs identified in Step 3 of the DQO process. These decision statements are provided below:

The following decision statement applies to confirmation of COPCs for this RI:

- If other VOCs, SVOCs, herbicides, pesticides, or PCBs attributable to the Garvey Elevator site are detected in soil or groundwater at concentrations greater than their applicable PRGs, then the list of contaminants of interest will be expanded for the RI field program and risk assessments.

The following decision statement applies to delineation of the on-site groundwater using DPT:

- If on-site DPT groundwater data indicate the groundwater plume is currently migrating off the Garvey Elevator property, then an interim Record of Decision (ROD) may be needed to enhance the existing groundwater extraction system to fully contain the existing plume on site.

The following decision statements apply to the DPT groundwater investigation:

- If DPT groundwater data indicate that CCl_4 and chloroform are delineated horizontally and vertically to concentrations less than their respective groundwater PRG, then the groundwater plume will be considered to be delineated.
- If DPT groundwater data indicate CCl_4 and chloroform concentrations have not been defined horizontally and vertically to their respective groundwater PRG, then the

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groundwater plume is not fully delineated and deeper samples or additional DPT borings are required.

The following decision statements apply to the on-site DPT soil investigation:

- If concentrations of COPCs (VOCs, SVOCs, herbicides, pesticides and/or PCBs) in soil are delineated horizontally and vertically to concentrations less than their respective soil PRG, then the area of soil contamination will be considered delineated for the purposes of the human health and ecological risk assessments and determination of soil volume for the FS.
- If concentrations of COPCs (VOCs, SVOCs, herbicides, pesticides and/or PCBs) in soil are not delineated horizontally and vertically to concentrations less than their respective soil PRG, then contaminated soil has not been fully delineated and deeper samples or additional DPT soil borings are required.

The following decision statement applies to the on-site soil gas investigation:

- If VOC concentrations in sub-slab soil gas are delineated to concentrations corresponding to indoor air risk levels, then the area of soil gas contamination will be considered sufficiently delineated for purposes of the human health risk assessment.
- If VOC concentrations in sub-slab soil gas are not delineated to concentrations corresponding to indoor air risk levels, then the area of soil gas contamination has not been fully delineated and additional soil gas sampling is required to define the area of contamination laterally.

The following decision statement applies to evaluation of the existing SVE system:

- If review of existing system data and site visit to review current status of the SVE system is not sufficient to evaluate system effectiveness or determine details of system expansion in the FS, if needed, then performance testing may be required.

STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

The decision maker's tolerable limits on decision errors, which are used to establish performance goals for the data collection design, are specified in this step. Decision makers are interested in knowing the true value of constituent concentrations. Because analytical data can only estimate these values, decisions that are based on measurement data could be in error (decision error). There are two reasons why the decision maker may not know the true value of the constituent concentration, these are:

- Concentrations vary over time and space. Limited sampling may miss some features of this natural variation because it is usually impossible or impractical to measure every point of a population. Sampling design error occurs when the sampling design is unable to capture the complete extent of natural variability that exists in the true state of the environment.
- Analytical methods and instruments are never absolutely accurate; hence, a measurement can only estimate the true value of an environmental sample. Measurement error refers to a

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combination of random and systematic errors that inevitably arise during the various steps of the measurement process.

The combination of sampling design and measurement error is the total study error. Since it is impossible to completely eliminate total study error, basing decisions on sample concentrations may lead to a decision error. The probability of decision error is controlled by adopting a scientific approach in which the data are used to select between one condition (the null hypothesis) and another (the alternative hypothesis). The null hypothesis is presumed to be true in the absence of evidence to the contrary. For this project, the null hypothesis is that the true concentrations of site contaminants are below target levels for the various sample matrices.

The alternative hypothesis is that the true concentrations of site contaminants are above target levels.

A false positive or "Type I" decision error refers to the type of error made when the null hypothesis is rejected when it is true, and a false negative or "Type II" decision error refers to the type of error made when the null hypothesis is accepted when it is false. For this project, a Type I decision error would result in deciding that one or more contaminants were present above target delineation levels when they were not. A Type II decision error would result in deciding that one or more contaminants were below target delineation levels when in fact they exceed these levels.

For this project, a Type II error is less acceptable than a Type I error because a Type II error could result in mistakenly not fully delineating site contamination to the necessary extent, whereas a Type I error could result in over-investigating the site. Neither type of decision error is desirable, but a Type II error is considered worse in that contamination may not be fully delineated.

The sampling process design has been developed so that decision errors are minimized to the extent possible. To aid in this, a "gray range" of ± 10 percent has been developed. This gray range will be used when comparing results to the delineation criteria, i.e. groundwater sample results for CCl_4 must be below 4.5 micrograms per liter (μg/L) to consider the groundwater plume delineated. Measurement quality objectives (MQOs) have additionally been established to limit the possibility of decision errors. MQOs include the quantitative criteria established to assess field and laboratory precision, laboratory accuracy, and completeness of the data collection effort. The MQOs are discussed in Section 3.2.4.

It should be noted that definitive data is needed for completion of the HHRA and ecological risk assessments and as the basis for any site decisions, such as determining when areas of soil or groundwater contamination have been fully delineated. The Hapsite mobile laboratory will be used to provide quick turnaround analysis of selected VOC samples, such as those to be collected at the distal end of the off-site groundwater transects. However, areas of contamination will need to be confirmed using definitive results (obtained from off-site fixed laboratory analysis). These data are more likely to be of known quality based on acceptable

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calibration and laboratory QC results to provide a reasonable assurance that decision error is minimized.

STEP 7: DEVELOP THE PLAN FOR OBTAINING DATA

Step 7 of the DQO process identifies the plan for generating the site data that are expected to satisfy the DQOs. The data collection plan (sampling program) is described in detail within Section 3.0 of the FSP.

3.2.4 Data Measurement Quality Objectives

Data quality indicators (DQIs) are quantitative and qualitative parameters that can help determine the acceptability of analytical data. The quantitative DQIs are precision, accuracy, completeness, and sensitivity. Qualitative DQIs include representativeness and completeness. MQOs are established for precision, accuracy, and completeness to determine the criteria by which these DQIs will be evaluated. The quantitative and qualitative DQIs and related MQOs are discussed below.

Precision - The precision of a measurement is an expression of mutual agreement among individual measurements of the same property taken under prescribed similar conditions. Precision is quantitative and most often expressed in terms of relative percent difference (RPD).

The RPD can be calculated from the following equation:

$$RPD = [|(x_1 - x_2)| / ((x_1 + x_2)/2)] \times 100$$

Where: x_1 = regular sample result
x_2 = duplicate sample result

Precision of reported results is a function of inherent field-related variability plus laboratory analytical variability. Various measures of precision exist, depending upon "prescribed similar conditions." Field duplicate samples and confirmation samples will be collected to provide a measure of the contribution to overall variability of field-related sources. Contribution of laboratory-related sources to overall variability is measured through various laboratory QC samples. The acceptable RPD limits for duplicates submitted to the EPA fixed-base laboratory and Hapsite mobile laboratory are less than 20 percent for water samples, and less than 50 percent for soil samples. Chemical analytical data will be evaluated for precision using field duplicates, laboratory duplicates, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory control sample/laboratory control sample duplicates (LCS/LCSDs), as applicable.

Accuracy - Accuracy is the degree of agreement of a measurement with an accepted reference or true value, and is a measure of the bias in a system. Accuracy is quantitative and usually expressed as the percent recovery (%R) of a sample result. Ideally, it is desirable that the reported concentration equals the actual concentration present in the sample. Acceptable QC limits for %R are 80 percent to 120 percent for LCS/LCSDs, method-defined for surrogates,

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and laboratory-defined for MS/MSDs. Chemical analytical data will be reviewed for accuracy using surrogates, MS/MSDs, and LCS/LCSDs, as applicable. The overall accuracy of laboratory data also will be assessed using the analysis of field blanks and review of equipment calibration by EPA data validators.

Completeness - Completeness is a measure of the amount of usable data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Data validation will assess usability of the results. Those data that are validated and need no qualification, or are qualified as estimated data, are considered usable. Rejected data are not considered usable. Completeness will be calculated after the data have been through quality review. For this work, a completeness goal of 90 percent is projected for all analytical data. If this goal is not met, additional sampling may be necessary to adequately achieve project objectives.

MQOs for precision, accuracy and completeness of the EPA analytical results are provided in Table 3.2.

Representativeness - Representativeness expresses the degree to which sample data accurately and precisely represent (a) a characteristic of a population, (b) parameter variations at a sampling point, and/or (c) an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling plan and the absence of cross contamination. Good representativeness will be achieved through:

(a) Careful, informed selection of sampling sites
(b) Selection of testing parameters and methods that adequately define and characterize the extent of possible contamination and meet the required parameter reporting limits
(c) Proper gathering and handling of samples to avoid interference and prevent contamination and loss
(d) Collection of a sufficient number of samples to allow characterization

Representativeness is a consideration that will be employed during all sample location and collection efforts and will be assessed qualitatively by reviewing field procedures and reviewing actual sampling locations versus planned locations.

Comparability - Consistency in the acquisition, handling, and analysis of samples is necessary for comparing results. Where appropriate, the results of analyses obtained will be compared with the results obtained in previous studies. Standard EPA analytical methods and QC will be used to ensure comparability of results with other analyses performed in a similar manner. Comparability is a qualitative parameter and cannot be assessed using QC samples.

Sensitivity - Sensitivity is related to the ability to compare analytical results with project-specific levels of interest, such as delineation levels or action levels. Analytical quantitation limits for the various sample analytes should be below the level of interest to allow an effective comparison. For this project, sample quantitation limits should be lower than the PRGs shown in Table 3.3, however this is not achievable for chloroform or ethylene dibromide in several

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matrices. The EPA Region 7 Laboratory Coordinator will be contacted when submitting the analytical services request form to ensure the lowest achievable reporting limits are obtained for these analytes. If actual reporting limits are above the PRGs in the reported data, this will be discussed in the uncertainty section of the risk assessment and in the RI report.

The EQLs provided in Table 3.4 for the on-site Hapsite mobile laboratory and fixed-base EPA laboratory are the minimum levels that the laboratory will report analytical results without a qualifier when an analyte is detected. The laboratory can typically detect analytes at concentrations of up to an order of magnitude lower than the reporting limits. In this case, when a positive detection is less than the reporting limit but above the method detection limit, the value will be reported and qualified as an estimated concentration (J). The EQLs shown in Table 3.4 are sufficiently low to allow the analytical results to be compared with PRGs.

It should also be noted that a J qualifier is commonly added by data validators when sample recoveries in laboratory QC samples are outside QC limits, but not so far that data are rejected. In this case, low or high bias is indicated depending upon whether recoveries are high or low. This should be considered when using J-coded data.

3.2.5 Field Measurements

Field measurements will include real-time air monitoring equipment for health and safety, multi-parameter water quality meters, turbidity meters, and water level meters. All equipment will be rented from a reputable commercial equipment vendor. This equipment will be maintained and calibrated to ensure accurate readings are taken as discussed in Sections 4.6 and 4.7.

In addition to these direct reading measurements, test kit analyses will be conducted in the field during monitoring well sampling for carbon dioxide, ferrous iron, and biofouling bacteria using biological activity reaction test (BART®) test kits. Information on the test kits that will be used for these analyses is provided in Attachment 1. These tests will be performed in accordance with manufacturer instructions. All field measurements will be recorded in the applicable field logbook.

3.3 SPECIAL TRAINING REQUIREMENTS

All HGL personnel and subcontractors working at the site will comply with the health and safety training requirements stated in 29 CFR 1910 and 1926. Personnel will additionally participate in an annual medical monitoring program as required by Occupational Health and Safety Administration (OSHA). This documentation will additionally be requested for any visitors to the site including EPA and NDEQ personnel. If documentation is not provided or if training/medical monitoring is not current, visitors will be accompanied by a member of the HGL field team and will not be allowed in the exclusion zone.

Other health and safety requirements of the project including daily tailgate safety meetings and

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required personal protective equipment are specified in the HSP included as Appendix C of the RI/FS work plan.

In addition to health and safety training requirements, all field crew members will understand the proper operation of the field meters and all sampling procedures contained in the FSP.

Documentation of training and medical monitoring will be maintained in the field office by the site health and safety officer for all personnel working on site.

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TABLES

Table 3.1
Data Types and DQO Categories

Data Type	Purpose	DQO Category
Upgradient of Site		
TOC in subsurface soil	Determine carbon content of soils to evaluate the feasibility of remedial alternatives	Definitive
VOCs, SVOCs, herbicides, pesticides and PCBs in surface water and sediment	Background data for ecological risk assessment	Definitive
Natural oxidant demand for subsurface soil	Determine oxidant demand of soils to evaluate the feasibility of remedial alternatives	Screening
Geotechnical data for subsurface soil	Evaluate feasibility of remedial alternatives and evaluate contaminant transport	Other
Dipole flow testing and slug testing	Aquifer flow characteristics to evaluate feasibility of remedial alternatives	Other
Source Area		
VOCs, SVOCs, herbicides, pesticides and PCBs in surface and subsurface soil	Collect data for site characterization to identify other COPCs besides CCl4 and chloroform, as applicable. Determine horizontal and vertical extent of contamination in soil. Shallow soil data will be used in the HHRA and ecological risk assessments.	Definitive
Geotechnical data for subsurface soil	Evaluate feasibility of remedial alternatives and evaluate contaminant transport	Other
VOCs in soil gas; indoor air; outdoor air	Evaluate inhalation pathway for the human health risk assessment	Definitive
VOCs, SVOCs, herbicides, pesticides & PCBs in surface water and sediment	Evaluate ecological risk	Definitive
VOCs, SVOCs, herbicides, pesticides & PCBs in groundwater	Determine horizontal and vertical extent of VOC contamination in groundwater and determine if groundwater has been impacted by any other COPCs	Screening/Definitive*
EC logging	Evaluate contaminant transport	Screening
PID field readings	Screen soil to help identify zones for sample collection	Other
Downgradient of Source Area		
VOCs in groundwater	Identify vertical and horizontal migration of contaminants downgradient from source area. Determine monitoring well locations.	Screening/Definitive*
VOCs, SVOCs, herbicides, pesticides & PCBs in surface water and sediment	Evaluate ecological risk	Definitive
EC logging	Evaluate contaminant transport	Screening
Geotechnical data from monitoring well borings	Evaluate contaminant transport	Other

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Table 3.1 (continued)
Data Types and DQO Categories

Data Type	Purpose	DQO Category
Groundwater Monitoring		
VOCs in groundwater from monitoring wells, private drinking water wells, and private irrigation wells	Evaluate risk to human health and the environment. Delineate horizontal and vertical extent of groundwater contamination.	Definitive
Alkalinity, chloride, sulfate, phosphates, iron, manganese, nitrates, TOC, and methane, ethane, and ethene in groundwater	Evaluate MNA as potential groundwater remedy	Definitive
Grain size data from monitoring well borings	Evaluate contaminant transport in groundwater	Other
TSS, TDS, total phosphorous in groundwater	Collect data to evaluate groundwater remedies in the FS	Definitive
Biofouling bacteria in groundwater	Collect data to evaluate groundwater remedies in the FS	Other
Water level measurements from new and existing monitoring wells	Determine groundwater flow direction	Other
pH, conductivity, turbidity, temperature, ORP, and DO using direct reading field meters	Obtain field readings to evaluate MNA as potential groundwater remedy and determine if wells are stabilized for sample collection	Other
Other		
IDW sampling data including VOCs and RCRA parameters	Obtain data to determine disposal requirements for IDW	Definitive
Surveying Measurements	Obtain horizontal and vertical location data to standardize measurements to mean sea level and accurately locate sample points and wells on GIS site maps	Other
Health and safety measurements using a PID, O2/LEL meter	Ensure the health and safety of on-site personnel	Other

*Note: VOC data produced by the onsite mobile laboratory will be considered screening data. VOC data produced by the EPA Region 7 fixed-base laboratory will be definitive data. Data used for risk assessments must be definitive data.
DO = dissolved oxygen
DQO = data quality objective
EC = electrical conductivity
FS = Feasibility Study
IDW = investigation-derived waste
MNA = monitored natural attenuation
O2/LEL = oxygen/lower explosive limit
ORP = oxygen reduction potential
PID = photoionization detector
RCRA = Resource Conservation and Recovery Act
TDS = total dissolved solids
TOC = total organic carbon
TSS = total suspended solids
VOC = volatile organic compound

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Table 3.2
Measurement Quality Objectives

Parameters	Precision (RPD)[1]			Matrix Spike Recovery[2] (%)	Laboratory Control Sample (%)	Duplicate Frequency		Completeness (%)
	Water	Soil	Air			Lab	Field	
Hapsite Mobile Laboratory								
VOCs	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
EPA Fixed-Base Laboratory								
VOCs	≤20	≤50	≤20	lab specified	80-120	1/20	1/10	90
SVOCs	≤20	≤50	NA	lab specified	80-120	1/20	1/10	90
Pesticides	≤20	≤50	NA	lab specified	80-120	1/20	1/10	90
PCBs	≤20	≤50	NA	lab specified	80-120	1/20	1/10	90
Herbicides	≤20	≤50	NA	lab specified	80-120	1/20	1/10	90
TSS	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
TDS	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Phosphorous	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Alkalinity (as $CaCO_3$)	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Chloride	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Iron, Total	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Manganese, Total	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Total Organic Carbon	≤20	≤ 50	NA	lab specified	80-120	1/20	1/10	90
Methane, Ethane, Ethene	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Nitrates/Nitrites (as N)	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Sulfate	≤20	NA	NA	lab specified	80-120	1/20	1/10	90
Phosphorous	≤20	NA	NA	lab specified	80-120	1/20	1/10	90

NA = not applicable

[1] RPD - Relative Percent Difference. The RPD control limits will be used for sample results greater than 5 times the reporting limit.

[2] Laboratory-specified criteria for MS/MSD recoveries and RPDs will be used.

Table 3.3
Preliminary Remediation Goals

Potential Contaminants of Interest	Estimated Quantitation Limits				Groundwater PRGs (µg/L)	Surface Water PRGs		Soil PRGs [1]		Shallow Gas Concentration Corresponding to Indoor Air Concentration (µg/m³)
	EPA Region 7 Laboratory			Hapsite Mobile Laboratory		Acute (µg/L)	Chronic (µg/L)	Residential (mg/kg)	Migration to Groundwater (DAF20) (mg/kg)	
	Soil[4] (µg/kg)	Soil Gas/Air[5] (µg/m³)	Water[6] (µg/L)	Water (µg/L)						
Carbon Tetrachloride	5	1.1	1	5	5	35,200	44.2	0.25[2]	0.066	1.6
Carbon Disulfide	5	1	1	5	250[3]	NE	NE	230[3]	2.0	7,000
Ethylene Dibromide (1,2-Dibromoethane)	5	1.6	0.02[8]	5	0.05	NE	NE	0.0071[3]	0.00026	0.11
Chloroform	5	0.86	1	5	0.19[2]	28,900	1,240	0.30[2]	0.0012	1.1
Dichloromethane (Methylene chloride)	5	0.72	1	5	5	NE	16,000	11[2]	0.023	52
Chloromethane (Methyl chloride)	5	0.36	1	5	1.8[3]	NE	NE	1.8[3]	0.013	24
Malathion	1.1	NA	0.05	NA	180[3]	NE	0.1	310[3]	0.19[2]	NA
2,4-D	1.1	NA	1	NA	70	NE	NE	170[3]	0.094[2]	NA
PCBs[7]	10 to 20	NA	0.4 to 1	NA	0.5	2	0.0017	0.17 to 0.98 [3]	$1.4x10^{-4}$ to $5.2x10^{-2}$ [2]	NA

TBD = to be determined
µg/m³ = micrograms per cubic meter
µg/L= micrograms per liter
µg/kg= micrograms per kilograms
mg/kg= milligrams per kilograms
RSL = Regional Screening Level
PRG=Preliminary Remediation Goal
RG = Remediation Goal
EQL = Estimated Quantitation Limit
VCP = Voluntary Cleanup Program
NE = not established
NA = not applicable
(1) Whenever available, levels associated with carcinogenic risk are listed, otherwise levels associated with non-carcinogenic risks are listed.
(2) EPA RSLs for Chemical Contaminants at Superfund Sites, May 2009
(3) Nebraska VCP RGs
(4) EPA Region 7 RLAB Method 3230.16D, GC/MS Analysis of Low Level Volatile Compounds in a Soil Matrix by Closed System Purge and Trap (Base Methods SW846 5035 and 8260C).
(5) EPA Region 7 RLAB Method 3230.4E, Analysis of Ambient Level Whole Air Samples for Volatile Organic Compounds by GC/MS (Base Methods TO-14, TO-14A, TO-15).
(6) EPA Region 7 RLAB Method 3230.13D, GC/MS Analysis of Low Level Volatile Organic Compounds in an Aqueous Matrix (Base Methods: Method 624, SW846 5030B, and SW846 8260C).
(7) PCBs consist of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Quantitation limits and PRGs vary depending on the arochlor.
(8) EPA Method 504.1, EDB and DBCP in Drinking Water by GC/ECD
Surface Water PRGs are from Nebraska Surface Water Quality Standards, Title 117, March 2009 (NDEQ, 2009).
Groundwater PRGs are from Nebraska Ground Water Quality and Use Classification, Title 118, March, 2006 (NDEQ, 2006a) unless otherwise noted.
Residential Soil PRGs are the lowest goals set from either the EPA RSLs, or the NE VCP RGs (NDEQ, 2006b), as noted.
Soil to Groundwater migration PRGs are Nebraska VCP Remediation Goal (RG) DAF 20 migration to groundwater, unless otherwise noted. If from the EPA RSLs, than the Risk-based SSL for protection of groundwater was used.
Shallow Gas Concentrations and Target Indoor Air Concentrations are from OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance, November 2002 (USEPA, 2002), (Table 2c 10^{-6} Risk Level).

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Table 3.4
Estimated Quantitation Limits
EPA Region 7 Laboratory

Analyte	Estimated Quantitation Limits			
	Soil (μg/kg)[1]	Water (μg/L)	Water – Hapsite (μg/L)	Air (μg/m^3)
Volatile Organic Compounds				
Acetone	25	5	20	5.5
Benzene	5	1	5	1.6
Bromochloromethane	5	1	5	5.5
Bromodichloromethane	5	1	5	5.5
Bromoform	5	1	5	20
Bromomethane	5	1	5	5.5
2-Butanone	25	5	20	5.5
Carbon Disulfide	5	1	5	5.5
Carbon Tetrachloride	5	1	5	5.5
Chlorobenzene	5	1	5	5.5
Chloroethane	5	1	5	5.5
Chloroform	5	1	5	5.5
Chloromethane	5	1	5	5.5
Cyclohexane	5	1	5	5.5
1,2-Dibromo-3-Chloropropane	5	1	5	5.5
Dibromochloromethane	5	1	5	5.5
1,2-Dibromoethane	5	0.02	5	5.5
1,2-Dichlorobenzene	5	1	5	5.5
1,3-Dichlorobenzene	5	1	5	5.5
1,4-Dichlorobenzene	5	1	5	5.5
Dichlorodifluoromethane (Freon 12)	5	1	5	NR
1,1-Dichloroethane	5	1	5	2
1,2-Dichloroethane	5	1	5	5.5
1,1-Dichloroethene	5	1	5	2
cis-1,2-Dichloroethene	5	1	5	2
trans-1,2-Dichloroethene	5	1	5	2
1,2-Dichloropropane	5	1	5	5.5
cis-1,3-Dichloropropene	5	1	5	5.5
trans-1,3-Dichloropropene	5	1	5	5.5
Ethylbenzene	5	1	5	2.2
2-Hexanone	25	5	20	5.5
Isopropylbenzene	5	1	5	5.5
Methyl Acetate	5	1	5	5.5
Methyl tert-butyl ether	5	1	5	5.5
Methylcyclohexane	5	1	5	5.5
Methylene Chloride	20	2	20	5.5
4-Methyl-2-Pentanone	25	5	20	5.5
Styrene	5	1	5	5.5
1,1,2,2-Tetrachloroethane	5	1	5	5.5
Tetrachloroethene	5	1	5	3.4
Toluene	5	1	5	1.9
1,2,3-Trichlorobenzene	5	1	5	5.5
1,2,4-Trichlorobenzene	5	1	5	5.5

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Table 3.4 (continued)
Estimated Quantitation Limits
EPA Region 7 Laboratory

Analyte	Estimated Quantitation Limits			
	Soil (μg/kg)[1]	Water (μg/L)	Water – Hapsite (μg/L)	Air (μg/m^3)
VOCs (continued)				
1,1,1-Trichloroethane	5	1	5	2.7
1,1,2-Trichloroethane	5	1	5	2.7
Trichloroethene	5	1	5	2.7
Trichlorofluoromethane (Freon 11)	5	1	5	NR
1,1,2-Trichlorotrifluoroethane	5	1	5	5.5
Vinyl Chloride	5	1	5	1.3
Total Xylenes	5	1	5	4.4
Semivolatile Organic Compounds				
Acenaphthene	80	2	NA	NA
Acenaphthylene	80	2	NA	NA
Anthracene	80	2	NA	NA
Benzo(a)anthracene	80	2	NA	NA
Benzo(a)pyrene	80	2	NA	NA
Benzo(b)fluoranthene	80	2	NA	NA
Benzo(g,h,i)perylene	80	2	NA	NA
Benzo(k)fluoranthene	80	2	NA	NA
Benzoic acid	400	10	NA	NA
Benzyl alcohol	200	5	NA	NA
bis(2-Chloroethoxy)methane	80	2	NA	NA
bis(2-Chloroethyl)ether	80	2	NA	NA
bis(2-Chloroisopropyl)ether	80	2	NA	NA
bis(2-Ethylhexyl)phthalate	200	5	NA	NA
4-Bromophenyl-phenylether	80	2	NA	NA
Butylbenzylphthalate	200	5	NA	NA
Carbazole	200	5	NA	NA
4-Chloro-3-methylphenol	200	5	NA	NA
4-Chloroaniline	400	10	NA	NA
2-Chloronaphthalene	80	2	NA	NA
2-Chlorophenol	200	5	NA	NA
4-Chlorophenyl-phenylether	80	2	NA	NA
Chrysene	80	2	NA	NA
Di-n-butylphthalate	200	5	NA	NA
Di-n-octylphthalate	200	5	NA	NA
Dibenz(a,h)anthracene	80	2	NA	NA
Dibenzofuran	80	2	NA	NA
1,2-Dichlorobenzene	80	2	NA	NA
1,3-Dichlorobenzene	80	2	NA	NA
1,4-Dichlorobenzene	80	2	NA	NA
3,3'-Dichlorobenzidine	400	10	NA	NA
2,4-Dichlorophenol	200	5	NA	NA
Diethylphthalate	80	2	NA	NA

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Table 3.4 (continued)
Estimated Quantitation Limits
EPA Region 7 Laboratory

Analyte	Estimated Quantitation Limits			
	Soil (μg/kg)[1]	Water (μg/L)	Water – Hapsite (μg/L)	Air (μg/m^3)
2,4-Dimethylphenol	200	2	NA	NA
Dimethylphthalate	80	2	NA	NA
4,6-Dinitro-2-methylphenol	400	10	NA	NA
2,4-Dinitrophenol	400	10	NA	NA
2,4-Dinitrotoluene	80	2	NA	NA
2,6-Dinitrotoluene	80	2	NA	NA
Fluoranthene	80	2	NA	NA
Fluorene	80	2	NA	NA
Hexachlorobenzene	80	2	NA	NA
Hexachlorobutadiene	80	2	NA	NA
Hexachlorocyclopentadiene	80	2	NA	NA
Hexachloroethane	80	2	NA	NA
Indeno(1,2,3-cd)pyrene	80	2	NA	NA
Isophorone	80	2	NA	NA
2-Methylnaphthalene	80	2	NA	NA
2-Methylphenol	200	5	NA	NA
4-Methylphenol	200	5	NA	NA
Naphthalene	80	2	NA	NA
2-Nitroaniline	200	5	NA	NA
3-Nitroaniline	200	5	NA	NA
4-Nitroaniline	400	10	NA	NA
Nitrobenzene	80	2	NA	NA
2-Nitrophenol	200	5	NA	NA
4-Nitrophenol	400	10	NA	NA
N-nitroso-di-n-propylamine	200	5	NA	NA
N-nitrosodiphenylamine	80	2	NA	NA
N-nitrosodiphenylamine	200	2	NA	NA
Pentachlorophenol	80	5	NA	NA
Phenanthrene	80	2	NA	NA
Phenol	80	2	NA	NA
Pyrene	80	2	NA	NA
1,2,4-Trichlorobenzene	80	2	NA	NA
2,4,5-Trichlorophenol	200	5	NA	NA
2,4,6-Trichlorophenol	200	5	NA	NA
Pesticides				
Aldrin	0.6	0.03	NA	NA
A-BHC	0.3	0.01	NA	NA
B-BHC	1	0.06	NA	NA
D-BHC	0.4	0.02	NA	NA
G-BHC	0.4	0.02	NA	NA
Chlordane, technical	4	0.2	NA	NA
p,p'-DDD	1	0.04	NA	NA
p,p'-DDE	1	0.05	NA	NA
p,p'-DDT	1	0.05	NA	NA

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Table 3.4 (continued)
Estimated Quantitation Limits
EPA Region 7 Laboratory

Analyte	Estimated Quantitation Limits			
	Soil (μg/kg)[1]	Water (μg/L)	Water – Hapsite (μg/L)	Air (μg/m^3)
Pesticides				
Dieldrin	0.6	0.03	NA	NA
Endosulfan I	0.6	0.03	NA	NA
Endosulfan II	0.8	0.04	NA	NA
Endosulfan Sulfate	0.8	0.04	NA	NA
Endrin	0.8	0.04	NA	NA
Endrin Aldehyde	1	0.05	NA	NA
Endrin Ketone	0.8	0.04	NA	NA
Heptachlor	0.6	0.03	NA	NA
Heptachlor Epoxide	0.6	0.03	NA	NA
p,p'-Methoxychlor	2	0.08	NA	NA
Toxaphene	20	2	NA	NA
PCBs				
Aroclor 1016	20	1	NA	NA
Aroclor 1221	20	1	NA	NA
Aroclor 1232	20	1	NA	NA
Aroclor 1242	20	0.8	NA	NA
Aroclor 1248	20	0.8	NA	NA
Aroclor 1254	10	0.6	NA	NA
Aroclor 1260	10	0.4	NA	NA
Groundwater Treatment Parameters				
Total dissolved solids (TDS)	NA	10,000	NA	NA
Total suspended solids (TSS)	NA	10,000	NA	NA
Phosphorous, total	NA	1,000	NA	NA
Natural Attenuation Parameters				
Alkalinity	NA	5,000	NA	NA
Chloride	NA	3,000	NA	NA
Sulfate	NA	5,000	NA	NA
Methane, ethane, ethene	NA	5	NA	NA
Nitrate/nitrate (as N)	NA	100	NA	NA
Total organic carbon (TOC)	2,000	100	NA	NA
Iron	NA	10	NA	NA
Manganese	NA	2	NA	NA
Phosphates	NA	1,000	NA	NA

[1] – Actual quantitation limits for soil will vary depending on sample matrix and water content.
μg/L = micrograms per liter
μg/kg = micrograms per kilogram
μg/m^3 = micrograms per cubic meter
NA = not applicable
NR = not reported

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4.0 MEASUREMENT AND DATA ACQUISITION

4.1 SAMPLE PROCESS DESIGN

The sampling process presented in the FSP was designed to meet the DQOs previously discussed in Section 3. Information in this section provides details related to the sample collection to ensure the data are of known and acceptable quality.

4.2 SAMPLING METHOD REQUIREMENTS

Sampling methods include EPA, HGL, and CDM Standard Operating Procedures (SOPs) to ensure samples are collected in a standardized method to ensure they represent actual site conditions. The SOPs are discussed in Section 3 of the FSP (Appendix B of the Work Plan). Information in this section discusses the sample container and collection requirements specific to each analytical laboratory where sample analysis will be performed.

4.2.1 Sampling Equipment and Preparation

Sampling equipment required for the field program (including environmental sampling, health and safety monitoring, equipment and personal decontamination, and general field operations) are listed in Table 3.1 of the FSP.

Field preparatory activities will include:

- Review of the FSP and QAPP and pertinent SOPs by all HGL field personnel
- Conducting a field planning meeting with HGL field personnel to discuss the content of the FSP, QAPP, and HSP and general logistics related to implementing the RI field program
- Procurement of field equipment and supplies.
- Mobilization of the Hapsite mobile laboratory and subcontractors including the DPT, and reverse circulation rotary driller.

4.2.2 Sample Containers

All sample containers will be precleaned and traceable to the facility that performed the cleaning. Sample containers will not be cleaned or rinsed in the field.

Table 4.1 provides the analytical methods, sample containers, preservation requirements, and holding times for the analyses that will be conducted by the EPA Region 7 laboratory. Containers, coolers and preservatives will be provided by the laboratory.

Table 4.2 provides the analytical method, sample containers, preservation requirements, and holding times for the analyses that will be conducted by the Hapsite mobile laboratory. Containers, coolers and preservatives will be provided by the laboratory.

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Table 4.3 provides the analytical methods, sample containers, preservation requirements, and holding times for the geotechnical analyses that will be conducted on soil by a subcontracted geotechnical laboratory and the natural oxidant demand analyses that will be conducted on soil by Carus Chemical Company.

Table 4.4 provides the analytical methods, sample containers, preservation requirements, and holding times for the field test kit analyses that will be conducted on groundwater during monitoring well sampling.

4.2.3 Sample Collection for EPA Hapsite Mobile Laboratory Analysis

The EPA Hapsite mobile laboratory will be used on site for VOC analysis of groundwater samples. The primary activity where Hapsite analysis will be used is for delineation of off-site contamination by quick-turn (24-hour) analysis of groundwater transect samples collected with the DPT. This will allow additional samples to be collected while personnel are still in the field, if necessary, to fully delineate the groundwater plume.

All sample collection procedures are outlined in Section 4 of the FSP. Samples will be delivered to the Hapsite mobile laboratory in 40-milliliter glass vials with HCl preservation and on ice as specified in Table 4.2. Documentation that will be delivered with the samples includes sample labels, field sheets, and chain-of-custody (COC) forms as specified in Section 4.3. Field teams will deliver samples to the Hapsite mobile laboratory as soon as practicable after sample collection.

4.2.4 Sample Collection for EPA Fixed-Base Laboratory Analysis

Samples that will be analyzed by the EPA Region 7 laboratory include VOCs, SVOCs, herbicides, pesticides, and PCBs in soil and groundwater as well as several general chemistry parameters for groundwater treatment and natural attenuation evaluation from monitoring well samples.

Soil samples collected for geotechnical analysis will additionally be submitted to the EPA Region 7 laboratory for analysis of total organic carbon (TOC) and pH.

Sample collection procedures outlined in Section 3 of the FSP will be used to collect these samples in the containers with appropriate preservatives as specified in Tables 4.1 and 4.2. Documentation that will be delivered with samples to the laboratory includes sample labels, field sheets, and COC forms as specified in Section 4.3. Samples will be shipped to the EPA laboratory daily Monday through Thursday for overnight delivery via Federal Express.

4.2.5 Sample Collection for Geotechnical Analysis and Natural Oxidant Demand

Soil samples will be collected for geotechnical analysis from selected DPT and monitoring well locations. Geotechnical analysis will include: grain size distribution, moisture content, soil porosity, bulk density, and permeability. Samples for permeability and bulk density analysis

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must be undisturbed samples collected in a thin-wall, drive tube, such as a Shelby tube. If soil is coarse grained, permeability samples may be submitted as 3 to 5 pounds of soil in zip-top closure bags, rather than in a drive tube. One or more undisturbed samples will be collected during installation of the hydraulic test well, if possible. Bag samples may be collected from DPT borings for permeability and bulk density analysis. Additional detail on required sample containers for the geotechnical samples is included in Table 4.3.

Select soil samples collected for geotechnical analysis will additionally be submitted to Carus Chemical Company for analysis of natural oxidant demand using method American Society for Testing and Materials (ASTM) D7262-07 Test A.

4.2.6 Sample Collection for Field Test Kit Analysis

During monitoring well sampling, selected samples will be analyzed for the presence of biofouling bacteria in the groundwater using BART™ kits. Test kits will additionally be used to analyze carbon dioxide, dissolved oxygen, and ferrous iron in the field from samples selected for monitored natural attenuation (MNA) analysis. Information on the test kits that will be used and analysis instructions are included in Attachment 1.

Additional sample volume will be required from each monitoring well to run test kit analyses. Test kits will be analyzed within the existing field office within a 24-hour period. Information on required containers and preservation for the test kit samples are provided in Table 4.4.

4.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Custody and documentation for field and laboratory work are described below, followed by a discussion of corrections to documentation.

4.3.1 Field Sample Custody and Documentation

The purpose and description of the sample label and the COC record are discussed in the following sections. All identification and tracking procedures for samples will follow EPA Region 7 SOP 2420.5D *Identification, Documentation, and Tracking of Samples*, December 2003.

Sample Labeling and Identification for Fixed-Base EPA Laboratory Samples - An alpha-numeric coding system will uniquely identify each sample collected during the field investigation. For samples that will be shipped to the EPA Region 7 laboratory for analysis, sample numbers will be pre-assigned by EPA laboratory personnel and will be preprinted on sample labels. The sample numbers will consist of a number designating the Analytical Services Request (ASR) number, and a sequential number for each sample (001, 002, etc.).

Quality control samples, including trip blanks, preservation blanks, and equipment rinsate blanks will be identified by an “FB” following the sequential number. Field duplicates will be identified by an “FD” following the sequential number.

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The location of each sample, as well as time and date of sample collections and requested analyses, will be recorded on a field sheet completed for each sample. An example field sheet is provided in Attachment 2 of the FSP.

Sample Labeling and Identification for non-EPA Samples - All pertinent sample information including: the project name, date and time the sample was collected, type of sample (e.g., soil), initials of person(s) collecting the sample, preservative used, and the analysis for which that sample is being submitted will be annotated on the sample label. The labels will be filled out with indelible ink, affixed to the appropriate sample containers and covered with clear cellophane tape.

An alphanumeric coding system will identify each sample collected during the field program that is not analyzed by the EPA Region 7 laboratory in Kansas City, Kansas. This will include samples delivered to the Hapsite mobile laboratory for onsite analysis. The coding system will provide a tracking record to allow retrieval of information about a particular sample and to ensure that each sample is uniquely identified. Sample numbers will correlate with locations to be sampled.

Sample identifications will consist of four sets of characters with a dash (-) separating each set in the general form:

GVY0U1-YY###-ZZ-###
GVY0U2-YY###-ZZ-###

The first set of characters indicates that the sample is from either the Garvey Elevator OU1 or OU2 site. Generally, this will mean collected on the Garvey Elevator property or off the Garvey Elevator property.

The second set of symbols (YY) identifies the sample location followed by a sequential number (SB001, MW010, etc.)

SB	=	Soil boring
SG	=	Subslab sample (soil gas)
DF	=	Intermittent drainage feature
IA	=	Indoors (air sample)
OA	=	Outdoors (air sample)
TS	=	Groundwater transect
MW	=	Monitoring well
HW	=	Hydraulic test well
WA	=	investigation derived waste

The third set of letters (ZZ) will indicate the sample matrix as follows:

GW	=	Groundwater
SL	=	Soil
SD	=	Sediment
SW	=	Surface water

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SG = Soil Gas
AR = Indoor or Outdoor Air

The fourth set of characters (###) represents the depth in feet bgs of the top of the sample interval. Three digits should be used for this number in all cases (i.e. 001, 012, 048).

Note: the complete sample depth interval, date and time of sample collection, along with any split sample IDs of samples shipped to the EPA laboratory will be noted on the field sheet.

The following are two sample identification number examples:

- GVYOU1-SB001-SL-005. This sample was taken from the Garvey Elevator Site OU1 from DPT soil boring location 001. It was a soil sample collected at a depth interval starting at 5 feet below ground surface (bgs).
- GVYOU2-TS202-GW-110. This sample was taken from Garvey Elevator OU2 along Transect 2 in the second boring. The sample was a groundwater sample, where the top of the screen was at 110 feet bgs.

Chain-of-Custody Requirements - COC procedures will follow the requirements set forth in EPA Region 7 SOP 2420.4C, Field Chain of Custody for Environmental Samples, December 2003. The COC record is employed as physical evidence of sample custody and control. This record system provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. An example COC record is included with the field forms in Attachment 2 of the FSP.

The COC record is initiated with the acquisition of the samples and remains with the sample at all times. The COC includes the name of the field personnel assuming responsibility for the samples and documents transfer of sample custody. To simplify the COC record and eliminate sample custody questions, as few people as possible should handle the samples during the investigation.

A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession
- The sample is within the sampler's view after being in possession
- The sample was in the sampler's possession and then was locked up to prevent tampering
- The sample is in a designated secure area

A separate COC record will be completed for samples based on which laboratory will be conducting the analysis. Samples for non-EPA laboratory analysis will be recorded on a separate COC from samples for EPA laboratory analysis.

In addition to the COC record, custody seals are used to maintain the custody of samples during shipment. Custody seals are adhesive seals placed on items (such as sample shipping containers) in such a manner that if the sealed item is opened, the seal would be broken. The

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COC seal provides evidence that no sample tampering occurred between shipment of the samples and receipt of the samples by the laboratory.

Records concerning the cleanliness of empty sample containers, container shipment from the laboratory to the site, and security of empty containers at the site also will be maintained in the project file.

COC Forms for EPA Laboratory Samples - A copy of the COC included in Attachment 2 of the FSP will be completed by hand for each sample that will be submitted to the EPA Region 7 laboratory for analysis. The COC will be completed by the field sampling team. The field sampler will sign off on the COC when the samples are relinquished to the Sample Coordinator in the field office for packaging and shipping of the samples to the EPA laboratory (see Section 4.3.2 for these procedures). The Sample Coordinator will sign the COC when accepting custody of these samples, and shall relinquish custody to Federal Express for shipment by noting "FedEx" and the FedEx air bill number on the COC form. The COC shall be shipped to the EPA laboratory with the samples, and a copy of the COC shall be maintained inside the field office.

Hard copy COC forms will additionally be used for samples delivered to the Hapsite mobile laboratory and other non-EPA off-site analyses including geotechnical soil analysis and soil analysis for natural oxidant demand.

4.3.2 Sample Packaging and Shipping

Samples will be packaged and shipped promptly after collection. When sent by common carrier, packaging, labeling, and shipping of hazardous materials are regulated by the U.S. Department of Transportation (DOT) under Code of Federal Regulations (CFR) 49, Part 172. Samples will be handled, packed, and shipped in accordance with CDM SOP 2-1, *Packaging and Shipping of Environmental Samples* (Attachment 1 of the FSP), which includes applicable DOT requirements.

Key steps for packaging samples for shipment are outlined below.

1.) Wrap glass containers in bubble wrap to protect them during shipment. Enclose and seal labeled sample containers in appropriately sized plastic zip-top bags. VOC samples shipped to the EPA Region 7 laboratory will be containerized inside a 1 liter (L) polyethylene cubitainer with a charcoal thimble.

2.) Place a large plastic garbage bag into a sturdy cooler in good repair. Place 2 to 4 inches of Styrofoam peanuts or bubble wrap into the plastic bag. Place the sample containers in the bag with sufficient space to allow for the addition of more packing material and ice between the sample containers.

3.) Place ice in large sealed, double-bagged zip-top plastic bags. Place the ice on top of and/or between the samples. Fill all remaining space between the sample containers with packing material. Enough bagged ice should be included to maintain the samples at 4 $^{\circ}$C until the cooler arrives at the laboratory. Seal the top of the garbage bag with fiber or duct tape.

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4.) Complete shipping/sample documentation including air bill shipment forms for each cooler. Seal COCs inside a waterproof plastic bag and tape the bag inside the shipping container lid. Include a return address for the cooler.
5.) Close the shipping container, affix signed and dated custody seals, and seal the cooler with nylon fiber strapping tape.

All samples will be shipped by an overnight delivery service (i.e. Federal Express) to the designated laboratory. The off-site laboratories only receive samples Monday through Friday, so samples will be shipped Monday through Thursday only. A copy of each air bill will be retained in the field office, and the air bill number will be recorded in a site logbook so the cooler can be easily tracked.

4.3.3 Field Logbook(s) and Records

Field Logbooks - An important element of field documentation is the proper maintenance by field personnel of the site-specific field logbooks. Field logbook(s) will be maintained by the field team in accordance with the SOP *Field Logbook Content and Control* (Attachment 1 of FSP). The logbook is an accounting of the accomplishment of scheduled activities, and will duly note problems or deviations from the governing plans and observations relating to the field program. Logbooks will be kept in the field team member's possession or in a secure place when not being used. The field team leader will periodically check logbook entries to make sure the required information is present as specified in the SOP.

Field Forms - In addition to the field logbooks, field forms will be used to record sampling activities and measurements taken in the field. Field forms to be used during this project are included in Attachment 2 of the FSP. Information included on the field sheets will not be repeated in the field logbook. Each completed field sheet will however, be referenced in the field logbook, as appropriate. Field forms include the following:

- Soil boring log
- Well development log
- Well purging and sampling form
- Water level measurement form
- Daily health and safety meeting record
- Equipment calibration records
- EPA field sheet
- Environmental Quality Information System (EQuIS) sample field sheet
- Field change request form
- Nonconformance report

At the conclusion of site activities or when the logbook is filled, the logbook will be incorporated into the project file as part of the document control procedure. Documents in the project file will be retained in a secure location at HGL's Lenexa, Kansas, office for a period of 10 years beyond the end date of the AES contract.

Information recorded on the EQuIS sample field sheets will be entered into the EQuIS database

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along with the analytical results. All hand entries will undergo a 100 percent QC check.

Photographs - Field activities and sampling points will be documented using a digital camera in accordance with CDM SOP 4-2, *Photographic Documentation of Field Activities* (Attachment 1 of the FSP). Photographs will be maintained in the project files. For each photograph, the following items will be noted in a photographic record recorded the applicable field logbook:

- Date of photograph
- Time of photograph
- Signature of the photographer
- Identification of the site or sample by sample number
- General direction the photograph is oriented
- Sequential number of the photograph recorded on the disk

Drilling Documentation - All soil borings and well boreholes will be lithologically logged in accordance with CDM SOP 3-5, *Lithologic Logging* (Attachment 1 of the FSP) using the drilling log form included in Attachment 2 of the FSP.

Construction details for each newly constructed monitoring well will be carefully recorded in the field logbook. Well construction diagrams will be prepared from this information for inclusion in the RI report. Drilling documentation will be maintained in the project files for a period of 10 years after completion of the project.

EC Logging - EC logging will be conducted by a DPT subcontractor. EC logs will be produced for each location that is logged and provided to the HGL geologist working with the EC field crew. The geologist will review the logs versus VOC sample results from nearby soil borings. The EC logs will be provided in the RI report.

Flowmeter Logging - As part of the sampling activities for the RI field investigation, the EPA TOPO will perform dipole flow testing in the hydraulic test well. The dipole flow test (DFT) is capable of providing reliable estimates of hydraulic conductivity on a small scale. Multiple tests can be performed in a well with a long screen to obtain a vertical profile of hydraulic conductivity. The EPA will provide the equipment supplies, and procedure to perform the flow testing. The EPA TOPO will conduct the DFT, with assistance provided by HGL as needed. The number of DFTs and the depths at which they will be performed will be determined by EPA. Selected off-site 4-inch monitoring wells may also be tested.

Slug Testing - The RI field investigation activities will include aquifer testing using the slug out method on select monitoring wells. The slug test is capable of providing reliable estimates of hydraulic conductivity on a small scale. A data logger and electronic water level indicator will be utilized to collect the water level data during the slug test. Based on these readings, the hydraulic conductivity will be calculated using an appropriate method based on the aquifer configuration. The number of tests performed will be determined based on subsurface conditions encountered during the well installation activities. The slug test data and results will be presented in the RI Report.

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4.3.4 Laboratory Custody Procedures and Documentation

Laboratory custody procedures are provided in each laboratory's QA Manual. Upon receipt at the laboratory, each sample shipment will be inspected to assess the condition of the shipping cooler and the individual samples. This inspection will include measuring the temperature of the cooler (if cooling is required) to document that the temperature of the samples is within the acceptable criteria (4 $\pm$ 2 ^{o} C) and verifying sample integrity. The pH of the samples will be measured, if preserved. The enclosed COC record(s) will be cross-referenced with all of the samples in the shipment. Laboratory personnel will then sign these COC records and copies provided to HGL will be placed in the project file. The sample custodian may continue the COC record process by assigning a unique laboratory number to each sample on receipt. This number, if assigned, will identify the sample through all further handling. It is the laboratory's responsibility to maintain internal logbooks and records throughout sample preparation, analysis, data reporting, and disposal.

4.3.5 Correction to and Deviations from Documentation

The procedures for correcting erroneous field entries are described in the SOP *Field Logbook Content and Control*, included in Attachment 1 of the FSP. If required, a single strikeout initialed and dated is required to document changes. The correct information should be entered in close proximity to the erroneous entry. The same procedure will be used on field logbooks, field sheets and COC records.

Any deviations from the guidance documents (FSP, QAPP, SOPs) will be recorded in the appropriate field logbook. A field change request form included in Attachment 2 of the FSP will be completed prior to implementing the deviation. The field change request form will be signed by the FTL and TOM. Significant deviations will additionally require signature by the EPA TOPO before the deviation is implemented. Completed field change request forms will be included and discussed in the RI report.

4.4 ANALYTICAL METHOD REQUIREMENTS

4.4.1 Laboratory Quality Assurance Program

Samples collected during this project will be analyzed in accordance with standard EPA and/or nationally-accepted analytical procedures. The laboratory will adhere to all applicable QA/QC requirements stated in the applicable method and its laboratory QA Plan.

4.4.2 Methods for Laboratory Analysis

Analytical methods that will be used by the EPA Region 7 laboratory, Hapsite mobile laboratory, test kit analysis, and other off-site laboratories are specified in Tables 4.1, 4.2 4.3, and 4.4.

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4.5 QUALITY CONTROL REQUIREMENTS

4.5.1 Field Quality Control Samples

Field QC samples will be used to gauge the accuracy and precision of field collection activities. QC samples will be submitted to the EPA Region 7 laboratory and include field duplicates, preservative blanks, trip blanks, and equipment rinsate blanks. Tables 2.1, 2.2, and 2.3 of the FSP provide information on the number and types of analyses that each laboratory is anticipated to perform, along with the number of QC samples that will be collected.

Field Duplicates - Field duplicate samples are collected and analyzed to assess the overall precision of the field sample collection. These duplicates will be submitted "blind" to the laboratory by using sample numbers that are different from their associated environmental sample. Duplicate samples will be collected at a frequency of 10 percent. The RPD criteria for water is less than or equal to 20, and the RPD criteria for soil is less than or equal to 50. Field duplicate samples will be collected in the same manner and from the same location as the primary sample, and will be submitted for identical analysis. These duplicates will be collected at a frequency of 10 percent for the soil and groundwater matrices. Field duplicates will be submitted to both the EPA fixed-base laboratory and the Hapsite mobile laboratory.

Trip Blanks - One trip blank will be included in each cooler shipped to the EPA laboratory containing VOC samples to assess whether any cross-contamination is occurring between samples during sample handling and transport. Trip blanks will be submitted for VOC analysis only. All trip blank samples will be prepared by the laboratory, and will be transported to the field with the VOC sample containers, and returned to the laboratory with the VOC samples for analysis.

Equipment Rinsate Blanks - Equipment rinsate blanks will be collected to assess the effectiveness of equipment decontamination procedures. Following decontamination procedures, the rinsate blank will be collected by pouring de-ionized water through or over the equipment and collecting this rinse in the appropriate container. One equipment blank will be collected for each type of sampling equipment. If any detections are noted in the blanks, the decontamination procedure will be evaluated and another equipment blank will be collected. The impact of the detections on the subsequent sample results will be determined.

4.5.2 Laboratory Quality Control Samples

The laboratory will adhere to all analytical and QC requirements specified in SW-846 Method 8260B. The purpose of using standard EPA-approved procedures is to provide analytical data of known quality and consistency.

Laboratory QC samples will include continuing calibration checks, method blanks, laboratory control samples, laboratory duplicates, surrogate spikes, and matrix spikes are required by the analytical method. Laboratory QC data are necessary to determine precision and accuracy and

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to demonstrate the absence of interferences and/or contamination. Each type of laboratory QC sample will be analyzed at a rate of 5 percent (1 per every 20 samples), or one per batch, whichever is more frequent. Surrogates are spiked into every VOC sample before analysis to gauge adequate recovery.

A description of each type of laboratory QC sample is provided below:

Calibration Check Samples - One of the working calibration standards (typically the mid-point standard) that is periodically used to check that the original calibration is still valid (e.g., continuing calibration standard).

Method Blanks - Method blanks contain all the reagents used in the preparation and analysis of samples and are processed through the entire analytical sequence to assess spurious contamination arising from reagents, glassware, or instrument carry-over introduced during the analysis.

Laboratory Duplicates - A duplicate aliquot taken from the same sample is carried through the entire preparative and analytical sequence. Duplicate samples will also be received from the field. The results of the laboratory and field duplicate samples are used to estimate the precision of the analytical procedures.

Spiked Samples - Known amounts of a particular constituent are added to high purity laboratory-grade water or solvent, or to a field sample. The percent recovery of the added amount is used to estimate the accuracy of the analytical procedure. If laboratory-grade water or solvent is spiked, the resulting sample may be called a laboratory control sample or blank spike. If a field sample is spiked, the resulting sample is a matrix spike or surrogate spike.

Laboratory Control Sample (LCS) - This sample is usually prepared from EPA Environmental Monitoring Systems Laboratory (EMSL) concentrates or National Institute of Standards and Technology (NIST) standard reference materials. LCSs are used to establish that an instrument or procedure is in control. An LCS is carried through the entire sample preparation and analysis procedure. These samples provide an indication of whether the laboratory processes are in control, in the absence of matrix effects.

Matrix Spike (MS) - One field sample (submitted to the laboratory as a triple volume sample) is divided into three aliquots. One aliquot is analyzed as is (without spiking) and the remaining two aliquots are spiked and analyzed. The percent recovery of the known spikes provides information on the accuracy of the analysis, matrix interferences, and provides an indication of the suitability of the method for the matrix.

Matrix Spike Duplicate (MSD) - When two aliquots are spiked, the analytical results provide information on analytical precision as well as accuracy and matrix interferences.

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Surrogate Spikes - Samples requiring analysis by gas chromatography/mass spectrometry (GC/MS) are routinely spiked with a series of deuterated analogues of the compounds of interest. These compounds are used to assess the behavior of actual analytes in individual project samples during the entire preparation and analysis sequence. Surrogate spike recoveries are also used to assess accuracy of the analysis.

The EPA fixed-base laboratory and Hapsite mobile laboratory will analyze laboratory QC samples in accordance with its in-house QA plan and method requirements. MQOs related to laboratory precision and accuracy resulting from analysis of these samples were discussed in Section 3.

4.6 EQUIPMENT MAINTENANCE PROCEDURES

All equipment will be maintained in accordance with manufacturer's instructions. All rental equipment will be inspected upon receipt to ensure the item complies with its intended use and is functioning properly. Nonconforming items will be identified and segregated using documentation to prevent inadvertent use. Other items may be identified as nonconforming during routine observation, inspection, or testing. These items will be replaced, and the nonconforming item returned to the vendor.

4.7 INSTRUMENT CALIBRATION PROCEDURES AND FREQUENCY

4.7.1 EC Probe

The DPT will be equipped with an EC probe so that a continuous log of soil conductivity can be recorded. The EC will be calibrated, and borings will be conducted in accordance with the current Geoprobe® Systems Standard Operating Procedure (SOP), Technical Bulletin MK3010, May 2003, which is included in Attachment 1 of the FSP. EC logs will be compared with visual lithologic logs to verify the EC response.

4.7.2 Field Equipment

Equipment handling and calibration procedures will follow the manufacturer's instructions and CDM SOP 5-1, *Control of Measurement and Test Equipment* included in Attachment 1 of the FSP. Each piece of field equipment used for measuring or monitoring will be calibrated daily and properly maintained to assure accuracy within specified limits. Any noted deficiencies will be resolved per CDM SOP 5-1 and manufacturer recommendations. Daily calibration will be documented on the applicable Equipment Calibration Log Form included in Attachment 2 of the FSP.

Field equipment will include the following:

- Multi-parameter water quality meters
- Turbidity meters
- Photoionization detectors
- LEL/oxygen meters

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4.7.3 Laboratory Equipment

Calibration of laboratory equipment will be based on written procedures approved by laboratory management and included in the laboratory's QA plan. Instruments and equipment will be initially calibrated and subsequently continuously calibrated at approved intervals, as specified by either the manufacturer or more frequent requirements (e.g., methodology requirements). Calibration standards used as reference standards will be traceable to the EPA, NIST, or another nationally recognized reference standard source.

Records of initial calibration, continuing calibration and verification, repair, and replacement will be maintained by the laboratory where the work is performed.

4.8 ACCEPTANCE REQUIREMENTS FOR SUPPLIES

Prior to acceptance, all supplies and consumables will be inspected to ensure that they are in satisfactory condition and free of defects. If defects are noted, the item will be replaced. HGL personnel will inspect all supplies and consumables provided by subcontractors.

4.9 NONDIRECT MEASUREMENT DATA ACQUISITION REQUIREMENTS

Non-direct measurement data include information from site reconnaissance, ecological surveys, literature searches, and interviews. The acceptance criteria for such data include a peer review of this data documentation by someone other than the author. Any non-direct measurement data obtained from secondary sources such as literature searches or interviews will determine further action at the Garvey Elevator Site only to the extent that those data can be verified.

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TABLES

Table 4.1
Analytical Methods and Sample Preservation, Holding Time, and Container Requirements
EPA Region 7 Laboratory

Analytical Parameter	Sample Matrix	Analytical Method	Sample Preservation	Holding Time[1]	Containers
Soil and Sediment					
VOCs	Soil	SW-846 5035/8260B	20% $NaHSO_4H_2O$; Cool to 4°C	14 days	Four 40-mL glass vials with Teflon septa (2 preserved with 5g plug of soil; 2 tightly packed with no preservative); one 4-oz glass jar for moisture content
SVOCs	Soil	SW-846 8270C	Cool to 4°C	14 days / 40 days	One 8 oz. glass jar
Pesticides including Malathion	Soil	SW-846 8081 & 8141	Cool to 4°C	14 days / 40 days	One 8 oz. glass jar
PCBs	Soil	SW-846 8082	Cool to 4°C	14 days / 40 days	One 8 oz. glass jar
Herbicides	Soil	SW-846 8151	Cool to 4°C	14 days / 40 days	One 8 oz. glass jar
pH	Soil	SW-846 9045	Cool to 4°C	NA	One 4-oz glass jar
Total Organic Carbon	Soil	EPA 415.1 (Lloyd Khan)	Cool to 4°C	28 days	One 4-oz glass jar
Groundwater					
VOCs	Water	EPA 624	HCl to pH <2; Cool to 4°C	14 days	Four 40-mL glass vials with Teflon septa
EDB	Water	EPA 504.1	HCl to pH <2; Cool to 4°C	14 days	Four 40-mL glass vials with Teflon septa
SVOCs	Water	EPA 625	Cool to 4°C	7 days / 40 days	One 1-L amber glass bottle
Pesticides including Malathion	Water	EPA 608	Cool to 4°C	7 days / 40 days	One 1-L amber glass bottle
PCBs	Water	EPA 608	Cool to 4°C	7 days / 40 days	One 1-L amber glass bottle
Herbicides	Water	SM 6640	Cool to 4°C	7 days / 40 days	One 1-L amber glass bottle
Alkalinity	Water	EPA 310.1	Cool to 4°C	14 days	One 500-mL polyethylene cubitainer
Chloride	Water	EPA 300.0	Cool to 4°C	28 days	One 500-mL polyethylene cubitainer
Sulfate	Water				

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Table 4.1 (continued)
Analytical Methods and Sample Preservation, Holding Time,
and Container Requirements
EPA Region 7 Laboratory

Analytical Parameter	Sample Matrix	Analytical Method	Sample Preservation	Holding Time[1]	Containers
Groundwater					
Methane, ethane, ethene	Water	RSK-SOP 175	HCl to pH <2; Cool to 4°C	14 days	Two 40-mL glass vials with Teflon septa
Iron, total	Water	SW-846 6010B	HNO_3 to pH <2; Cool to 4°C	6 months	One 500-mL polyethylene cubitainer
Manganese, total	Water				
Nitrates/Nitrites (as N)	Water	EPA 353.2	H_2SO_4 to pH <2; Cool to 4°C	28 days	One 250-mL polyethylene cubitainer
Total Organic Carbon	Water	EPA 415.1	HCl to pH <2; Cool to 4°C	28 days	Three 40-mL glass vials with Teflon septa
Phosphorous, total	Water	EPA 365.3	H_2SO_4 to pH <2; Cool to 4°C	28 days	One 250-mL polyethylene cubitainer
TSS	Water	160.2	Cool to 4°C	7 days	One 1-L polyethylene cubitainer
TDS	Water	160.1	Cool to 4°C	7 days	One 1-L polyethylene cubitainer
Soil Gas/Air					
VOCs	Air	TO-15	None	30 days	4-L Summa Canister

°C = degrees Celsius
HCl = hydrochloric acid
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
L = liter
mL = milliliter
NA = not applicable
$NaHSO_4H_2O$ = sodium bisulfate
oz = ounce
[1] - Holding time is given as number of days prior to extraction / number of days prior to analysis. Dates from day and time of sample collection.

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Table 4.2
Analytical Methods and Sample Preservation, Holding Time,
and Container Requirements
EPA Hapsite Mobile Laboratory

Analytical Parameter	Sample Matrix	Analytical Method	Sample Preservation	Holding Time	Containers
Water					
VOCs	Water	EPA 624	HCl to pH <2; Cool to 4°C	14 days	Two 40-mL glass vials with Teflon septa

°C = degrees Celsius
HCl = hydrochloric acid
mL = milliliter

Table 4.3
Analytical Methods and Sample Preservation, Holding Time,
and Container Requirements
Geotechnical Laboratory and Carus Chemical Company

Analytical Parameter	Sample Matrix	Analytical Method	Sample Preservation	Holding Time	Containers
Soil					
Permeability	Soil	ASTM D 5084	None	NA	One 8-inch long soil sample tube, undisturbed[1]
Porosity	Soil	NA[2]	None	NA	NA[2]
Grain size sieve and hydrometer test	Soil	ASTM D 422/ ASTM D 423	None	NA	Two 8-oz glass jars
Moisture content	Soil	ASTM D 2216	None	NA	One 4-oz glass jar
Bulk density	Soil	ASTM D 1895B	None	NA	One 8-inch long soil sample tube, undisturbed
Natural Oxidant Demand	Soil	ASTM D7262-07 Test A	None	NA	One 250-mL and one 500-mL wide mouth glass jars with Teflon™-lined screw cap
Maximum Index Density and Unit Weight using a Vibratory Table	Soil	ASTM D4253	None	NA	1 cf bag or bucket sample

ASTM = American Society for Testing and Materials
NA = not applicable
mL = milliliter
oz = ounce
[1] - If soil is coarse grained, 3-5 pounds of soil can be submitted in ziplock bags, rather than a drive tube.
[2] - Porosity - calculated using results from moisture content, density, and specific gravity. No additional soil is needed.

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Table 4.4
Analytical Methods and Sample Preservation, Holding Time, and Container Requirements
Field Test Kits

Analytical Parameter	Sample Matrix	Analytical Method	Sample Preservation	Holding Time	Containers
Groundwater – Test Kit Analyses					
Carbon dioxide	Water	HACH 8233	Cool to 4°C	24 hours	One 1-L polyethylene cubitainer
Ferrous iron	Water	HACH 8146			
Dissolved oxygen	Water	HACH or Chemetrics	NA	Analyze immediately	Provided with kit
Biofouling bacteria	Water	DN-BART, N-BART, IRB-BART, SRB-BART, and SLYM-BART	NA	Analyze immediately	Provided with kits

BART = biological activity reaction test
°C = degrees Celsius
DN = denitrifying bacteria
IRB = iron related bacteria
L = liter
N = nitrifying bacteria
NA = not applicable
SLYM = slime forming bacteria
SRB = sulfate reducing bacteria

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5.0 ASSESSMENT AND OVERSIGHT

5.1 ASSESSMENTS AND RESPONSE ACTIONS

Assessments are project reviews that may include audits, surveillances, technical, management, or peer reviews. Assessments are conducted to access compliance with the requirements of the HGL Quality Program, project-specific planning documents such as the FSP and QAPP, or other client or regulatory requirements. The assessment may cover technical, safety, administrative, or regulatory subjects, as required (HGL, 2005).

Assessments may be independent or self-assessments of the internal quality systems, or may be technical reviews for the task to be evaluated. Audits, which are a type of assessment, shall be conducted by personnel who do not have responsibility for performing the activities being audited such that the auditor has the organizational freedom, authority, and capability to identify problems and perform effective assessments (HGL, 2005).

The QA Manager will schedule audits or other assessments as dictated by project activities. The QA Auditor will be appropriately trained and deemed qualified by the QA Manager to perform the audit (HGL, 2005).

The results of assessments shall be documented and reported to the QA Manager. Nonconforming conditions needing corrective action shall be identified and corrective actions performed promptly. Corrective actions implemented in the field shall be recorded in the applicable field logbook and verbally reported to the field team leader. Corrective actions shall be evaluated to ensure adequate effectiveness and proper completion, documented, and reported to the QA Manager. The QA Manager will report deficiencies and corrective actions to the President, as appropriate (HGL, 2005).

One field audit and one health and safety audit have been planned for this project.

5.2 REPORTS TO MANAGEMENT

Reports will be generated for all QA audits that are conducted and provided to the QA Manager. Reports will include deficiencies that were noted during the audit and corrective actions that were planned or implemented.

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6.0 DATA VALIDATION AND USABILITY

6.1 QUALITY CHECK OF EPA DATA

Analytical data packages will be received from the EPA laboratory in both hard copy and electronic data deliverable (EDD) format for uploading into the EQuIS database. Hard copy reports and EDDs will be provided for both the fixed-base laboratory results and the Hapsite results. EPA will validate its own data prior to providing it to HGL. The project chemist or designee will perform a quality check of the EPA results by reviewing sample numbers versus COCs and EPA field sheets for consistency and completeness, reviewing any qualifiers added by the EPA validator to determine usability of the results, and reviewing results of field QC samples such as field duplicates, trip blanks, or rinsate blanks that are submitted to the EPA fixed-base laboratory or Hapsite mobile laboratory for analysis.

6.2 RECONCILIATION WITH USER REQUIREMENTS

6.2.1 DQO Reconciliation

After the data quality reviews and validation are complete, HGL will determine if and which data are usable for their intended purposes based on the DQOs that have been established for this project. Reconciliation with the DQOs and overall project objectives will be discussed in the RI report.

6.2.2 Data Reduction and Tabulation

Data reduction and tabulation will be performed using the various data that have been uploaded into the EQuIS database during the course of the RI field program as described in Section 7.

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7.0 DATA MANAGEMENT

7.1 INTRODUCTION

The sample collection activities to be conducted at this site will generate fixed laboratory data from the analysis of samples from multiple media; survey data; field measurements; and other site-derived information. The resulting data will be entered into a single data management system for consistency in tracking samples; storing and retrieving data; evaluating analytical results; and generating data tables, figures, and reports. The Data Management Plan (DMP) presented in this section was prepared to assist in implementing a successful data management strategy. The DMP is augmented by the requirements and procedures for field sample collection detailed in the FSP, and the sampling and analytical methodologies detailed in the QAPP.

7.1.1 Objectives of Data Management Plan

Successful data management results from coordinating data collection, control, storage, access, reduction, evaluation and reporting. This DMP documents the methodology that will be employed during project execution to link the various data management tools, including software packages, to assure that the various data and information types to be collected are systematically collected and managed.

The specific objectives of this DMP are:

- Standardize and facilitate the collection, formatting, and transfer of project data into the data management system and components.
- Provide a structured data system that will support the end uses of the data, including planning, decision making and reporting. (Note: The end uses of the data are detailed in Section 3.2.1 of the QAPP.)
- Minimize the uncertainties associated with the data, data-derived products, and interpretation of results through defined QC measures and documented processes, assumptions and practices.
- Provide data that are adequately documented with descriptive information for technical defensibility and legal admissibility of the data.

7.1.2 Data Management Team Organization

A data management team has been established for the Garvey Elevator Site. The team will work together to properly execute the DMP and ensure that the project objectives and scope are realized. The team is composed of specialists in each related discipline and technical resource. The PM is an integral part of the data management team, and has overall responsibility for assuring the data are collected in accordance with the EPA-approved FSP and QAPP. The members of the data management team are as follows:

- Project Manager
- Data Manager (DM)

- Field Team Leader (FTL)
- Project Geologist
- Project Chemist
- Sample Manager (SM)
- Database Administrator (DBA)
- GIS Developer
- Modeler

The functional responsibilities of the data management team are described in Section 7.1.3. One person may perform multiple roles on a project depending on the level of data to be managed and analyzed.

7.1.3 Roles and Responsibilities of Data Management Team

The responsibilities of the members of the data management team are summarized below. Should the scope of the data require a division of labor, the TOM in consultation with the Data Manager will determine assignments as appropriate to assure the best work flow.

Team Member	Roles and Responsibilities
Task Order Manager	• Responsible for preparing the work plan, schedule and milestones. • Coordinates efforts with the EPA TOPO. • Determines the needs and objectives for tasks. • Assigns appropriate personnel to review data deliverables and complete the project. • Ultimately responsible for the completion of the project.
Data Manager (DM)	• Coordinates, documents and reports on all data management activities. • Acts as a liaison between the data users and the data holders, making certain that data are provided to those who need it in the appropriate format. • Loading EDDs into EQuIS.
Field Team Leader (FTL)	• Responsible for the collection and documentation of all field generated data. • Reports collection efforts and information to the Sample Manager.
Project Geologist	• Provides field geological data to the DM as required to populate the geological fields within EQuIS database. • Prescribes the database input and output data formats as required to support the function of specialized geological software to create logs, borings, and other customized products.
Project Chemist	• Works with Subcontracts Manager to develop the scope of work for laboratory subcontracts. • Assists the SM in communicating with laboratories and data validators as needed. • Performs quality checks of the data deliverables. • Assists in the definition of regulatory criteria and threshold values, and maintains the regulatory criteria in the database. • Provides assistance to the PM and technical staff in interpreting analytical results.

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Team Member	Roles and Responsibilities
Sample Manager	• Responsible for tracking samples from collection through analysis to their inclusion in the project database. • Conducts QC checks between anticipated collection and actual collection; the accuracy of documentation; submission to and receipt from laboratories; and submission to the DBA.
Database Administrator (DBA)	• Has overall responsibility for the operation and maintenance of the project database. • Responsible for the implementation and evaluation of standard operating procedures to ensure integrity of the database system.
GIS Developer	• Creates the GIS project including geographical features and area characteristics. • Incorporates analytic data through query functionality.

7.1.4 Data Management Process Model

The Data Management Process Model is provided as Figure 7.1. At the early planning stage of the Garvey Elevator project, the data sources, required tools, and end uses of the data were identified and were used to develop this site-specific Data Management Plan.

QC steps are implemented at each step of the data flow in which data undergoes a transformation. Transformations include conversion from hardcopy to electronic form, uploads to the database, output queries from the database, etc. After each process step, a 10 percent QC check is performed of the transformed data against the original data set to ensure that no data was corrupted or lost. The major QC steps are numbered and listed on the process flow diagram.

The Data Management Process Model illustrates the following core concepts of the data management process:

- The top line of the diagram illustrates the overall path of data, regardless of type, through the timeline of the project.
- The DM oversees the transfer of data from one member of the data management team to another and serves as the link between each step in the process and each identified party in the diagram.
- The many sources and uses for the data are reduced to a single input and output line to demonstrate that all data passes through a single repository to minimize the chance that data is duplicated or lost.

The post-processing (analysis) and reporting phases of the DMP are shown together on the diagram, illustrating that the majority of deliverables are generated from the analysis of data and those who conducted that analysis. The DM is responsible for providing to the staff responsible for the analysis of the data both the data needed and a clear list of the output required. The DM is not, in most cases, involved in the creation of deliverables from analyzed data, but rather checks the completed deliverables against the scope and FSP to ensure that they are complete.

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7.2 EQUIS DATABASE

The project data will be stored in an EQuIS database (EPA Region 5 version). EQuIS is a product of Earthsoft Inc. and is a broad data structure with a robust toolset with compatibility with multiple peripheral software packages. It is an industry standard both for contractors and regulators that has a positive usage record, as well as the longevity and stability to support a project of this scope.

7.2.1 Data Collection

All analytical sample data generated during the RI field program will be received as an EDD for direct upload into the database. Other data collected such as historical sample information and results, geotechnical analyses, field parameter readings also will be loaded into the database. EQuIS-required content of an EDD is provided as Attachment 2.

7.2.1.1 Data Tracking Sheets

Once data have been collected, sample result packages will be checked by the DM for completion and entered onto a sample tracking sheet by the SM. A sample tracking sheet will inventory samples collected and determine which results have not been received from the laboratory. COC forms generated for sample delivery to the laboratories will assist in the completion of sample tracking sheets. If data are missing, the DM will contact the appropriate laboratory coordinator to obtain electronic/hard copies of the missing data.

7.2.1.2 Database Log

During the data manipulation process, the DM will maintain a database log updated with project-specific assumptions and changes made.

7.2.2 Pre-Processing of Non EDD Data

All data not received as an EDD will be entered into an appropriate EDD in order to be loaded into the EQuIS database, rather than directly keyed into the database through the user interface. This is done so that the loading quality checks are uniformly applied, and to assure that all data pass through the same QC process. Data included in this step are sample collection information, geologic information, well construction specifications, and field parameters. All hand-entered data will receive a 100 percent QC check.

7.2.3 Processing Electronic Data Deliverables

Each EDD will be loaded into the EQuIS database by the DBA using the data loading tool provided in the software. The loading process includes multiple quality checks on the data for format, compatibility, and referential integrity. Any data set that fails any of these quality checks will not be accepted into the database.

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EDDs that are rejected will be returned to their originator along with the error log generated by the EQuIS system. Using the error log as a guide, the EDDs will be corrected and resubmitted until they pass the quality checks and are accepted into the database.

7.2.4 Post-Processing

Data will be exported to Environmental System Research Institute (ESRI) ArcGIS Geographic Information System (GIS) for data presentation in the RI and FS reports as discussed in Section 7.3 below.

7.2.5 Reporting

Database queries will be used to prepare analytical results tables for the RI and FS reports after all data are entered and pass the quality checking process. Copies of the database will be provided as a deliverable to EPA with the interim data report, draft and final RI report.

7.3 GEOGRAPHIC INFORMATION SYSTEM

ArcView GIS is a product of ESRI Corporation. It is a desktop version of GIS that can connect directly to the EQuIS database. ArcView displays information provided by the database in conjunction with spatial base-mapping. The power of the GIS lies in its ability to display a series of results in their natural arrangement and to allow the user to manipulate data based on proximity to various features – a function that cannot be accomplished in a database alone. The GIS will be developed to facilitate visualizing environmental data, mapping, generating figures for reports, and project tracking.

The following types of data will be included in the project GIS:

- Sampling locations
- Northing/easting coordinates
- Buildings, roads, site features and utilities
- Topography and land features

The base map data will be gathered from the existing GIS compiled and maintained by the city of Hastings and used in conjunction with layers from previous site-specific investigations, if available. The analytical data point layers will be created from temporary database queries during the sampling phase of the project.

The GIS Developer will be responsible for standardizing all the spatial data sources into the project coordinate system. The GIS Developer also will be responsible for maintaining the GIS including:

- Assigning colors, titles, symbols, fonts and sizes to each theme to ensure consistency of views and themes within the GIS.
- Organizing files stored within the GIS to ensure that they are located in the correct folders.

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The GIS Developer will generate figures for final reports as directed by the PM to meet data reporting needs.

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FIGURE

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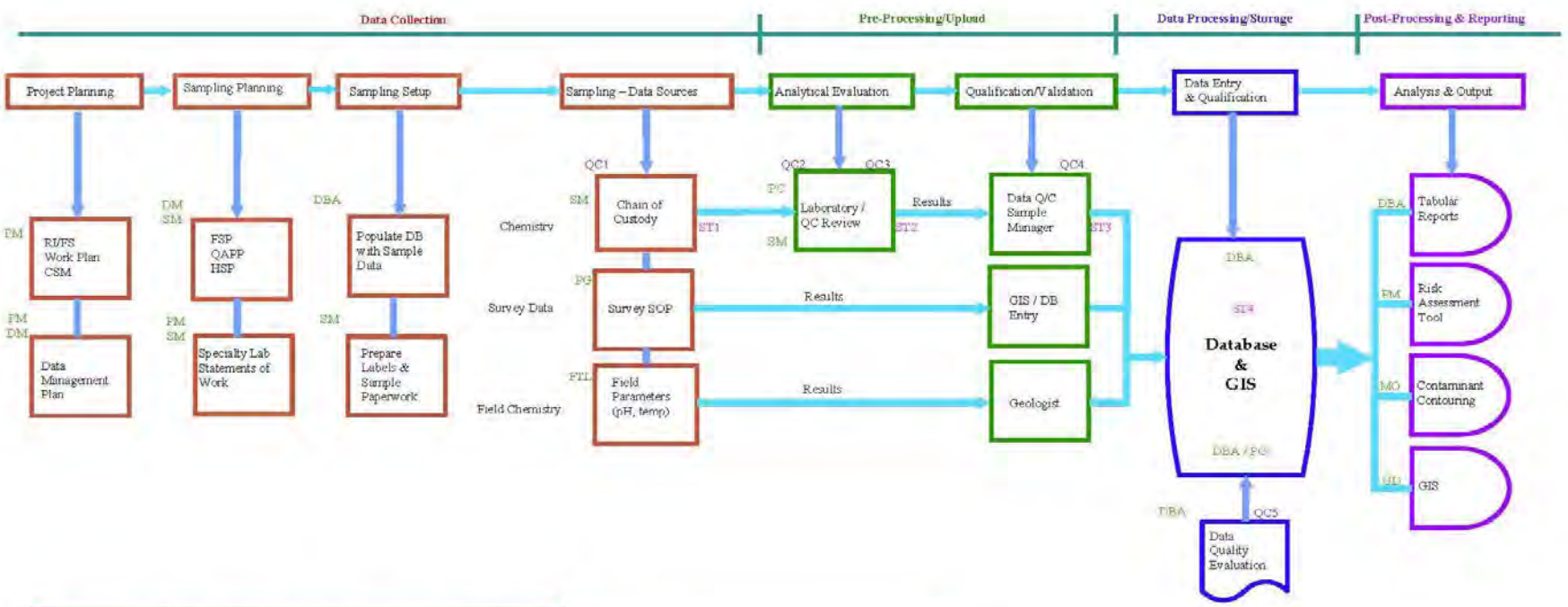

Phases of Data Quality Assurance / Quality Control (QC)

- QC1 - Compare planned collection to actual (SM)
- QC2 - Verify all samples received by lab. (SM)
- QC3 - Lab QC to confirm EDD matches hardcopy (SM)
- QC4 - System validation during loading process (DBA)
- QC5 - Post load eval. (DBA)

Phases of Sample Tracking (SM)

- ST1 - Samples collected and sent to lab
- ST2 - Results (EDD & Hardcopy) rec'd from lab / DV
- ST3 - Qualified results rec'd by SM
- ST4 - Qualified results loaded into database.

Roles

- PM – Project Manager
- DM – Data Manager
- SM – Sample Manager
- DBA – Database Administrator
- PC – Project Chemist
- GD – GIS Developer
- PG – Project Geologist
- FTL – Field Team Leader
- MP – Modeler

Figure 7.1
Data Management Process Model

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ATTACHMENT 1

TEST KIT INFORMATION

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Biological Activity Reaction Test

BART™

User Manual

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1.0 ABOUT THE *BART™*

The environment contains a myriad of different bacteria that are all capable of causing problems. These problems can range from slimes, plugging, discoloration and cloudiness to corrosion and infections. Such a wide variety of bacteria are not easy to detect and identify using a single test and yet their impact can make the water unsafe, unacceptable or unavailable due to losses in flow through plugging or equipment failure due to corrosion. The biological activity reaction test (BART™) is a water testing system for nuisance bacteria and can involve several different tests. These tests detect the activity (aggressivity) of these nuisance bacteria by the time lag (TL, measured in the number of days from the start of the test to when a reaction is observed). The longer the TL before the observation of activity, the less aggressive the bacteria are in that particular sample.

There are seven different tests that are recognizable by colored cap coding and the initial letters preceding the word BART™. These include selective tests for:

Iron Related Bacteria	IRB-BART™	Red Cap
Sulfate Reducing Bacteria	SRB-BART™	Black Cap
Heterotrophic Aerobic Bacteria	HAB-BART™	Blue Cap
Slime Forming Bacteria	SLYM-BART™	Green Cap
Denitrifying Bacteria	DN-BART™	Grey Cap
Nitrifying Bacteria	N-BART™	White Cap
Fluorescing Pseudomonads	FLOR-BART™	Yellow Cap
Acid Producing Bacteria	APB-BART™	Purple Cap
Biochemical Oxygen Demand	BOD-BART™	Light Blue Cap

Each of these bacterial groups cause different problems and often a combination of these tests should be used to determine which bacteria are present and causing problems. In the event that further information beyond presence/absence is needed, information on these reactions can be accessed using the Internet: www.DBI.ca. To read all of the reactions, lift the inner test vial carefully out of the outer BART™ test vial and view through the inner vial against an indirect light.

1.1 METHODOLOGIES

A common list of the methodologies and applications would be:

IRB-BART™ test becomes positive when there foam is produced and/or a brown color develops as a ring or dirty solution. The TL (time lag) to that event is the delay**.** A negative has no brown color developing, no foaming or clouding. This test is commonly used to detect plugging, corrosion, cloudiness and color. The bacteria that may be detected by this test include iron oxidizing and reducing bacteria, the sheathed iron bacteria, *Gallionella*, pseudomonad and enteric bacteria.

SRB-BART™ A very simple test to perform in which a positive test occurs when there is a blackening either in the base cone of the inner test vial (80% of the time) or around the ball (20% of the time). The culture medium is specific for the sulfate reducing bacteria, such as *Desulfovibrio* and *Desulfotomaculum*. This is a more specific test and specifically relates to corrosion problems, taste & odor problems ("rotten egg" odors), and blackened waters. Slimes rich in SRB tend to also be black in color. A negative indication occurs when there is an absence of blackening in the base cone of the inner test vial or around the ball.

HAB-BART™ There is a very real need to determine the amount of heterotrophic aerobic bacterial activities in some wastewater, particularly those that are aerobic. Here, biodegradation may be a primary concern, such as on a hazardous waste site. This test relies upon the ability of the heterotrophic aerobic bacteria to reduce a methylene blue dye. To add the methylene blue to the sample, the test vial once charged is simply placed upside down for 30 seconds or 5 minutes in a saline environment, to allow the blue color to develop. A positive is detected by the blue color becoming bleached (due to the activity of methylene blue reductase). Bleaching may begin at the base of the test vial or just below the ball. Note that a residual blue ring is likely to remain around the ball, but this does not mean heterotrophs are absent. A negative indication occurs when there is an absence of the blue color becoming bleached. This test is used to detect slimes, plugging, taste & odor, cloudiness and can also detect the amount of aerobic heterotrophic activity on hazardous waste sites.

SLYM-BART™, some bacteria can produce copious amounts of slime that can contribute to plugging, loss in efficiency of heat exchangers, clouding, taste and odor problems. This is one of the most sensitive BART™ tests. A positive involves a cloudy reaction in the inner test vial often with thick gel-like rings around the ball. A negative test remains clear.

FLOR-BART™ A major group of aerobic heterotrophs are the pseudomonads. These bacteria are very well adapted to breaking down some chemicals such as jet fuel and solvents but also can infest recreational waters and cause conditions ranging from skin, eye, ear, and nose infections to pneumonia-like infections. The infectious pseudomonads do produce an ultra-violet fluorescence that is usually a pale blue color. Presence for this test means that either a greenish-yellow or a pale blue glow is generated by the careful application of an ultraviolet light just below the ball. The degraders tend to generate the greenish-yellow glow while the health risk group generates the pale blue glow. A negative indication occurs when the sample remains clear.

DN-BART™ Nitrates in water are a serious health concern particularly for babies. There is one group of bacteria called the denitrifying bacteria and many of these are able to reduce the nitrate to nitrogen gas. In this test, this gas forms a foam of bubbles around the ball, usually within three days. The presence of this foam by the end of day two is taken to be an indication of an aggressive population of denitrifying bacteria. Absence of foam, regardless of any clouding of the water, indicates that the test is negative for the detection of denitrifying bacteria. This test is applicable to any waters where there is likely to be potential septic or organic contamination. The presence of denitrifiers would indicate a potential health risk due to either septic wastes or nitrates in the water.

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1.2 The six W's of the BART™ Testers

There are numerous ways in which microbes can become a nuisance in water. Often these events are ignored, considered inevitable or put down to simple physical and chemical effects. Ignorance may be bliss, but it is expensive. These microbes can cause corrosion, plugging, failing water quality and the shortening in the life span of the installation. In today's world, disposability is being replaced with sustainability and ignorance replaced with knowledge. There has been a considerable lack of attention paid to the nuisance events caused by bacteria other than those associated with hygiene risks. In ground waters, it has been a common practice until a decade ago to consider the environment to be essentially sterile and so microbial events were not considered important. In surface waters, larger and more obvious organisms tended to receive more attention than the slimes and clouds in the water. Today, it is becoming recognized that microbes are present in all waters and that they have a nuisance impact that needs to be managed if sustainability is to be achieved. This document addresses the advantages of becoming more aware of the microbes and their activity in water. It should be remembered that there is no such place as a totally sterile water environment and that, if the microbes are active, there will be affects on the environment.

1.2.1 WHAT ARE THE BART™ TESTERS?

BART™ stands for the patented biological activity reaction test. As the name implies, the test detects biological activity by looking for activities and reactions. Activities relate to growth events such as the formation of clouds, slimes, and gels. Reactions relate to the manners in which the microbes interact within the BART™ test. These reactions may take the form of color changes, generation of gasses, and precipitation. The unique nature of the BART™ test which makes it very different, and possibly superior, to the agar techniques is the fact that the water used in the test all comes from the sample and contains the microbes still within their natural environment. The water in the agar methods comes with the agar but it is tightly bound. This means that the microbes have to be taken from the water, placed into contact with the agar surfaces, and expected to "mine" the bound water for growth from the agar. Many microbes in the environment are not able to easily do this and so may be missed using agar cultural techniques (i.e., no grow, no show, no count and so not important).

The BART™ uses a unique system for encouraging the microbes to grow in the test. First, there is normally no dilution of the sample. Secondly, the sample becomes adjusted to a variety of different habitats by the nature of the BART™. Thirdly, the microbes that can be active and/or react with the selective conditions created within the BART™ test can be considered to belong to a specific group of bacteria (e.g., iron related bacteria). These selective conditions are created using two devices. The first (1) is a floating ball, FID-floating intercedent device, that restricts the entry of oxygen into the sample below. The second device (2) is the use of a crystallized deposit of selective nutrients, which sits in the bottom of the tube and encourages the activities and reactions by a specific group of microbes. In the first device, the oxygen enters around the floating ball to allow oxygen requiring (aerobic) microbes to grow. They will use all of the oxygen diffusing down so that the sample further down becomes devoid of oxygen. This volume underneath becomes suitable for the growth of microbes that do not require oxygen (anaerobic). Thus, the single BART™ provides environments which are aerobic (oxidative) and anaerobic (reductive). Essentially this is a reduction-oxidation gradient with a transitional zone (redox front) in the middle.

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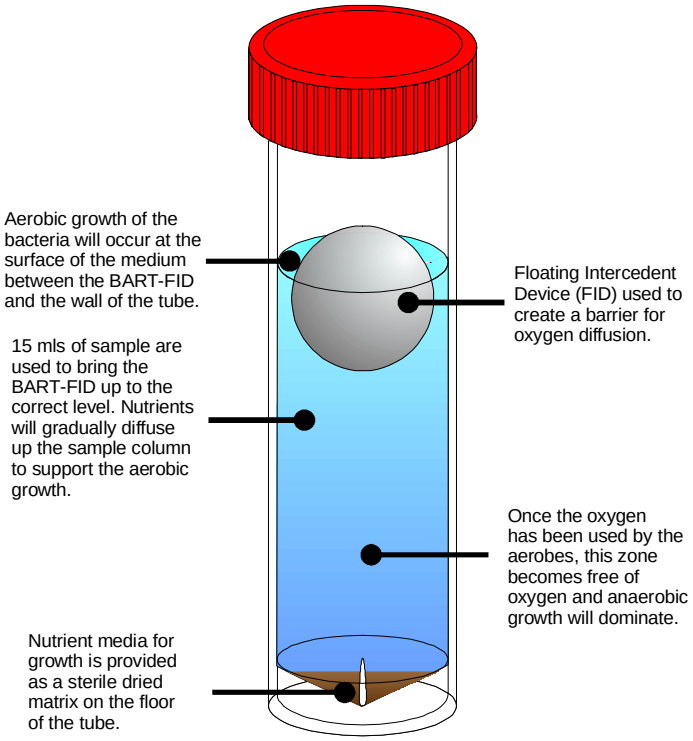

Sergei Winogradsky originally reported this type of phenomenon forming in waters kept in tall glass cylinders at the end of the nineteenth century. The beauty of this device is that different microbes prefer to function at different sites on the redox gradient and so can be seen being active and reacting within that zone. Very often, the first sign of this is the development of a cloud of growth that may be fuzzy and diffuse or a flat plate floating in the watery medium.

The key to determining the presence of different groups of microbes is the crystallized selective medium attached to the floor of the BART™ device. This medium will begin to slowly dissolve when the sample is added. As the medium dissolves, a series of chemical diffusion fronts become established and move slowly up the BART™ tube. This slows upwards progression which can take as long as two days, gives the microbes in the sample time to adapt to the increasing concentration of nutrients and, if suitable, begin to become active. Even the very sensitive microbes that would normally fail to grow on any agar media are better able to adapt and grow within a BART™ test if the crystallized medium is suitable for their growth. The location of the growth gives an early indication of the type of microbes involved. Activity in the base of the BART™ test would tend to suggest anaerobic organisms while activity at the top around the ball is more likely to be aerobic. Often the activity may center along the diffusion front for the dissolving crystallized medium. When this happens, the microbes are likely to be able to grow under aerobic and anaerobic conditions (facultative anaerobes).

Given that the BART™ test presents a whole range of environments for the microbes to grow, the key becomes the form of the crystallized culture medium that is in the BART™. It is this factor that causes different communities of microbes to become active and, hence, be detected. The eight BARTs™ employ different culture media to make the test selective. These are listed below (Table One) defining the microbial group first (acronym is given in brackets) followed by the form of the selective culture medium used.

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Table One

Principal Microbial Groups Determinable Using the BART™ Biodetectors

Microbial Community		Selective Culture Medium*
Iron Related Bacteria	**IRB**	Winogradsky's medium
Sulfate Reducing Bacteria	**SRB**	Postgate's medium
Slime Forming Bacteria	**SLYM**	Glucose Peptone medium
Heterotrophic Aerobic Bacteria	**HAB**	Sugar Peptone medium
Algae	**ALGE**	Bold's medium
Fluorescent Pseudomonads	**FLOR**	Peptone base medium
Denitrifying Bacteria	**DN**	Nitrate Peptone medium
Nitrifying Bacteria	**N**	Ammonium salts medium
Acid Producing Bacteria	**APB**	Modified Glucose Peptone medium
Biochemical Oxygen Demand	**BOD**	Modified Sugar Peptone medium

* Media have been modified to maximize the potential for recovery of the microbes using the BART™ system.

Considerable attention has been paid to drying these media in a manner so that they do not loose their selective function and are not able to re-hydrate until the sample is added. Each medium is dried in a different manner to ensure a stabilized form. To prevent re-hydration, the test vials are immediately packed in foil pouches, which act as effective moisture barriers. A three-year shelf life can be achieved when stored in a cool, dry place. Refrigeration is not necessary.

Reading the Results Using a BART™ Testers

There are two important forms in which information can be obtained. These relate to the type of consortial (community) microbial activity that may be occurring and the determination of the population. The consortial microbial activity can be determined from the reaction patterns observed. Essentially, the reactions displayed can be used to build up a "picture" of the community (consortium) of microorganisms in the sample being tested.

Populations are determined by the length of the time lag with the proposition that the longer the time lag to the detection of a reaction, the smaller the aggressive population of the microbial consortium being determined. This time lag is normally measured in days to the first detection of a reaction. Since the BART™ tests each detect a different consortial population, the time lag for one consortium does not directly relate to the time lag for a different test type.

Interpreting the Test Data

It is relatively easy to interpret a negative test because the bacterial groups do not generate any signals of activity in the BART™ test. A positive detection means that: (1) a minimum number of bacteria must have been present to cause the observed activity and reaction, and (2) that the TL to that observation can be used to project the population size. The following tests are normally used at the presence-absence level:

N-BART™ minimal population detected: 1,000 cfu/ml
FLOR-BART™ minimal population detected: 100 cfu/ml

It should be noted that lower detection limits can be achieved by extending the TL for the N-BART™ before examining the contents for the presence of nitrite, a transitional bi-product of nitrification.

The remaining tests can either be used as a presence/absence or as a semi-quantitative test by determining the TL at which the first positive activity/reaction occurred.

For determination of more acurate populations and/or populations at 28^0C, Quick Pop software can be used. The sowtware can be downloaded from www.DBI.ca.

Recognizing Positive Reaction Patterns

Reaction Patterns are the visible evidence that some activity is occurring in the BART™ tester as a result of the interaction between the active microorganisms in the sample with the redox gradient and the chemicals diffusing upwards from the base of the inner BART™ test vial. As a result, reactions range from clouded zones and gas bubbles to changes in the color of a part or the whole length of the sample. Each reaction pattern will be addressed by BART™ type.

1.2.2 WHY USE BART™ TESTERS?

The BART™ testers have two major advantages:

1. You do not need a laboratory to set up the test to determine whether there are aggressive bacterial problems in the sample being tested. They are easy to read since the signals (reactions) generated are observable.
2. The BART™ testers provided a greater variety of environments within which the bacteria of concern can grow. This is a very major advantage over the traditional agar techniques in common use in the microbiology laboratories today. This feature makes the BART™ testers far more sensitive and reactive to aggressive bacterial populations.

These are two main advantages in using the BART™ testers since they offer convenience, simplicity, sensitivity and durability.

Convenience means that the techniques employed to set up the test is easy to follow. The BART™ testers are supplied in individual, moisture proof, foil pouches that prevent the tester from degenerating as a result of premature rehydration. Within the foil pack is the double tube tester. The outer tube acts as a:

- Protection from damage to the inner test vial in which the test is actually performed.
- Security measure to reduce the risk of any odors and accidental leakage generated from the inner test vial escaping from the tester.
- Providing a bigger base for the tester so that it is more stable and less likely to be knocked over.
- Convenient determination of any reactions without having to directly handle the inner test vial after the test has been started.

Meanwhile, the inner tube offers all of the patented advantages of providing a very broad spectrum of environments in a watery environment where the different parts of an aggressive bacterial consortium can elect to grow. These environments can be described in broad terms as changing primarily with the descent down beyond the ball:

- There is a water film covering the top 20% of the surface area of the ball above the surface level of the sample. Biofilms can grow up into this very oxidative zone to be seen as a slime-

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like coating. Slime forming bacteria and molds are two common groups of microbes that can grow at this location.

- The sample above the equatorial region of the floating ball. Here, the liquid medium remains saturated while oxygen diffuses downwards from the atmosphere above the floating ball. As a result, it is common for the aerobic slime forming bacteria to grow into various types of slime-rich ring-like structures. Additionally, these biofilms that form slime rings entrap any gas bubbles being generated deeper down in the active inner test vial. These gas bubbles bounce up around the lower side of the ball and get caught up in the mass of biofilm growth to cause a foam that collects around the ball. Molds (fungi) will also grow in a commonly fuzzy manner down into this zone. This site is very oxidative and the chemicals may be moved into colored oxidized states (e.g., reds, browns and yellows).
- In the liquid medium just below the ball (usually between 3 and 8 mm below) there is a reduction – oxidation (redox) front where the oxidation-reduction potential (ORP) changes from a positive oxidative state above to a negative reductive state below. Many aggressive bacteria tend to grow first at this redox front. Normally, this will take the form of cloudy growth that may be very "fuzzy" in form or quite "tight" and form very distinct plate-like structures in the medium. Bacteria growing at these sites are commonly a mixture of aerobic and facultatively anaerobic forms able to utilize, directly or indirectly, the selective medium diffusing up the liquid medium column in the inner test vial.
- Below the redox front in the lower third to half of the liquid medium, the ORP is negative (reductive). This means that only those bacteria able to grow anaerobically (without oxygen) will be active here. Commonly, there is more color reactions at these sites associated with the reductive end products (e.g., blacks and greens). Generally, visible growths are more gel-like (colloidal) and denser.
- Inside the base of the inner test vial, two major events occur. First, the medium crystallized into the floor dissolves and diffuses upwards meaning that the deposited chemicals disappear and, commonly in some of the BART™ testers, it is possible to see the liquid medium through the base. Second, there are reactions within the inner test vial that cause changes in the color and texture of the basal chemical deposits. These reactions can cause the base to blacken or change to a different color. It should be noted that the occurrence of a white deposit commonly occurs in an IRB-BART™ but has not yet been assigned as a significant reaction.

The BART™ has two modes in which it can be used. For the field testing where the BART™ tests are actually performed in the field, then the full BART™ test should be used in which the outer tube gives the additional advantages discussed above. In the laboratory setting, the outer tube is redundant since the inner test vials are being used in a more secure environment. As a result, well-equipped laboratories with trained technical staff may prefer to use the more economical LAB-BART™ versions of the standard field test. This test (LAB) is packed in units of fifteen tests rather than the standard BART™ tester (with outer tubes) that are packed in units of nine tests.

1.2.3 WHO SHOULD USE THE BART™ TESTERS?

Gradually, the roles of bacteria in the myriad of natural and engineered events are becoming appreciated. These range from the obvious (e.g., taste, odor, corrosion and slime formation) to the subtle (e.g., bioaccumulation and occlusion). Virtually any management practice involving water could be subjected to the impacts of bacteria and other microorganisms and the BART™ testers

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provide a means to monitor either the state of the microbial aggressivity or the impact of a treatment.

For managers of water systems, there is a need to understand the potential and real challenges that can be caused by these nuisance microorganisms. Unfortunately, very often, microbiological fouling of a system (whether the base medium is water, oil or gas) is slow and covert without any obvious signals to show that it is microbial in origin. Often, these degenerative processes are put down to the normal aging of the facility and it is not considered that these processes could be driven by microbes and managed by monitoring the levels of aggressivity in these nuisance bacterial events using the BART™ testers.

Who should use the BART™ testers? Anyone who understands that bacteria and other microbes can affect the lifespan of a facility in a very real manner. These effects can range through a whole range of characteristic changes including:

- Corrosion in which the microorganisms corrode the solid structures (e.g., steel or concrete) in such a manner as to severely weaken the structure causing failure.
- Plugging in which the microorganisms form thick biofilm growths (slimes) within porous media which causes significant losses in conductivity (hydraulic or thermal).
- Radical changes in water quality caused by the casual sloughing of the slimes which are loaded with microbial cells and their associated accumulates. This sloughing can cause sudden dramatic changes in the concentrations of some chemicals (e.g. iron and phosphorus) in the water.
- False data generation due to the biofilms within the upstream zone above the site of special interest. These biofilms (or slimes) can accumulate vary large concentrations of recalcitrant chemicals that would otherwise have found their way into the sampling site. This is a form of bio-filtration and accumulation which gives a falsely improved water quality until the growths begin to slough. Monitoring wells may be particularly prone to these events when organic pollutants (e.g., BTEX, PAH, VOH) approach the well and are accumulated into the biofouled zone around the well. This biological interface acts as an effective filter until maturation causes the collapse of the biofilm structures.
- Odors can be generated by a whole range of microorganisms with some of the most well known being:

  (1) rotten egg (SRB generating hydrogen sulfide),
  (2) fishy (commonly heterotrophic aerobic bacteria and, in particular, *Pseudomonas* species),
  (3) earthy-musty (geosmins generated primarily by the *Streptomyces*),
  (4) septic (generated by various members of the enteric bacteria including the coliform bacteria) and
  (5) vegetable/fruity odors (from a variety of algae and yeast).

  One useful tool to aid in the confirmation of the source of odors is that the odors will concentrate between the outer tube and the inner test vial of the BART™ test when odor-generating microbes have grown in the tester. Loosening the outer cap and cautiously "sniffing" the gap between the cap and the outer tube will reveal the types of odors being generated by these microbes. Often this smell is coincident with an odor being detected in the sample itself. This can often convince a doubter that it is the microbes in the BART™ that are capable of causing the odor problem and a focus on managing the problem is now understood.

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- Turbidity has often been thought of as simply a chemical event associated with chemical colloids, silts or precipitation. These will cause the sample to go cloudy. More commonly than not, the cloudiness in the sample is a combination of turbulence swirling up sediments into the liquid medium and the growth of microbes within that sample. If the cloudiness is microbial, then it can be expected that the BART™ testers will detect very aggressive microbial populations.
- Color is most commonly generated by microbes through the accumulation of iron (yellows, browns, reds and oranges) although occasionally pigment can be generated by the microbes themselves as pigments. These pigments are most commonly browns, yellows, greens, blue-greens and reds and are generally more transient.
- Biodegradation is a major industry today as a part of the environment industry. Where there is a biologically driven degradation occurring, there is an inevitable increase in the aggressivity of those microbes in the environment that are associated with an observed degradation. To monitor this aggressivity, the BART™ testers can be used. Generally, if the degradation is basically aerobic and involves a narrow spectrum of organic pollutants, then the heterotrophic aerobic (HAB), the fluorescing Pseudomonad (FLOR) and the slime forming (SLYM) BART™ testers are most likely to detect the increased aggressivity of the degraders. This can then be used as a "benchmark" for the vitality of the microbial consortium causing the degradation. If the degradation is anaerobic, then a different spectrum of bacteria may be the most aggressive. These could include the sulfate reducing (SRB), the slime forming (SLYM) and the denitrifying (DN) bacteria.

The BART™ testers are suitable as a field test for any manager or consultant concerned about managing problems which are likely to be either instigated by, or worsened by, the presence of the various groups of microorganisms detectable using the BART™ testers. Just who would use the BART™ testers would depend upon the level of biological activity occurring whether this be biofouling, biofiltration, or biodegradation. Some examples of who would use the BART™ testers are listed below:

- **Water Well Operators**. Water wells are a "site unseen" operation. The extent of any visible fouling is limited to camera logs down the well or obvious fouling of filters and lines downstream of the well head. Often, the bulk source of all of the biological activity is outside of the well screen and not visible. What is visible is the "tip of the iceberg" which is the colloidal structures floating in the well water column (well snow), encrustations, tubercles and slimes attached to the walls and screens of the well and as deposits in the bottom of the well. Detecting even the most aggressive bacteria under these conditions is not simple. The bacteria often have to be "tricked" by changing the normal operational procedures for the well in order to be able get them into the water so that they can be detected using the BART™ testers. Most commonly used of the BART™ testers are:
    - the IRB (where there are known iron problems);
    - SRB (where there are anaerobic, black water and corrosion problems);
    - SLYM (where there are slimes forming in and over the well casing, screen or pump); and
    - HAB (if there is turbidity, odd odors, cloudiness, fluorescence and high organic loadings in the water).
- **Water Treatment Plant Operators**. Water treatment facilities usually involve water that has become aerated, possibly filtered, disinfected, clarified and stored. It should be remembered that the BART™ testers are proofed against the possible effects of chlorine based disinfectants by the inclusion of a neutralizer that is effective for concentrations of up to

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5,000 ppm of chlorine. In general, apart from the concern for the elimination of coliform bacteria from the water (see the separate section on the COLI-BART™), there is little regulated limitations to the microbial loadings in potable, industrial and recreational waters. Consequently, the need to monitor nuisance microbes is more in the interest of the operator rather than regulatory compliance. Unfortunately, the common attitude that water should be free disenfranchises the ability of the operator to assure a maximum operational efficiency in favor of bulk acceptable water produced at the lowest cost. Biofouling causes many covert (and commonly negative) impacts which often go unnoticed until it is too late to effectively control and then radical "surgery" has to be performed to replace the fouled parts. Common problems relate to massive slime formations (SLYM and HAB are good for checking this), corrosion of equipment (SRB), encrustations in pipes, tanks and filters (IRB and FLOR), and sudden fluctuations in water quality (HAB, SRB and DN). Fluctuating nitrate problems could be related to changes in the biofouling with a greater probability of nitrate expression in waters high in oxygen and low in organics. The organics would trigger a greater rate of denitrification particular under a suppressed oxygen regime. Routine use of BART™ tests in the ongoing operations of the treatment plant can allow earlier control of potential serious biofouling events.

- **Bottled Water Plant Operators**. Bottled water represent a growing fraction of the consumed water since it reflects a superior product in the minds of the consumer to potable water supplies provided by local agencies. While ozonated and carbonated waters do have the microbial loadings suppressed to varying degrees depending upon the techniques employed, there is still a potential for the water to degenerate as a result of microbiological activity. Most commonly, this will take the form of clouding, deposits, tastes and odors. If these events occur when the product is already with the distributor or final retailer, then this would have serious consequences for the bottling company. Quality assurance and quality control can be achieved using the BART™ testers to determine that the source water is not fouled with aggressive bacteria and that the ozonation or carbonation has effectively acted as a disinfectant to suppress the nuisance microbes.
- **Environmental Managers**. The largest biomass by far on Earth belongs to the microorganisms. This group is not sitting there passively while the biota (animals and plants) quietly does all of the "work". Microorganisms are ubiquitous and functionally active whether they are in the human body (90% of the cells in the human body are microbial cells), in soils, waters, oil and gas, muds and sedimentary rocks. Environmental managers face the task of "managing" the environment and it is essential that the role of microorganisms in that environment be recognized. The BART™ testers offer the potential to take "snapshots" of the aggressivity of the various components in the microbial biomass that can have a significant impact on the environment of concern.
- **Sanitary Landfill Operators**. There are a number of microbial challenges faced by sanitary landfill operators simply because of the highly organic nature of the fill materials deposited in the landfill. In going down through a landfill, there are a series of stratified activities predominantly microbial in form. These include (going from the top down):

    - Surface growths on the redox front dominated by methanogenic bacteria that are able to degrade methane.
    - Biogas generation zone in which methanogenic bacteria are very active producing copious quantities of methane.
    - Drainage systems in which bacterial activity causes the generation of thick plugging slimes (dominated often by SRB and SLYM bacteria). Should these growths get too

aggressive, then there could be reduced permeability that would lead to the water mounding in the landfill and breaking out through side erosions.

- Leachate outflows from the drains. Very aggressive aerobic activity is likely to occur around the redox fronts at these sites leading to radical nitrification (nitrate production) and heavy slime growths (dominated by HAB, SLYM, FLOR and IRB).

Both the functionality and stability of sanitary landfill operations can be severely compromised by aggressive microbial activities. An ongoing monitoring of these nuisance microbial groups using the BART™ testers can aid in predicting and controlling problems before they become uncontrollable.

- **Operators of Recreational Waters**. These waters range from spas, swimming pools, hot tubs and beaches. With these waters there is a primary concern to reduce the hygiene risks to the users by the routine examination for coliform bacteria. However, there are other problems particularly with hot tubs, swimming pools and spas that are caused by other nuisance bacteria that can be detected using the BART™ testers. The effects of the nuisance bacteria would fall under the categories of reducing plant efficiencies, reducing water quality, and generating unacceptable slime growths. There are both economic and user acceptability issues involved in the microbial biofouling problems which can be monitored and managed using the BART™ testers.
- **Irrigation Operators**. Vast volumes of water are used in the irrigation industry. This water is subjected to radical changes in pressures and flow rates often under increasingly oxidative conditions. Such shifts in conditions can cause a focusing of microbial slime growths within the system and nozzles that can radically reduce efficiencies and increase operating costs. Most commonly, the SLYM and IRB are likely to dominate under low iron and high iron conditions respectively. If there is a low oxygen concentration in the water, high sulfates or hydrogen sulfide ("rotten" egg odor, black water), then the SRB may be dominant in the irrigation system. Cleanliness and sanitization of the equipment (confirmed by the routine use of the BART™ testers) is likely to pay dividends through improved efficiencies and higher quality water for irrigation.
- **Hazardous Waste Site Operators**. While these sites may be very hazardous to humans, the environments created may be very conducive to extensive microbial activity. Such activity can be related to the rates of biodegradation and bioaccumulation activities being generated by the naturally attenuated consortia active at the site. Additionally, the operation of treatment facilities, injection and recovery wells, distribution lines and storage tanks can all become severely compromised. For example, injection wells returning treated water back into the formation has often become aerated (oxidative) and, upon injection, forms a redox front around which bacterial slime growths would form causing erratic reductions in permeability. For the operator of hazardous waste sites, the BART™ testers provide a simple monitoring tool to determine the level of bacterial activity occurring when used routinely. Management of the site can subsequently be improved through this routine monitoring of the levels of aggressivity (most simply monitored by the time lags observed).
- **Cooling Tower and Heat Exchanger Managers**. As a matter of routine, water is used as the heat sink in many processes. The heat in that water is removed to the air (e.g., cooling tower) or to a greater volume of water (e.g., heat exchanger). For the heat to move efficiently in the transfer from the water to the receiving medium there should be no interferences. Biofilms (slimes) forming at these interfaces can severely reduce this heat exchange in several ways. Failure to control these biofilms can be expensive due to losses in the process efficiency that causes equipment to fail to meet specifications. Controlling the biofilms is usually achieved by the application of biocides. By the routine testing of the waters using the BART™ testers, the effectiveness of the biocides in suppressing the biofilms can be determined conveniently

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and easily. Increases in the aggressivity can be determined by the shortening in the time lags while the success of a biocide treatment may be seen through lengthening of the time lags. As a rule of thumb, a one-day increase in the time lag reflects a one order of magnitude reduction in the numbers of bacteria in the water.

1.2.4 WHERE TO USE BART™ TESTERS?

BART™ testers were primarily developed to determine the aggressivity of different groups of bacteria in water. The reason the BART™ testers are so suitable for the determination of the types of aggressive bacteria is that so many different environments are presented in such a small volume (15ml). When there is activity, this is recognized by activity within the test vial that may be seen as such events as color shifts, cloudiness, and gassing. These are convenient to observe and so a full laboratory is not necessary in order to conduct BART™ tests. As a result, the tests themselves can be performed away from the laboratory in an office, a field station, even in a trailer, a tent or even in a hotel room! It should be remembered that the BART™ format for field use has the outer tube that provides an additional barrier to prevent possible odors or leakage coming out from the inner test vial.

One important question is always "What temperature should I use to keep the BART™ test at while they are running?" Microbiologists usually refer to the temperature at which the BART™ test is "running" as the incubation temperature. Commonly, the incubation temperature of choice is room temperature and that can be anywhere from 19^{o}C to 25^{o}C. Samples can range in temperatures from 4^{o}C to 35^{o}C. The ideal would be to operate the BART™ tests within 5^{o}C of the temperature at which the sample was taken. For waters with temperatures of between 15 and 35^{o}C, room temperature may be fine since the maximum difference between sample and incubated temperature would be 17^{o}C and, commonly, it would be less than 5^{o}C. If the water was sampled from a site where the temperature was less than 15^{o}C, then the types of bacteria that would be aggressive would probably grow better at lower temperatures. These types of bacteria are called "psychrotrophic" and can probably best be grown in a refrigerator set at 8 to 10^{o}C. This is not a very cold setting but would be within the optimal growth range for many psychrotrophic bacteria. In tropical countries where the temperature is close to blood heat year round, then optimal incubation conditions would at 35 to 37^{o}C. This could be undertaken in a room that is not air-conditioned. It should be remembered that the BART™ tests should always be incubated out of direct sunlight although regular room lighting does not appear to affect the tests. The exception to this rule is the ALGE-BART™ that does require indirect sunlight or continuous daylight fluorescent lights to allow the algae to photosynthesize.

Where water samples have been obtained from source water at temperatures higher than 35^{o}C, there is a concern about where and how to conduct the BART™ tests. As a rule of thumb, the incubation temperature should be, in these circumstances, within 10^{o}C of the original water temperature (preferably within 5^{o}C above that temperature). To conduct these tests, there would need to be an incubator adjustable to those temperatures or a very warm location would have to be found. It should be remembered that the safe upper limit for incubating the standard BART™ test is 70^{o}C. Above that temperature, the grade of polystyrenes used in the test vials begins to lose its structural integrity and buckle.

1.2.5 WHEN TO USE THE BART™ TESTERS

There are three conditions under which the BART™ tests may be used:

1) To determine the cause of abnormal event that may involve microbial activity

2) To monitor the effectiveness of a treatment designed to control the abnormal event diagnosed as being at least in part microbial
3) To effectively prevent a recurrence of the abnormal event through an ongoing testing and reactive treatment scenario.

Each of these three circumstances involves a different approach. For condition 1, the type of BART™ to be used is not certain because an abnormal event has occurred that is thought to involve microbial activity. As a result of this uncertainty, a broad spectrum of BART™ testers should be used to test the water sample. Commonly, the range of testers that could be used would include (aerobic conditions):

HAB, SLYM, IRB, FLOR and SRB

While under anaerobic conditions, a different spectrum of BART™ testers may be selected:

SRB, BIOGAS, SLYM and IRB

For condition 1, the sample should be taken from the site where the abnormal event is occurring or just downstream of the event. Remember that for most of the time greater than 90% of the microbes are in slimes (biofilms) attached to surfaces and so these would not even be present in the water sample! A negative BART™ does not mean a negative problem but simply means that the bacteria causing the problem were not in the water sample being tested (they were in the slimes the water passed over before being sampled).

For condition 2, the circumstances are slightly different in that BART™ tests have already been conducted and, normally, the time lags would be different, at least marginally, for each of the types of the BART™ tests used. Commonly, it is the two BARTs™, which have the shortest time lag that may be selected to determine whether a treatment management strategy now being applied to the sample is effective. It should be remembered that BART™ tests giving longer time lags might also be important. This is particularly true of the IRB-BART™ that can produce complex reaction patterns that reflect the form of the bacterial consortium in the sample (seen as the sequence within which the reactions actually are observed). If these reaction pattern signatures do shift during the treatment, then there is a list of the meaning of each reaction pattern signature (the order in which the reactions occur) in terms of which type of bacteria are dominant.

Essentially in condition 2, the objective is to try and evaluate the success of the treatment strategy applied primarily through the impact on the time lags. A dogmatic interpretation of this would be that:

- For each day of additional time lag delay, it can be considered that there would be one order of magnitude reduction in the population for each day's lengthening in the time lag. For example, a water sample contained 100,000 cfu/ml and had a time lag of 2 days before treatment and this lengthened for 4 days after treatment. This meant that the treatment cased a two-day lengthening to the time that would be two orders of magnitude (99% reduction to 1,000cfu/ml).
- If the time lag did not increase or decrease, then the treatment applied did not have any effect on the aggressivity of the bacteria being monitored using the BART™ tests.
- If the time lag shortened after the treatment, then not only did the treatment prove to be ineffective, but it created a condition in which the bacteria were able to become more aggressive. This stimulation of the bacteria may have been due to either: (1) the treatment including chemicals that could directly stimulate the bacteria (e.g., ineffective organic biocides, phosphates, organic carriers); or (2) the treatment could cause the release of bacteria into the water that had been attached. Remember that, in the latter case, when the

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bacteria are in the attached state, they will not be in the water and so essentially could be missed as simply not detected. In this case, the treatment may have worked effectively at dislodging the attached (sessile) bacterial growths, but had not killed, or removed, the cells from the water being tested.

Condition 2 is one that would be used to begin to determine whether the treatment was effective at controlling the microbial driven problem and also which BART™ testers could most conveniently be used to determine the effectiveness of an elected treatment management strategy.

Nothing lasts forever and so a single treatment of a water problem should not be viewed as ending the problem forever! Condition 3 is an essential part of a preventative maintenance strategy. Here, one or two types of BART™ testers are used in a routine manner to check to see that the water is still showing the lower bacterial activity level that was achieved by the treatment. If the time lags return to the pre-treatment levels then, clearly, the treatment may need to be repeated to again suppress the bacterial activity. If the time lag begins to shorten, then there is that potential to conduct a lower intensity of treatment to return to time lag to the post-treatment lengths. For water wells, one common scenario is to conduct monthly testing with just one or two BART™ tests (e.g., IRB and SRB). If the post-treatment time lags for these were 10 and 14 days respectively, monthly testing would show that the recovery was holding if the time lags remained the same. In practice, it may be determined that a time lag of 8 or 10 days respectively was a concern. It may be that the water sample contained some sloughing material that triggered the shorter time lag. Repeating the testing but this time does confirmation with duplicate BART™ tests to determine whether the aggressivity was a result of a chance sloughing or the bacteria becoming more aggressive. If the time lags remain shorter in that duplicates, then a preventative treatment would need to be applied to again suppress the bacteria and get the time lags back to the longer (and more acceptable) levels.

It is not responsible to propose the same time lags as being acceptable for water systems of all the various types that require management. Since each water system or well offers some unique parameters, it is much better for the routine (conditions 1, 2 and 3) be followed and a practical strategy developed that is appropriate to that water. The target should be set in the light of the activity associated with conditions 1 and 2 and then used to support sustainable water management of that system with a minimum of diversions from the established schedule of testing and treatments. Condition 3 would then be used to operate the system with the confidence of an “advanced warning system” and a treatment that has been validated by repeated appropriate application. Should the treatment start to fail, this may be because the microbes causing the problem have adapted to that treatment. It should be remembered that microorganisms are adaptable and they have the ability to adapt to treatments when these are used repeatedly. The history of antibiotic therapy is plagued with failures due to the adaptation of the targeted bacteria to the treatments.

1.2.6 WHICH BART™ TESTERS TO USE?

Some would call this the million-dollar question! There are two ways to address this question:

(1) Define the environments that each of the BART™ testers can best be used to detect microbial aggressivity
(2) Take each environment and define which BART™ testers would be most appropriately applied on condition 1 events.

This assumes that many of the applications of the BART™ testers would begin with an imminent or serious problem for which rehabilitation is urgently required. It has to be

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remembered that bacterial consortia may not be detectable by just one of the BART™ testers. Sometimes the consortium can cause reactions in more than one of the BART™ testers. This means that there can be over-lap. The range of detection of nuisance microorganisms will be discussed below for each of the major BART™ testers.

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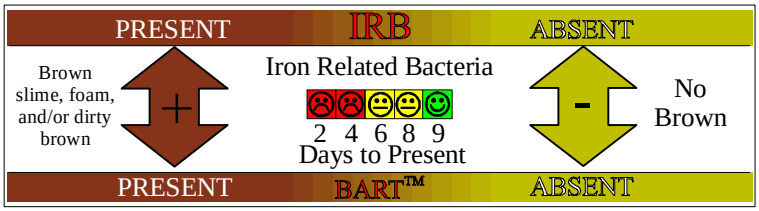
2.0 IRON RELATED BACTERIA, IRB-BART™



Iron is well known to be a critical substance for all life. In animals, it is a common part of the mechanisms for moving oxygen throughout the living body. Because iron plays such an important function in the energy metabolism, there is considerable biological competition for iron. Microorganisms also compete for iron and the use of various types of proteins called siderophores (e.g., hydroxamates and catechols). Additionally, many bacteria can also bind ferric (Fe^{+++}) ions into chelating structures know as ligands. This means that many bacteria are able to bind and hold iron in many forms to make large iron-rich structures that are sometimes seen as encrustations, tubercles and bog iron ore deposits. Little is known of the possible use of this iron to generate electro-motive forces (EMF) as a part of the growth of these iron-related bacteria. There is one group of bacteria, called the magnetotactic bacteria, which actually posses small magnet-like structures (magnetosomes) and are able to sense magnetic fields.

So complex are these various biochemical systems for holding onto iron, the precise nature of these events remain only partially understood. However, there are many bacteria which can continue to accumulate iron to the point that the growth becomes almost saturated with oxidized iron and forms a hardening clog or encrustation. Such mineralizing growths may also incorporate carbonates and sulfides with a high iron content (going from 1% up to as high as 40% dry weight) and reducing organic content (declining to as low as <1% organic carbon). The formation of hardening clogs/encrustations can seriously impair the designed hydraulic characteristics of the infested region, causing degenerated water quality and production capacities.

In using the IRB-BART™ to examine waters for the presence of iron related bacteria, it has to be remembered that iron bacteria grow predominantly on surfaces and not directly in the water. When testing water, the BART™ user has to assume that the IRB have detached, are suspended, and possibly are active in the water. As a consequence of this problem, there is a potential for an IRB-BART™ to give a “false” negative since the IRB are absent from the water but are present on the surfaces over which the water is flowing towards the sampling site. To get IRB to release and enter the flowing waters, it is necessary to cause a shift in the local environment that will make the conditions more hostile to the IRB. This is easily done by changing the pumping conditions (e.g., turn the pump off for a day if it is an active well) or applying a mild chemical shock using something like a low-dosage hypochlorite.

IRB infestations usually occur in the presence of oxygen and so may be more readily seen as slimes, clogs or encrustations. Over the century, these growths have had two common features: the presence of high concentration of ferric (Fe^{+++}) and of high populations of IRB (either as stalked *Gallionella*, the sheathed IRB or the heterotrophic IRB). The seriousness of these growths in engineered structures has led to the use of the term "Iron Bacteria". Recent research has shown that these bacteria are able to shunt the iron through oxidative and reductive states through ferric (Fe^{+++}) and ferrous (Fe^{++}) forms respectively. The BART™ biodetector is designed for the detection of these bacteria and is able to perform both the oxidative and reductive based reactions involving iron. This comprehensive group is known as the "Iron Related Bacteria" (IRB).

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The medium selected for the culture of the IRB is based on an original formulation developed by Sergei Winogradsky in which the major form of iron is presented as Ferric Ammonium Citrate. The IRB-BART™ thus provides the major carbon (citrate), nitrogen (ammonium) and iron (ferric) from the same complex chemical form. When the crystallized pellet in the base of the test vial begins to dissolve after the sample has been added, a complex series of reactions occur. These reactions are influenced by both the chemical and biological composition of the sample and the redox and nutrient gradients created in the BART™ test. Under sterile conditions, a sample may be expected to cause a gradual dissolving of the nutrients from the pellet with the formation of a colored transparent diffusion front which gradually ascends through the fluid column until all of the liquid medium has a similar color. Where there has not been any major chemical reaction and the sample contains some oxygen (oxidative), the resultant color can generate yellow. If the sample is reductive (devoid of oxygen) and contains a relatively high calcium-magnesium concentration, the diffusion front may become a transparent green color.

RPS (reaction pattern signatures) revolve around a complex pattern of signals which are generated when the IRB in the water sample begin to utilize the nutrients and manipulate the ferric form of iron present in the base of the inner BART™ test vial. Common events range from:

- gas formation (common where anaerobic conditions exist),
- clouding (commonly at the REDOX (reduction-oxidation) front),
- slime formations (commonly starting at the base or around the FID ball in the test vial),
- color changes (which can pass through various shades of yellow, red, brown, to black, or through shades of green).

Careful QC is employed during manufacturing to ensure that the ferric ammonium citrate yields a consistent reproducible response to the various test cultures.

Iron related bacteria (IRB) are difficult to enumerate since they are subdivided into a number of groupings (e.g., iron oxidizing and iron reducing bacteria). These bacteria function under different REDOX conditions and utilize a variety of substrates for growth. By the routine (e.g., monthly) testing of water or wastewater using this technique, the levels of aggressivity, possible population and community structure (RPS) can all be determined. The status of an iron related bacterial population within a given sample can be determined and related to any biofouling in the surrounding environment.

To conduct the test, it is necessary to add 15mL of the sample to the biological activity reaction test biodetector. The ball floats up and restricts the entry of oxygen into the liquid medium. At the same time, components in the modified Winogradsky selective culture medium for IRB begin to diffuse upwards into the sample from a dried medium pellet in the base of the biodetector. Two gradients form within the fluid column: nutrients diffusing upwards, and oxygen diffusing downwards. These gradients form a variety of different habitats in which IRB can flourish. The color displayed by microbial activity may be a result of the form into which the ferric iron becomes modified in the medium.

It should be noted that, in a biologically active BART™ tester, the ferric form of the iron added with the selective Winogradsky medium will revert to the ferrous form along the reductive (lower) part of the redox gradient. Commonly, where there is a radical reduction of the ferric form to the ferrous during the early phase of an IRB-BART™ test, the color of the diffusing medium in the bottom of the BART™ tester may shift from a yellow to a green. This should be considered negative unless this “greening” at the base of the inner test vial is accompanied with clouding.

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2.1 Reaction Patterns, Iron Related Bacteria

There is a range of reactions that can occur in the IRB-BART™, all of which can be observed. It is recommended that the BART™ tester be held up to a diffuse light to confirm some of these reactions which may be difficult to see against a dark background.

BC -Brown Cloudy
BG -Brown Gel
BL -Blackened Liquid
BR -Brown Ring
CL -Cloudy Growth
FO -Foam
GC -Green Cloudy
RC -Red Cloudy

Each of the reactions has been produced in a unique manner by the various species and consortia of bacteria becoming active in the test. There is therefore no specific form of any reaction pattern because these are controlled by the form of bacterial growths. Below is listed the descriptions for each of the IRB-BART™ test reactions.

CL – Clouded Growth
When there are populations of aerobic bacteria, the initial growth may be at the REDOX front that commonly forms above the medium diffusion front. This growth usually takes the form of lateral or "puffy" clouding which is most often grey in color. It should be noted that if the observer tips the BART™ slightly, the clouds will move to maintain position within the tube. Commonly, the medium will be darker beneath the zone of clouding and lighter above.

BG – Brown Gel
In this reaction, a basal, gel-like brown growth forms that maintains structure and position even when gently rotated or tilted. This brown gel can occupy the whole of the basal cone of the inner test vial and also extend up the sidewall of the inner test vial to a height of <15 mm. The solution above the gel is commonly clear and colorless. Over time it is often noticed that the size of the gel mass will grow and later shrink. Detachment sometimes happens so that a single brown gel-like mass can be seen floating in the test vial.

BC – Brown Cloudy
Unless there is a very large population of IRB in the sample, this reaction is normally a secondary reaction (often following reactions CL, FO, or RC) and may be recognized as a dirty brown solution that may have a brown ring around the ball.

FO – Foam
This is a very easy reaction to recognize since gas bubbles around the ball form a foam ring or sometimes the bubbles collect over greater than 50% of the underside of the ball. On some occasions, bubbles will collect on the walls of the inner test vial but is not significant until the bubbles collect around the ball. The solution usually remains clear but commonly has a yellow or greenish-yellow color. The bubbles can sometimes be seen in the foam to be individually coated with slime that may give the bubbles a color ranging from brown through to orange, yellow or grey. Sometimes when integrated together into a foam, this foam is tough enough to either "lift" the FID out of the liquid solution or submerge the FID below the surface of the liquid solution.

Do not confuse this reaction with the generation of bubbles (usually randomly) when oxygen supersaturates as the sample temperature comes up from a lower temperature (of the sample's source). These bubbles are recognized as being reflective and not bound in any slime and dispersed within the inner test vial under the ball and on the walls. They usually disappear within two days.

This FO reaction is most commonly related to a sample in which many microbes are functioning anaerobically. It can often be "harmonized" with the presence of SRB (reactions BB, BT or BA). In other words, the occurrence of a FO in the IRB-BART™ can often be followed by a positive detection of SRB in the SRB-BART™ if that test has been performed on the same sample.

RC – Red, Slightly Clouded
The liquid medium remains a clear to a dark reddish solution. The solution will cloud fairly quickly and shift to a BC reaction generally after a BR has formed around the ball.

BR – Brown Ring
A reddish- brown to dark brown slime ring forms around the ball. This ring is entire and tight and usually <3 mm in width. Generally, the brown slime ring will sit between the liquid surface and the equator of the ball and commonly intensifies over time. On some occasions this reaction possesses unusual feature in that the slime ring can "bio-lock" the ball to the walls of the test vial. In these cases, when the test vial is turned upside down, the ball remains (glued) in-place and the liquid remains above the ball. What has happened is that the ring has become formed biologically into a hydraulic barrier.

GC – Green Clouded
Solution goes to a shade of green and becomes cloudy without, necessarily, the formation of defined clouds or gel-like forms. No slime ring is formed around the FID. This cloudiness will gradually increase and often this reaction will shift to a dark green very cloudy solution. As the solution becomes a darker green and cloudier, a BR reaction may form but this is usually fairly thin.

BL – Blackened Liquid
This is commonly a secondary or tertiary reaction rather than an initial reaction. It is recognized as a clear, often colorless, solution surrounded by large blackened zones in the basal cone and up the walls of the inner test vial.

Other reactions not coded are described below. These reactions occur less than 1% of the time in water testing using the IRB-BART™:

"Fuzzy" growths around the ball, IRB-BART™, occasionally where a water sample has traveled through a semi-saturated zone, there are fungal spores present. These create reaction thirteen in which a white, grey or speckled "fuzzy" mat forms around and even over the ball. The upper surface of the mat often forms into a tight mass with an irregular surface. The lower surface of the mat can often be seen to be extending into the liquid medium by thread-like processes 2 to 5 mm in length. These growths may bio-lock the ball to the wall of the inner test vial for a period of time. Solution usually remains fairly clear but globular-like deposits may be present. Solution may cloud over time. This reaction is caused by the presence of large populations of fungal spores in the water.

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2.2 RPS (Reaction Pattern Signatures) for the IRB-BART™

Because of the complex communities that form the iron bacteria, the reaction patterns can develop some very distinctive sequences. In the last ten years, the meaning of the sequences (RPS) has been determined. The common characterizations are listed below:

- **BC – WB – BR** IRB with carbonate deposition and some slime formers present
- **CL – GC** Mixed heterotrophic IRB dominated by Pseudomonads
- **CL – BG** Mixed heterotrophic IRB with some Enteric bacteria (possibly *Enterobacter*)
- **CL – BC** Mixed heterotrophic IRB
- **CL – BC – BR** Mixed heterotrophic IRB with some slime formers
- **CL – FO** IRB with mixed aerobes and some anaerobic activity
- **CL – BC** A white deposit forms in the vial. Aerobic IRB with carbonate deposition
- **FO – CL** Anaerobic bacteria with some aerobic heterotrophic IRB
- **FO – CL – RC** Anaerobic bacteria with some aerobic heterotrophic IRB and Enteric bacteria (possibly *Enterobacter, Citrobacter* or *Serratia*)
- **FO – CL – BC – BR** Mixed anaerobic and Enteric bacteria with some slime forming IRB
- **FO – BR – BC** Mixed anaerobic and IRB with some aerobic slime forming bacteria
- **FO – GC** Mixed anaerobic and aerobic bacteria dominated by Pseudomonads
- **FO – GC – BL** Mixed anaerobes, Pseudomonads and Enteric bacteria
- **GC** Most of the bacteria present are Pseudomonads
- **GC – BL** Pseudomonads dominate with some IRB and Enteric bacteria present
- **RC – CL – BR** Enteric bacteria dominate

The IRB are generally slow growing and often will display the first reaction as either a foam (FO) or a cloudy plate (CP). The consortium is complex and involves a mixture of stalked and sheathed bacteria along with heterotrophic and slime forming bacteria. Because of the complex nature of this consortium, it takes longer to become established and is more likely to show a succession of secondary reactions as the consortium stabilizes.

2.3 Time Lag (days of delay) to IRB-BART™ Populations

The populations of IRB can be determined using the time lag to the observation of the first reaction. This relationship is shown in Table Four.

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Table Two

The Relationship between Time Lag and the Population For Iron Related Bacteria

Time Lag (days)	Population cfu/ml
1	540,000
2	140,000
3	35,000
4	9000
5	2300
6	500
7	150
8	25

2.4 Risk Potential Assessment – IRB-BART™

The IRB are a complex of many bacteria that possess a common ability to utilize iron. As a result this test has a complex set of reactions which can be displayed. The shorter the time lag to the IRB displaying a reaction, the greater the aggressivity and the need to treat. Not all reactions are equally important in determining the aggressivity of the IRB (and therefore the need to treat). Below is a list of the reactions described previously and the relative importance in relation to the need to treat. Concern can be expressed through the shortness of the time lag (in days) as:

1-2. Very aggressive (treatment should be started as early as convenient)
2-4. Aggressive (treatment should be considered in the near future before the condition degenerates further)
5-8. Moderately Aggressive (treatment may not be required but vigilance through ongoing testing should be practiced)

5-9. >8. Normal Background Levels (routine testing is recommended)

Table Three

Relationship between the Time Lag to the First reaction in an IRB-BART™ and the Aggressivity of the Iron Related Bacteria

		Aggressivity			
		Very	Sign.	Moderate	Not
BC	-Brown Cloudy	<2	3	4-8	>8
BG	-Brown Gel	<1	2-6	7-8	>8
BL	-Blackened Liquid	<2	3-6	7-8	>8
BR	-Brown Ring	<1	2	3-6	>6
CL	-Cloudy Growth	<0.5	0.5-2	3-4	>4
FO	-Foam	<0.5	0.5-1	2-4	>4
GC	-Green Cloudy	<1	2-4	5-8	>8
RC	-Red Cloudy	<1	2-3	4-8	>8

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Some remedial treatments should be considered urgently where the time lag (in days) shows aggressivity to be at the 1 or 2 level. Where there has been a RPS (sequence of reactions to form a signature), then the aggressivity should be considered to be equivalent to the most aggressive of the reactions using the above table.

2.5 Hygiene Risk Considerations

Four of the possible reactions can indicate a potential hygiene risk. These include: BG, BL, GC. and RC. Where these are found to have a time lag that would project an aggressivity of 1 (very aggressive) or 2 (aggressive), then a fecal coliform test should be performed to ensure that there were no fecal coliform bacteria present. Note that the use of the total coliform test could yield a positive since some of the bacteria causing these reactions could be environmental enterics. If the RPS includes GC, a test for the presence of fluorescing Pseudomonads should also be performed.

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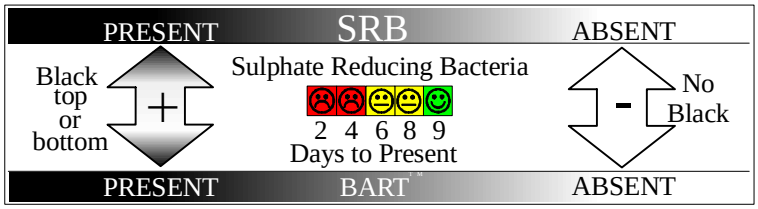
3.0 SULFATE REDUCING BACTERIA, SRB-BART™



Sulfate reducing bacteria (SRB) are a group of anaerobic bacteria that, as a part of their normal activities, generate hydrogen sulfide (H_2S). This product can cause a number of significant problems. These range from "rotten egg" odors, through to the blackening of equipment, waters and slime formations, and the initiation of corrosive processes.

Detection of these microorganisms is made more challenging because they are anaerobic and tend to grow deep within biofilms (slimes) as a part of a microbial community (consortium). Detection of the SRB is therefore made difficult because SRB may not be present in the free-flowing liquid over the site of the fouling but are growing deeper down in the biofilms. Because of this, the symptoms of SRB fouling may precede their detection using the SRB-BART™ unless a successful attempt is made to disrupt these biofilms and cause the SRB to come up into the liquid.

The sulfate reducing bacteria are an unusual group in that they utilize hydrogen rather than oxygen as the basic driver for many of the metabolic activities. As a result of this, the SRB are anaerobic and are inhibited by the presence of oxygen. Sulfate reduction appears to be coupled to the formation of ATP (a major energy driver in metabolism) by a proton motive force (PMF) derived from electron transport. The bottom line is that the sulfate is reduced in a step-wise fashion to H_2S while releasing energy for growth. It is the H_2S which creates the problems through electrolytic corrosion, "rotten" egg smells, bad taste problems and the formation of black slimes.

There is another group of SRB which cause the reduction of sulfur to H_2S but these are not detected using the SRB-BART™. Usually, these sulfur-reducing bacteria are less common and, hence, have been discounted in the SRB-BART™ tester. Upon special request, there is a tester for the sulfur reducing bacteria (SRB-BART™) which can be made to special order.

SRB activity in the BART™ tester is easily recognized since the sulfate becomes reduced to hydrogen sulfide. This product now reacts with the diffusing ferrous iron to form black iron sulfides. This sulfide commonly forms either in the base (as black precipitates) and/or around the ball (as an irregular black ring). In the latter event, the SRB may form a part of an aerobic consortium forming around and on the FID ball. Generally, where this happens, the blackening may be seen as granular structures held within the slime ring that is commonly not totally black.

The SRB-BART™ uses the short chain fatty acids to provide the substrates for the growth of the SRB. On some occasions, heterotrophic anaerobic bacteria can also become very active in the BART™ test and often grow faster than the SRB. When this happens, the liquid will tend to go cloudy. Usually, this is seen as a gel-like clouding most commonly in the bottom third of the BART™ inner test vial and shows that anaerobic heterotrophs are present and active. It should be remembered that these bacteria might not necessarily grow in the SLYM-BART™ since the major organic carbon nutrients are not short chain fatty acids.

Under exceptional circumstances, an SRB-BART™ may display a blackening very quickly (e.g., less than half an hour). In this case it is likely that the sample being tested contains some residual hydrogen sulfide which has rapidly reacted with the iron in the test vial. Where this happens, it is recommended that the water sample be aseptically aerated to drive off the gaseous hydrogen sulfide

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from the sample before conducting the SRB-BART™ test. While the aeration would admit oxygen to the sample, the SRB should survive through being protected by the other bacteria within the slime formations.

3.1. Reaction Patterns, Sulfate Reducing Bacteria

BB - Blackened Base
BT - Blackening around Ball

There are three reaction patterns that are positive for the SRB. Detailed descriptions of these is given below:

BB – Blackened Base
The reaction is recognizable by the formation of a blackened deposit in the basal cone of the test vial. It may be first observed by looking up into the underside of the cone of the inner test vial. Blackening frequently starts as a 2 to 3-mm wide ring around the central peg and gradually spreads outwards. Black specking may also occur on the bottom 15 mm of the walls of the test vial immediately above the cone. The liquid medium should be clear (see reaction CG below) and there should be no slime ring around the ball.

BT – Blackening around the Ball
A slime ring may be viewed around the ball with patches of black specking or zones intertwined in the slime growths. The slime itself is not a characteristic of this reaction but the blackening is. The slime usually is either a white, grey, beige, or yellow color and tends to form on the upper side of the ball. The blackening often begins as a specking which gradually expands to patches within the slime.

Combination of BB and BT
A combination of reactions BB and BT constitute a reaction BA. Blackening occurs both in the base and around the ball although the length of the inner test vial may not be blackened.

The other recognized reaction is a negative for SRB but commonly occurs where there are aggressive anaerobic bacteria present. Often this reaction will precede a positive reaction for SRB (i.e., BB and BT). This negative SRB reaction is:

CG – Cloudy Gel-Like
While not a positive indication for the presence of SRB, this reaction is recognized since it does indicate the presence of anaerobic bacteria and often precedes the generation reactions BB, BT or BA. It is recognized by the appearance of cloud-like structures in the colorless liquid medium. Usually these form from the bottom up and initially at a height of 20 to 25 mm up the sidewall of the inner test vial. This clouded zone may expand to render the liquid medium turbid. These clouds are relatively stable structures and have defined edges.

3.2.RPS (Reaction Pattern Signatures) for the SRB-BART™

- **BB** Deep-seated anaerobic bacteria dominated by *Desulfovibrio*
- **BT** Dominant aerobic slime forming heterotrophs include SRB in the consortium
- **BB – BA** Dominant anaerobic consortium including SRB with a fraction able to function aerobically as slime formers incorporating the SRB
- **BT – BA** Aerobic slime formers incorporate SRB and are also able to colonize anaerobic

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Conditions

Note that the SRB-BART™ includes another common test reaction, which does not relate to the presence or absence of the SRB in the sample under test. This test reaction is recognized by the development of a cloudy growth that often begins close to the base and gradually fills at least 20% of the liquid volume. Often this growth reaction appears almost gel-like and has a fuzzy but distinct edge. This may be admitted as a reaction:

CG - Cloudy Gel-like

This reaction does not mean that SRB are present but that anaerobic bacteria are. Commonly, the **CG** reaction precedes the blackening or occurs shortly after the commencement of the blackening.

3.3. Time Lag (days of delay) to SRB-BART™ Populations

The common relationship between the time lag measured in days of delay and the population of SRB is given in Table Six. Because the SRB commonly are aggressive as a part of a consortium of different species of bacteria, their numbers may be difficult to determine using some of the standard procedures for SRB. This methodology allows the growth of the consortium in the SRB-BART™ that, consequently, initiates greater levels of aggressivity. The populations given in Table Six reflect the higher recovery rates and comparisons with other tests may show the SRB-BART™ to be the more sensitive.

Table Four

The Relationship between Time Lag and the Population For Sulfate Reducing Bacteria

Time Lag (days)	Population cfu/ml
1	6,800,000
2	700,000
3	100,000
4	18,000
5	5000
6	1200
7	500
8	200

Sulfate reducing bacteria (SRB) are a narrow group of bacteria that have the common facility to reduce sulfates to hydrogen sulfide. It is this sulfide which reacts with metals (commonly iron) to form the black sulfides. It is these black deposits that cause an identifiable reaction in the base of the tube (BB) or around the ball (BT). In both cases, the SRB do function as part of a consortium that is either anaerobic (BB) or aerobic (BT).

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3.4. Risk Potential Assessment-SRB-BART™

The SRB are a relatively simple consortium in which the SRB tend to either dominate over a facultative/strict anaerobic heterotrophic bacterial flora (BB), or become integrated into an aerobic slime forming heterotrophic bacterial community growing around the ball (BT). Where a more complex and aggressive form of SRB are present (involving both forms of consortial activity BA), then the SRB are usually very aggressive and the BA reaction occurs without being preceded by either of the other two reactions. The risk potential for the severity of a detected SRB event can be expressed through the shortness of the time lag (in days) as follows:

1. Very aggressive (treatment should be started as early as convenient)
2. Aggressive (treatment should be considered in the near future before the condition degenerates further)
3. Moderately Aggressive (treatment may not be required but vigilance through ongoing testing should be practiced)
4. Normal Background Levels (routine testing is recommended)

Table Five

Relationship between the Time Lag to the First Reaction in an SRB-BART™ and the Aggressivity of the Sulfate Reducing Bacteria

			Aggressivity			
			Very	Sign.	Moderate	Not
BB	-	Black Base	<1	2-3	4-8	>8
BT	-	Black Ball	<1	2-4	5-8	>8
BA*	-	Black All	<2	2-5	6-8	>8

Note: The BA reaction (*) listed above must have occurred without either of the other reactions occurring first. If either the BB or the BT reaction did occur first, then the aggressivity should be based on the first of the reactions that did occur. Some remedial treatments should be considered urgently where the time lag (in days) shows aggressivity to be at the 1 or 2 level.

A non-SRB reaction can also commonly occur in this test when a cloudy gel (CG) forms. This is indicative of the presence of anaerobic bacteria (not SRB). However, on some occasions, these anaerobic bacteria can also become very aggressive and can cause deep-seated plugging. The aggressivity for these bacteria can be judged using the table below:

Table Six

Relationship between the Time Lag to the CG Reaction in an SRB-BART™ and the Aggressivity of the Anaerobic Bacteria

			Aggressivity			
			Very	Sign.	Moderate	Not
CG	-	Cloudy Growth	<0.5	0.5-2	3-4	>4

3.5. Technical Advisory

The advisory notifies users of the SRB-BART system for the detection of sulfate reducing bacteria that the standard maximum length for the monitoring of the reaction patterns is commonly ten (10) days. Operators using the SRB-BART tester for the detection of deep-seated SRB infestations in water systems associated with wells and distribution systems may find it advantageous to continue observations until the fifteenth (15^{th}) day. This is because some SRB do not exhibit reaction patterns (i.e. BT or BB) until after other bacterial consortia have already grown within the tester (e.g. anaerobic bacteria). This delays the observation of a positive detection for the SRB. In water pipelines and biofouling water wells the time lags can be delayed until days 11 to 15. It is not possible to project the size of the SRB populations but this extension of the testing period can be used to determine the presence/absence of the SRB when they are present in the environments either in very low numbers or in a consortial association with other microbial species. It can be expected that where routine monitoring is being undertaken, sudden decreases in the time lags to 10 days or less can be taken to indicate that the SRB are becoming significantly more aggressive and may require corrective action (e.g. disinfection, pigging the lines, etc.).

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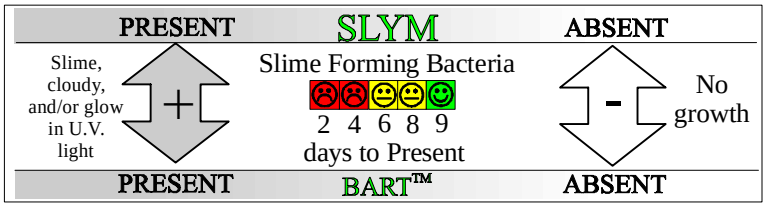
4.0 SLIME FORMING BACTERIA, SLYM-BART™



Slime-Forming Bacteria (SLYM) is the name given to bacteria that are able to produce copious amounts of slime without necessarily having to accumulate any iron. These slime-like growths are therefore often not dominated by the yellows, reds and browns commonly seen where IRB are present. Some of the IRB also produce slime but it is sometimes denser and has more texture due to the accumulation of various forms of insoluble iron. SLYM bacteria can also function under different reduction-oxidation (REDOX) conditions but generally produce the thickest slime formations under aerobic (oxidative) conditions. These can develop in the SLYM-BART™ as slime rings growing around the floating ball. Slime growth can also be seen as a cloudy (fluffy or tight plate-like structures) or as gel-like growths which may be localized or occur generally through the body of water medium. Very commonly the gel-like slime growths form from the bottom up in the test vials. One common check for these types of growth is to tilt the BART™ gently and see that the cloud- or gel- like growths retain their structure and tilt with the tube.

A vast majority of bacteria can produce slime-like growths. The slime is actually formed by a variety of exopolysaccharide polymers that are long thread like molecules. These extracellular polymeric substances (EPS) literally coat the cells into a common slime-mass within which large volumes of water become clustered and bound. Often 95 to 99% of the volume of slime are actually water. Some bacteria produce an EPS that remains tightly bound to the individual cell. These are called capsules. Other bacteria generate such a copious amount of EPS that it envelops whole masses of cells within a common slime.

The role of the slime appears to be protective. If environmental conditions are harsh (e.g., due to shortage of nutrients), the slime layers tend to get thicker. Not only does the slime act as a protectant to the resident bacteria but it also acts as a bio-sponge by accumulating many chemicals that could form either a nutrient base, or be toxic to the cells. EPS may be produced by enzymatic activity (e.g., dextran sucrase or levan sucrase) on carbohydrates. In addition, EPS may be synthesized within the bacterial cells and released to form an enveloping slime.

Slime forming bacteria tend to be aerobic and form slimes at REDOX fronts. In the BART™ tester, this front may form around the ball causing a slime ring, or deeper down in the liquid medium column to form an observable growth. This growth may be plate-like and appear to float at a specific depth, cloud-like with indefinite edges, form as basal dense slimes in the conical base of the test vial, or be gel-like and maintain its shape even when the vial is tilted. Since slime tends to be formed by bacteria under stress, it is common for the slimes to form after there has been an initial growth that may take the form of a localized or general cloudiness.

Many slime bacteria can produce various pigments that will color the slime. Such growths are usually white, grey, yellow or beige in color. These often darken over time particularly in the presence of daylight. Distinctive colored slimes include red (commonly associated with *Serratia marcescens*) and violet (associated with either *Chromobacterium* or *Janthinobacterium* species). Blackening may also occur particularly after growth. This may be a result of the production of either

iron sulfides or carbonates which is commonly associated with the presence of mixed cultures including enteric bacteria in the SLYM-BART™.

SLYM-BART™ can be used as a simple presence/absence (P/A) test capable of indicating to some extent the population size and the types of SLYM organisms present in the sample. Different microorganisms utilize various sites along the REDOX gradient under the ball to grow and regular careful observations are needed to catch the start of growth so that the time lag can be determined.

Slime forming bacteria cause very serious engineering problems since the slime formation can compromise the engineered specifications into many systems. Primarily, the effects of the slime growths are to reduce hydraulic or thermal conductivity and reduce water quality (generally, the first symptom is increased turbidity followed by taste, odor or color problems. As the slimes slough into the fluid later during the infestation, it can be expected to see sudden rises in the total organic carbon, increases in aggressivity and reductions in water quality.

4.1 Reaction Patterns, Slime Forming Bacteria

DS -Dense Slime (Gel-Like)
SR -Slime Ring around the Ball
CP -Cloudy Plates layering
CL -Cloudy Growth
BL -Blackened Liquid
TH -Thread-Like Strands
PB -Pale Blue Glow in U.V. Light
GY -Greenish-Yellow Glow in U.V.

Of the above reactions, it is the CL (cloudy) reaction that is by far the most common. Often the CL will be preceded by a CP which will be transient (lasting commonly less than 24 hours). Descriptions of the various reaction is given below:

DS – Dense Slime
This reaction may not be obvious and require the observer to gently rotate the BART™ test at which time slimy deposits swirl up. These deposits may swirl in the form of a twisting slime when the tube is gently rotated. This swirl can reach 40 mm up into the liquid column, or it may rise up as globular gel-like masses that settle fairly quickly. Once the swirl has settled down, the liquid may become clear again. In the latter case, care should be taken to confirm that the artifact is biological (ill-defined edge, mucoid, globular) rather than chemical (defined edge, crystalline, often white or translucent). Generally, these dense slime growths are beige, white or yellowish-orange in color.

CP – Cloudy Plates Layering
When there are populations of aerobic bacteria, the initial growth may be at the REDOX front that commonly forms above the yellowish-brown diffusion front. This growth usually takes the form of lateral or "puffy" clouding which is most commonly grey in color. Often the lateral clouds may be disc-like in shape (plates) and relatively thin (1 to 2 mm). It should be noted that if the observer tips the BART™ slightly, the clouds or plates often move to maintain position within the tube. The edges of the plates are distinct while the edges of the “puffy” forms of layering are indistinct. These formations are most commonly observed 15 to 30 mm beneath the fill line. While cloud formations will tend to extend to cause an overall cloudiness of the liquid medium (CL). These plates sometimes appear to divide (multiple plating) before coalescing into a cloudy liquid medium.

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SR - Slime Ring
A slime ring, usually 2 to 5 mm in width forms on the upper side of the ball. The appearance is commonly mucoid and may be a white, beige, yellow, orange or violet color that commonly becomes more intense over time on the upper edge.

CL – Cloudy Growth
Solution is very cloudy and there may sometimes be a poorly defined slime growth around the ball. Sometimes a glowing may be noticed in at least a part of the top 18mm of the liquid medium. This glowing is due to the generation of U.V. fluorescent pigments by some species of *Pseudomonas*. The common pigments doing this are a pale blue (PB) or a yellowish green (YG) color. Note that this glowing may not be readily observable unless a U.V. light is used. The occurrence of the glowing in a U.V. light means that there is a probability of potentially pathogenic species of *Pseudomonas* and confirmatory testing is recommended.

BL – Blackened Liquid
This is commonly a secondary or tertiary reaction rather than an initial reaction. It is recognized as a clear, often colorless, solution that is surrounded by large blackened zones in the basal cone and up the walls of the test vial. The BL often parallels the BL reaction in the IRB when the two BARTs™ are used together to test the same sample.

TH – Thread-Like Strands
On some occasions, the slime forms into threads that form web-like patterns in the liquid medium. Sometimes these threads which interconnect from the ball to the floor of the inner test vial.

4.2 RPS (Reaction Pattern Signatures) for the SLYM-BART™

- **DS - CL** Dense slime forming bacteria producing copious EPS, facultative anaerobes dominate
- **SR - CL** Aerobic slime forming bacteria (such as M*icrococcus*) dominating with some facultative anaerobes
- **CP - CL** Motile facultatively anaerobic bacteria dominate (e.g., *Proteus*)
- **CL - SR** Mixed bacterial flora including some aerobic slime-formers
- **CL - BL** Slime formers dominated by Pseudomonads and Enteric bacteria
- **CL - PB** *Pseudomonas aeruginosa* dominant member of the bacterial flora
- **CL - GY** *Pseudomonas fluorescens* species group present in the flora
- **TH - CL** Aerobic bacteria dominant which are able to generate slime threads (e.g., *Zoogloea*)

4.3 Time Lag (days of delay) to SLYM-BART™ Populations

The slime forming bacteria are among the fastest growing aggressive consortia and the medium used in this BART™ is very enriching and causes a wide variety of bacteria to grow rapidly. However, when the bacteria do not grow quickly this indicates a very low population of aggressive bacteria. As a result of this, the time lags of between 3 and 6 days show a rapid decline in populations when compared to the IRB or SRB BART™ tests.

Table Seven

The Relationship between Time Lag and the Population For Slime Forming Bacteria

Time Lag (days)	Population cfu/ml
1	1,800,000
2	350,000
3	66,500
4	12,500
5	2500
6	500
7	100
8	10

4.4 Risk Potential Assessment – SLYM-BART™

The slime forming bacteria are complex consortia involving many bacteria. These consortia inhabit a common "growth" of slime that acts as a communal chamber. Within these slimes, the bacterial cells are commonly dispersed and occupy only a small part of the total volume (<0.1%). Most of the slime is water bound to the organic polymers that bind the slime together. The SLYM-BART™ reflects the activities of bacteria that are present in the water as a result of the sloughing from the slime. As a result of this, the test may exhibit a complex set of reactions depending upon precisely which bacterial species are present in the sample. Like the other BART™ tests, the shorter the time lag to the SLYM-BART™ displaying a reaction then the greater becomes the aggressivity and the more urgent the need to treat. Not all reactions are equally important in determining the aggressivity of the slime forming bacteria (and therefore the need to treat). Below are a list of the reactions described above and their relative importance in relation to the need to treat. Concern can be expressed through the shortness of the time lag (in days) as:

1. Very aggressive (treatment should be started as early as convenient)
2. Aggressive (treatment should be considered in the near future before the condition degenerates further)
3. Moderately Aggressive (treatment may not be required but vigilance through ongoing testing should be practiced)
4. Normal Background Levels (routine testing is recommended)

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Table Eight

Relationship between the Time Lag to the Reactions in a SLYM-BART™ and the Aggressivity of the Slime Forming Bacteria

		Aggressivity			
		Very	Sign.	Moderate	Not
DS	-Dense Gel Slime	<1	2	3-7	>7
SR	-Slime Ring	<1	2-3	4-6	>6
CP	-Cloudy Plates	<0.5	1-2	3-6	>6
CL	-Cloudy Growth	<1	2	3-6	>6
BL	-Blackened Liquid	<1	2-4	5-8	>8
TH	-Threads	<2	3-4	5	>6
PB	-Pale Blue Glow	<1	2-4	5-8	>8
GY	-Green-Yellow Glow	<1	2-3	4-8	>8

Some remedial treatments should be considered urgently where the time lag (in days) shows aggressivity to be at the very aggressive or aggressive (1 or 2) levels. Where there has been a RPS (sequence of reactions to form a signature), then the aggressivity should be considered to be equivalent to the most aggressive of the reactions using the above table.

4.5. Hygiene Risk Considerations

The most significant hygiene risk generated by this test is the BL reaction that indicates that Pseudomonads and enteric bacteria are present. If this reaction occurs within eight days then a fecal coliform test should be performed on that water to determine the hygiene risk directly. Where PB or GY reactions are observed, this should be confirmed using the FLOR-BART™.

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5.0 HETEROTROPHIC AEROBIC BACTERIA, HAB-BART™

Some bacteria are able to degrade organics as their source of energy and carbon. These are known as heterotrophic bacteria. By far, the majority of these heterotrophs function most efficiently under aerobic conditions. Much of the biodegradation that occurs under aerobic conditions is due to the activities of these heterotrophic aerobic bacteria (HAB, formerly the total aerobic bacteria or TAB). Since these bacteria play a major role of biodegradation and their presence in oxygen-rich environments can be critical to the efficiency of the engineered operation, the HAB-BART™ was developed to detect these bacteria.

The unique feature of this test is the addition of methylene blue that acts as an indicator of respiratory activity. While there remains free oxygen in the sample, the methylene blue dye in the liquid medium remains blue. As soon as all of the oxygen has been consumed by bacterial (respiratory) activity, the methylene blue shifts from its observable form to a colorless form. In other words, in the HAB-BART™ tests, when the liquid medium turns from blue to a colorless (non-blue) form, then the heterotrophic aerobic bacteria have been sufficiently aggressive to have “respired off” the oxygen. At this time a methylene blue reductase enzyme becomes activated and this reduces the methylene blue to its colorless form.

Microorganisms present at depths in this test are short of oxygen and "look" for alternatives. The blue dye (methylene blue) in this test forms such an alternate substrate. When the aerobic bacteria use this dye, the color is bleached out. This usually occurs from the bottom (bottom up) or the top (top down) of the tester first. This bleaching action (decolorizing the blue dye) is the indicator of a positive reaction. Note that the dye is added to the test by inverting the charged HAB-BART™ for 30 seconds to allow the methylene blue chemical dried in the cap time to dissolve into the sample. When the HAB-BART™ is returned to its normal state (cap side up), the ball rolls up through the liquid medium causing the methylene blue to become mixed into the sample to form an even blue solution.

Methylene blue is a basic dye that can bind readily to the negatively charged microbial cells. Traditionally, therefore, this dye has been used to stain microbial cells. A feature of methylene blue is that it changes from a blue color in the oxidized state to a clear form in the reduced state. When methylene blue is added to a medium that is actively converting energy due to microbial respiration, the electrons are transferred to the dye causing it to become reduced and the dye changes from a blue to a clear state (the color disappears). The protocol has been based on the methylene blue reductase test that has been used in the dairy industry for decades to determine the potential for bacterial spoilage of milk. In the HAB-BART™ the objective is for the user to be able to determine the aerobic bacterial population which may be related to various forms of biofouling and bioremediation. Essentially, the methylene acts as an oxygen substitute and its reduction (bleaching) from the blue to the colorless form can be used an indication of the amount of respiratory function of the bacteria in the sample.

This test is therefore an answer to the need to test water and wastewater for the presence of heterotrophic aerobic bacteria as such without trying to determine the particular groups of bacteria that may be present.

The HAB-BART™ determines the activity of the Heterotrophic Aerobic Bacteria. When these bacteria are present and active, the blue dye in the biodetector becomes bleached (colorless) either

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from the bottom up or the top down. The faster this happens, the more aggressive are the heterotrophic aerobic bacteria.

5.1 Reaction Patterns, Heterotrophic Aerobic Bacteria

UP -Bleaching moves upward from base
DO -Bleaching moves downward from ball

There are only two recognized reactions (UP and DO) and both of these relate to the form with which the bleaching occurs. There are different forms of clouding which follow the bleaching of the methylene blue and these are recognized using the BARTSCAN™ system.

UP – Bleaching moves upwards
Blue solution bleaches from the bottom up. The bleached zone may be clear or clouded. In the latter case, the medium tends to have a light to medium yellow color. Rarely does the bleaching extend beyond the equator of the ball so that a blue ring will remain around the ball with a width of 1 to 5 mm.

DO – Bleaching moves downwards
Blue solution bleaches from the top down. The bleached zone is more commonly cloudy. The bleached liquid medium tends to have a light to medium yellow color. Commonly the bleaching does extend up beyond the equator of the ball and any blue ring remaining around the ball is relatively thin with a width of 0.5 to 2 mm.
Note: that there is almost always a blue ring remaining around the ball and that the DO reaction will usually leave this ring intact. Furthermore, the test reaction can only be one or the other and so interpretation is restricted to one or other of these two reactions.

5.2 RPS (Reaction Pattern Signatures) for the HAB-BART™

- **UP** Strictly aerobic bacteria may be dominant with some facultative anaerobes often present
- **DO** Facultatively anaerobic heterotrophs dominate along with some anaerobic bacteria

5.3 Time Lag (days of delay) to HAB-BART™ Populations

The relationship between the time lag (days of delay) to the bacterial population is given in Table Eleven.

Table Nine

The Relationship between Time Lag and the Population For Heterotrophic Aerobic Bacteria

Time Lag (days)	Population cfu/ml
1	7,000,000
2	500,000
3	50,000
4	7000

The heterotrophic aerobic bacteria, like the slime formers, grow very quickly and are readily detectable because of the reduction of the methylene blue from the blue (oxidative) to the

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colorless (reductive) state. Essentially, the methylene blue acts as a redox indicator and rapidly shows when respiratory activity is occurring because the test liquids become reductive and the methylene blue decolorizes. This test is one of the fastest of the BART™ tests as well as being the easiest to read. It functions most effectively when the bacterial consortia in the sample are dominated by heterotrophic aerobes.

5.4 Risk Potential Assessment – HAB-BART™

The heterotrophic aerobic bacteria are subdivided into two major consortial groups in the HAB-BART™. These are dominated by either: the strictly aerobic (UP), or the facultatively anaerobic (DO) heterotrophic bacteria. The risk potential for the severity of a detected HAB event can be expressed through the shortness of the time lag (in days) as follows:

1. Very aggressive (treatment should be started as early as convenient)
2. Aggressive (treatment should be considered in the near future before the condition degenerates further)
3. Moderately Aggressive (treatment may not be required but vigilance through ongoing testing should be practiced)
4. Normal Background Levels (routine testing is recommended)

Table Ten

Relationship between the Time Lag to the Reactions in an HAB-BART™ and the Aggressivity of the Heterotrophic Aerobic Bacteria

		Aggressivity			
		Very	Sign.	Moderate	Not
UP	-Bleach Up	<0.5	1-2	3-4	>4
DO	-Bleach Down	<1	2-3	4-6	>6

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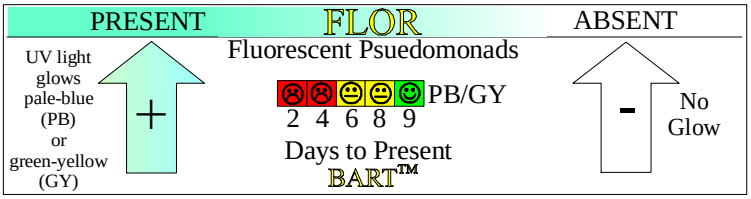
6.0 FLUORESCING PSEUDOMONADS, FLOR-BART™



The Pseudomonads are a very important group of Gram negative bacteria that are found in very substantial numbers in soils, waters and many other natural materials. In associations with many plants and animals, the Pseudomonads can act as agents for disease. In aerobic bioremediation and biodegradation processes, members of the Pseudomonads often play critical roles in the biochemical breakdown of critical organic compounds. These various important aspects have led to the development of the FLOR-BART™ which generate conditions favorable to the growth of the Pseudomonads.

One critical aspect of this biodetector is the ability to generate soluble fluorescent pigments when some species of the genus *Pseudomonas* are dominant in the water. These pigments are usually produced after growth has occurred and generally can be detected most easily in the culture medium around the ball (top 20mm of the liquid column). Detection is by the use of an ultra violet (UV) lamp aimed at the top one third of the liquid column in the FLOR-BART™. Maximum excitation of these fluorescing molecules is at 400nm. There are two main pigments, pyocyanin and pyoverdins. Pyocyanin is a distinctive pigment that fluoresces with a pale blue to blue color and is most commonly associated with the species, *Pseudomonas aeruginosa*. This species is commonly associated with clinical specimens (wounds, burns, otitis, sepsis, pneumonia, urinary tract infections), a condition known as "blue pus", and is a hygiene concern in recreational waters. Pyoverdins is the name given to a group of other fluorescent pigments generated by different species of *Pseudomonas*. Commonly these pigments are referred to as fluorescens and generally have a greenish-yellow glow. The species *Ps. fluorescens* generates these types of pigments and is commonly associated with the spoilage of foods (eggs, cured meats, fish and milk). The FLOR-BART™ has been designed to generate these pigments where there is a dominance of fluorescent Pseudomonads (hence the prefix, FLOR). If *Ps. aeruginosa* is detected in a water sample and there is a concern for the potential hygiene risk, it is recommended that confirmatory diagnosis be performed in a recognized diagnostic microbiology laboratory using either the positive FLOR-BART™ or a fresh sample as the source for the diagnosis.

Other pigments are sometimes produced. These are usually insoluble and non-fluorescent in UV light. These are commonly yellow, beige or orange in color and tend to be transitory. One species *Ps. stutzeri* sometimes generates a reddish-brown pigment later in the growth cycle that is very distinctive. This pigment may concentrate either in the slime ring around the FID ball or in the base of the test vial.

Microorganisms present around the ball in the FLOR-BART™ can generate these different pigments in the presence of oxygen. Usually these pigments are generated after a cloudy growth has developed in the liquid medium but before there are intense slime-like growths around the ball (as a slime ring). The fluorescent pigments may be difficult to observe with natural and artificial light but they can be seen using a typical broad spectrum UV light whereupon the pigments glow (fluoresce).

There is often a need to test environments for the presence of Pseudomonad bacteria because these bacteria are often dominant in fluids which contain oxygen and are rich in a narrow range of organic pollutants (e.g., gasoline, jet fuel, solvents). When these bacteria are present and active, there are two particular events that may need to be considered. First, the presence of Pseudomonad

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bacteria may indicate that aerobic biodegradation is occurring and biofouling may also be happening within the system being tested. Second, some of the Pseudomonad bacteria that produce the fluorescent (glowing in UV light) pigments may be a hygiene risk. The faster that clouding and fluorescing happens, the more aggressive are the Pseudomonad bacteria.

For the FLOR-BART™ there are two UV fluorescent pigments which can be recognized as:

PALE BLUISH GLOW that will last for one to four days and then gradually fade. The glow is normally fairly faint and should be viewed against a darkened background since direct light may make viewing more difficult. One major species bearing this pigment (pyocyanin) is *Pseudomonas aeruginosa*. It is of concern since this species can be associated with a range of opportunistic infections. It is also one of the bacterial species found associated with mastitis in cattle. This species can also be found in a variety of waters.

GREENISH-YELLOW GLOW that may last for two to ten days and then gradually fades away. The glow becomes fairly obvious and is often visible even without using the UV light. One major species bearing this pigment (the pyoverdin, fluorescein) is *Pseudomonas fluorescens*. Generally this species is not as virulent as *Ps. aeruginosa* and is often more abundant in waters and can be involved in specialized aerobic degradation of organic pollutants.

In essence, this test selectively allows the detection of Pseudomonad bacteria in the water with the separation of the fluorescent species. Pseudomonad bacteria can cause a range of problems in waters. Problems range through slime formations, turbidity, taste and odor, corrosion and biodegradation through to greater hygiene risks. In recreational waters (such as swimming pools, hot tubs, restricted natural bathing sites), the presence of aggressive fluorescent pseudomonads should be taken as a potential cause for concern since these bacteria may cause a range of skin, eye, ear and urinary tract infections. Occasionally the pseudomonad bacteria will cause skin infections particularly under tight fitting bathing apparel. This is particularly a potential problem in warmer waters and hot tubs where the bathers remain relatively inactive in the waters for prolonged periods.

The pseudomonad bacteria often dominate aerobic biodegradation of organic pollutants and determining the aggressivity and possible population size can often monitor the rates of degradation. If the organic pollutant is being degraded aerobically or in a situation where there is a significant quantity of nitrates to support respiration, there is a potential for the degradation to be dominated by the Pseudomonad bacteria. Monitoring the aggressivity of these bacteria using the FLOR-BART™ enables the user to monitor the amount of biodegradation occurring.

Pseudomonad bacteria are also sometimes associated with taste and odor problems in water since many of the species produce distinctive odors such as a "fishy" or a "kerosene-like" which can become very dominant in the water.

6.1 Reaction Pattern, Fluorescing Pseudomonads

PB	-	Pale Blue Glow in UV Light
GY	-	Greenish-Yellow Glow in UV Light

These Reactions are described in more detail. Care should be taken to follow manufacturers cautionary notices when using an UV light source to observe glowing in the BART™ tests.

PB – Pale Blue Glow

Solution very cloudy and then generates a glowing around FID when ultra violet light is shone onto the side walls of the inner test vial. This glowing fluorescence occurs usually in the top 15 to 20 mm around the ball and gives a pale blue glow. This glowing commonly lasts 2 to 3 days

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GY – Greenish Yellow Glow
Solution very cloudy and then generates a glowing around FID when ultra violet light is shone onto the side walls of the inner test vial. This glowing fluorescence occurs usually in the top 15 to 20 mm around the ball and gives a greenish-yellow glow. This glowing lasts commonly for 4 to 8 days (latter case).

6.2 RPS (Reaction Pattern Signatures) for the FLOR-BART™

- **PB** *Pseudomonas aeruginosa* likely to be present
- **GY** *Pseudomonas fluorescens* species group likely to be present

6.3 Time Lag (days of delay) to FLOR-BART™ Populations

Table Eleven

The Relationship between Time Lag and the Population For Fluorescing Pseudomonad Bacteria

Time Lag (days)	Population cfu/ml
1	1,000,000
2	100,000
3	10,000
4	5,000
5	1,000
6	100
7	100
8	100

The fluorescing Pseudomonads are only a part of typical slime forming or heterotrophic aerobic bacterial consortia. As such, they have to be in high populations and very aggressive in order to begin to produce the Ultra Violet (UV) fluorescence that is typical for the species of *Pseudomonas* that are capable of doing this. A time lag of longer than five days may have a small population but if the UV glow produced is pale blue. This would still be a concern if the nosocomial pathogenic bacterial species *Pseudomonas aeruginosa* was present in the sample and confirmatory tests using the traditional microbiological procedures may need to be undertaken as a precaution.

6.4 Risk Potential Assessment – FLOR-BART™

6.4.1 BART™ Extinction Dilution Technique

To measure the population of fluorescing pseudomonad bacteria, four dilutions of the original sample should be used. These dilutions can be achieved using the following semi-quantitative technique:

1. Dispense 14 ml of sterile water into each of four FLOR-BART™ tests. Label these tubes: “1”, “2”, “3”, and “4’.
2. Charge a FLOR-BART™ with the water sample (15 ml) and label “0”
3. Withdraw 1 ml of water from tube “0” and transfer into tube “1”. Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).

4. Withdraw 1 ml of water from tube "1" and transfer into tube "2". Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
5. Withdraw 1 ml of water from tube "2" and transfer into tube "3". Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
6. Withdraw 1 ml of water from tube "3" and transfer into tube "4". Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
7. Observe the tubes for PB or GY fluorescence after three days of incubation at room temperature. Note that this day may be changed if an alternate day is found to display maximum fluorescence.
8. Refer to table below to semi-quantitatively determine population based upon the tests that exhibit fluorescence in an UV light.

Table Twelve

The Relationship of Positive Detection of Fluorescence to The Population

Tube #	Population Assessment				
"0"	F	F	F	F	F
"1"	F	F	F	F	----
"2"	F	F	F	----	----
"3"	F	F	----	----	----
"4"	F	----	----	----	----
Possible Population:	>5.0	>4.0	>3.0	>2.0	>1.0

(Log Fluorescing Pseudomonads/ml)

6.5 Hygiene Risk Considerations

If a PB reaction is observed, there is a risk that *Pseudomonas aeruginosa* may be present in the water sample and could cause an infection in humans. These infections can range from pneumonia to skin, eye and ear infections. Where a population is detected and confirmed using the extinction dilution technique described above, the tube "0" FLOR-BART™ should be submitted to a suitable microbiology laboratory to confirm the diagnosis. If the fluorescence is of the GY type, then a similar precaution should be taken if the population is >2.0 log Fluorescing Pseudomonads/ml.

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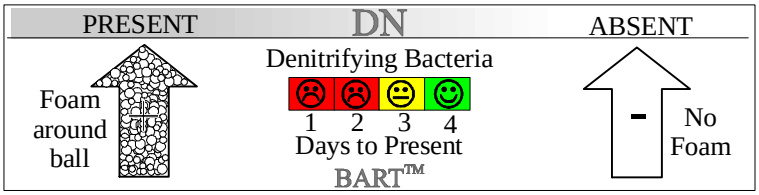
7.0 DENITRIFYING BACTERIA, DN-BART™



DN is short for denitrification. This activity is extremely important not only in environmental but also in geochemical terms. The reason for this is that the essentially all of the atmospheric nitrogen (N_2) has been derived from the process of denitrification which is driven by the denitrifying bacteria. It is therefore an extremely important stage in the nitrogen cycle in the crust of planet Earth. There is a distinctive cycle in which nitrogen from the atmosphere is fixed, cycles through the biomass, is oxidized to nitrate by nitrification (see N-BART™) and reduced back to nitrogen gas by denitrification which is controlled by the denitrifying bacteria.

The denitrifying bacteria are therefore an important indicator group for the decomposition of waste organic nitrogenous materials. These denitrifiers reduce nitrate through to nitrite and some continue the nitrification on down to gaseous nitrogen (complete denitrification). In waters, the presence of an aggressive population of denitrifiers can be taken to indicate that there are significant amounts of nitrate in the water. Such waters are most likely anaerobic (free of oxygen) and relatively rich in organic matter. A common use for the presence of aggressive denitrifying bacteria in waters is that these bacteria signal the latter stages in the degradation of nitrogen-rich sewage and septic wastewater. Aggressive presence of denitrifiers in water can be used to indicate that there is a potential for the water to have been polluted by nitrogen-rich organics from such sources as compromised septic tanks, sewage systems, industrial and hazardous waste sites. It is recommended that, where a high aggressivity is determined, the water should be subjected to further evaluation as a hygiene risk through a subsequent determination for the presence of coliform bacteria. In soils, the presence of an aggressive denitrifying bacterial population may be taken to indicate that the denitrification part of the soil nitrogen cycle is functional.

Denitrification therefore serves as the major route by which complex nitrogenous compounds are returned to the atmosphere as nitrogen gas. There are four steps in the denitrification process:

$$\underset{\text{Nitrate}}{NO_3^-} \xrightarrow{(1)} \underset{\text{Nitrite}}{NO_2^-} \xrightarrow{(2)} \underset{\text{Nitric oxide}}{NO} \xrightarrow{(3)} \underset{\text{Nitrous oxide}}{N_2O} \xrightarrow{(4)} \underset{\text{Nitrogen}}{N_{2\,gas}}$$

Denitrifying bacteria are not necessarily able to perform all four steps in the denitrification process and have been divided into four distinctive groups that can perform one or more of the various steps in the denitrification process. These are listed below:

Group 1- step (1) only
Group 2- steps (1), (2), and (3)
Group 3- steps (2), (3), and (4)
Group 4- steps (1) and (3) only.

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One of the largest groups of denitrifying bacteria are the enteric bacteria which includes the coliform bacteria. All of these bacteria perform denitrification under anaerobic (oxygen-free) conditions in a reductive environment.

Some of the principal genera associated with denitrification are:

Actinomyces	*Aeromonas*	*Agrobacterium*	*Alcaligenes*
Arthrobacter	*Bacillus*	*Bacteroides*	*Campylobacter*
Cellulomonas	*Chromobacterium*	*Citrobacter*	*Clostridium*
Enterobacter	*Erwinia*	*Escherichia*	*Eubacterium*
Flavobacterium	*Geodermatophilus*	*Halobacterium*	*Halococcus*
Hyphomicrobium	*Klebsiella*	*Leptothrix*	*Micrococcus*
Moraxella	*Mycobacterium*	*Nocardia*	*Peptococcus*
Photobacterium	*Proteus*	*Pseudomonas*	*Rhizobium*
Salmonella	*Serratia*	*Shigella*	*Spirillum*
Staphylococcus	*Streptomyces*	*Thiobacillus*	*Vibrio*

As can be seen from the list, a very wide ranging number of bacteria are capable of denitrification. Their ability to perform denitrification is controlled, in part, by the availability of the nitrate, nitrite, nitrous or nitric oxide substrates.

The patented denitrifying bacterial activity reaction test biodetector (DN-BART^{TM}) has been designed to detect the aggressivity of the denitrifying bacteria that will reduce the nitrite to gaseous nitrogen (steps 2, 3 and 4). These bacteria are an important part of the nitrogen cycle in soils and waters. In waters, their aggressivity may be used to signal the fact that there is a significant degradation of nitrogenous material occurring.

7.1 Reaction Patterns, Denitrifying Bacteria

FO - Foam around Ball

Solution usually cloudy but the major positive for FO is the presence of very many bubbles collecting over >50% of the area under and around the ball to form a foam around the ball. This shows that complete denitrification has occurred and the denitrifying bacteria are present.
There is only one reaction recognized in the DN – BART™ that occurs when the nitrate is completely denitrified to nitrogen gas that collects as foam (interconnected gas bubbles) around the ball. This is more of a presence/absence test and the foaming usually is generated on the second test of testing at room temperature.

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7.2 Time Lag (days of delay) to DN-BART™ Populations

Populations can be assessed by the time lag to the foam formation (Table Fifteen)

Table Thirteen

The Relationship between Time Lag and the Population For Denitrifying Bacteria

Time Lag (days)	Population cfu/ml
1	1,000,000
2	200,000
3	50,000
4	10,000

The denitrifying bacteria tend either to be aggressive and cause a rapid denitrification, or to be relatively placid. This test now functions through the detection of the complete denitrifiers. These bacteria reduce the nitrate to dinitrogen gas that appears as a foam ring around the ball. Generally, if the test is still negative after a time lag of two days, the population can be considered to be very small and non-aggressive.

7.3 Risk Potential Assessment –DN-BART™

7.3.1 BART™ Extinction Dilution

To quantify the numbers of denitrifying bacteria in the sample, a dilution (extinction) technique would need to be used. To measure the population of denitrifying bacteria, four tenfold dilutions of the original water sample should be used. These dilutions can be achieved using the following technique:

1. Dispense 14 ml of sterile water into each of four DN-BART™ tests. Label these tubes: “1”, “2”, “3”, and “4’.
2. Charge a DN-BART™ with the water sample (15 ml) and label “0”
3. Withdraw 1 ml of water from tube “0” and transfer into tube “1”. Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
4. Withdraw 1 ml of water from tube “1” and transfer into tube “2”. Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
5. Withdraw 1 ml of water from tube “2” and transfer into tube “3”. Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
6. Withdraw 1 ml of water from tube “3” and transfer into tube “4”. Invert and gently shake tube for 10 seconds. Allow to settle (5 seconds).
7. Observe the tubes for **FO** (foam) after two days of incubation at room temperature.
8. Refer to Table Sixteen below to determine population.

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Table Fourteen

Interpretation of the BART™ Extinction Dilution For Denitrifying Bacteria

Tube #	Population Assessment				
"0"	FO	FO	FO	FO	FO
"1"	FO	FO	FO	FO	----
"2"	FO	FO	FO	----	----
"3"	FO	FO	----	----	----
"4"	FO	----	----	----	----
Possible Population: (log DN/ml)	>5.0	>4.0	>3.0	>2.0	>1.0

7.4 Hygiene Risk Considerations

Denitrifying bacteria flourish in environments that have sources of nitrate and organics. Such sources may involve wastewater that contain some septic material and could therefore present a potential hygiene risk. A coliform test should be considered to assess this risk where there is a detected population of denitrifiers (FO observed). Where the DN population is >3.0 log DN/ml, a coliform test should routinely be used to determine the health risk.

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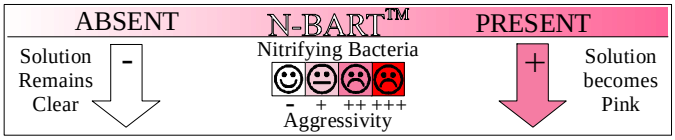
8.0 NITRIFYING BACTERIA, N-BART™



Nitrification serves as the major route by which ammonium is aerobically oxidized to nitrate. There are two steps to nitrification process:

(1) (2)
NH_4^+ ----------→ NO_2^- ----------→ NO_3^-
Ammonium Nitrite Nitrate

Nitrifying bacteria are divided according to which of the above reactions they are able to perform:

Group 1-step (1) only - Nitrosofiers - *Nitrosomonas*
Group 2-step (2) only - Nitrifiers – *Nitrobacter*

The polarized relationship between the nitrifying and the denitrifying bacteria is a problem in the testing of natural samples since the two groups are either producing or utilizing nitrate respectively. In developing a biodetection system for the nitrifying bacteria in natural samples, the terminal product (nitrate) may not be recoverable because of the intrinsic activities of the denitrifying bacteria which are also likely to be present and active in the sample. It is because of this difficulty that the N-BART™ restricts itself to detecting the nitrosofiers that generate nitrite. This nitrite will be oxidized to nitrate by the nitrifiers only to reappear when reduced back to nitrite by any intrinsic denitrification occurring in the sample.

The nitrifying bacteria are an important indicator group for the recycling of organic nitrogenous materials from ammonium (the end point for the decomposition of proteins) to the production of nitrates. In waters, the presence of an aggressive population if nitrifiers is taken to indicate that there is a potential for significant amounts of nitrate to be generated in waters which are aerobic (rich in oxygen). Nitrates in water are a cause of concern because of the potential health risk particularly to infants who have not yet developed a tolerance to nitrates. In soils, nitrification is considered to be a very significant and useful function in the recycling of nitrogen through the soil. Nitrate is a highly mobile ion in the soil and will move (diffuse) relatively quickly while ammonium remains relatively "locked" in the soil. In some agronomic practices, nitrification inhibitors have been used to reduce the "losses" of ammonium to nitrate.

A common use for the presence of aggressive nitrifying bacteria in waters is that these bacteria signal the latter stages in the aerobic degradation of nitrogen-rich organic materials. Aggressive presence of nitrifying bacteria in water can be used to indicate that there is a potential for the water to have been polluted by nitrogen-rich organics from such sources as compromised septic tanks, sewage systems, industrial and hazardous waste sites and is undergoing an aerobic form of degradation. Nitrification and denitrification are essentially parallel processes that function in reverse sequence of each other. It is recommended that, where a high aggressivity is determined, waters should be subjected to further evaluation as a hygiene risk through a subsequent determination for the presence of nitrates. In soils, the presence of an aggressive denitrifying bacterial population may be taken to

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indicate that the nitrification part of the soil nitrogen cycle is functional. Nitrification is fundamentally an aerobic process in which the ammonium is oxidatively converted to nitrate via nitrite. Nitrite produced by the denitrification of nitrate may also be oxidized back to nitrate.

8.1 Reaction Patterns, Nitrifying Bacteria

This test is an unusual test in that the presence of nitrifying bacteria is detected by the presence if nitrite in the test vial after a standard incubation period of five days. Nitrification involves the oxidation of ammonium to nitrate via nitrite. Unfortunately, in natural samples, there are commonly denitrifying bacteria present in the water and these reduce the nitrate back to nitrite. If denitrification is completed, this nitrite may be reduced further to dinitrogen gas (under anaerobic conditions). That is why this test is laid upon its side with three balls to provide a moistened highly aerobic upper surface where nitrification is most likely to occur. The reagent administered in the reaction cap detects nitrite specifically by a red color reaction. This test is interpreted by the amount of pink-red coloration generated, and the location of this color.

PP -Pink-red color on roughly half the ball
RP -All balls are reddened, solution may be pale pink
DR -Balls and the solution is reddened

This test is different to the other BART™ tests in that a chemical reagent is added to detect the product (nitrite) after a standard incubation period. The typical reactions are described below:

PP – Partial Pink on the Balls

Clear solution but a pink reaction may be generated on the FID hemispheres indicating that nitrification has just begun and the nitrite detected is in the biofilm on the balls.

RP – Red Deposits and Pink Solution

Reaction causes a light pink solution with red deposits all over the three balls. Nitrite is now present in solution as well as in the biofilms on the balls.

DR – Dark Red Deposits and Solution

Reaction causes dark red solution with heavy red deposits on ball. High concentrations of nitrite have been detected indicating an aggressive level of nitrification has occurred in the test period.

8.2 RPS (Reaction Pattern Signatures) for the N-BART™

The reaction represents the population size and does not reflect the variety of microorganisms present in the water sample:

- **PB** Small population of nitrifiers ($< 10^2$ nitrifiers/ml) associated with aerobic slime forming bacteria in a consortium
- **RB** Moderate population of nitrifiers ($> 10^2$ and $< 10^5$ nitrifiers/ml) forming a major component in the bacterial flora
- **RT** Dominant population of nitrifiers ($> 10^5$ nitrifiers/ml)

8.3 Hygiene Risk Considerations

The presence of an aggressive population of nitrifying bacteria in water is taken to indicate that there is a potential for significant amounts of nitrate to be generated in waters, which are aerobic. This may indicate a potential health risk particularly to infants who have not yet developed a tolerance to nitrates. It is recommended that, where a high population is determined, waters should be subjected to further evaluation as a hygiene risk, through subsequent determination for the presence of nitrates.

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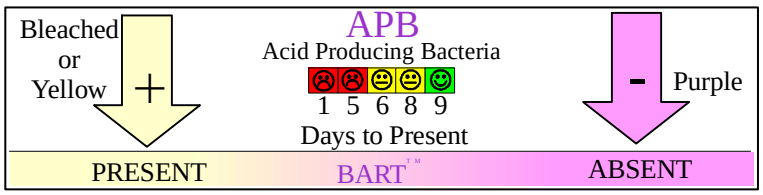
9.0 ACID PRODUCING BACTERIA, APB-BART™



A major concern in the management of water systems, as well as oil and gas systems, is the risk of corrosive fluids. In the oil and gas industry, corrosion is a major concern because of the irreversible nature of the damages and the high cost of prevention (e.g., through cathodic protection and the application of biocides). Over the last forty years the cause of corrosion has shifted from being considered as a complex electro-chemical process to one that is commonly mediated by microorganisms. There are two groups of bacteria that can be instrumental in causing corrosion that include the sulfate reducing bacteria (SRB) and the acid producing bacteria (APB). This test focuses on the detection of acid producing bacteria as a potential cause of acidic waters and corrosion problems.

Historically, the recognition of microbially induced / initiated corrosion (MIC) placed emphasis on the SRB because of their clear links to the production of hydrogen sulfide which was well recognized as the initiator of electrolytic corrosion in steels. With the development of an understanding of the nature of biofilms in the production of slimes, tubercles, nodules and encrustations, it was found that there was a considerable amount of acidic products formed particularly deeper down in the biofilm. The association of some corrosion problems with the formation of acids led to the need to determine whether APB was involved. The acids produced by these bacteria are a result of fermentation of organics under very reductive (oxygen-free) environments. If oxygen were present, these APB would not be able to ferment significant amounts of acid. When fermented, the most common acids produced are the smaller fatty acids such as acetate, lactate, propionate and butyrate along with some of the volatile fatty acids.

The APB activity is a result of a community, or consortia, of bacteria rather than one single species. The exact nature of the bacterial species involved and the composition of the acidic products can vary throughout systems. It remains important that the APB can produce sufficient acidic products to significantly drop the pH at the interface between the biofilm and the supporting structures, and also in the water passing by the biofilm. APB is suspected when the pH in the impacted environment begins to fall into the acidic range under conditions when there is little or no oxygen available. If oxygen is present then the APB will not generate acid conditions in the water but may at the interface between the biofilm and the supporting material (e.g., concrete, steel). If acid production is occurring under oxidative conditions then the sulfur oxidizing bacteria such as *Thiobacillus* may be the cause. These bacteria can be detected using the AMD-BART™ commonly employed to determine the cause of acidic mine drainage.

Essentially, the APB could be viewed as setting up the conditions for increased levels of aggressivity by both the SRB and the methane (biogas) producing bacteria with both utilize the fatty acids generated by the APB. In this environment, there is microbial competition for the acetate (under reductive conditions) between the SRB and the bacteria able to generate methane. This latter group is known as the methanogenic bacteria (MPB) and can generate significant quantities of biogas. In the scheme of “things”, the APB ferment organics to acetate that is now

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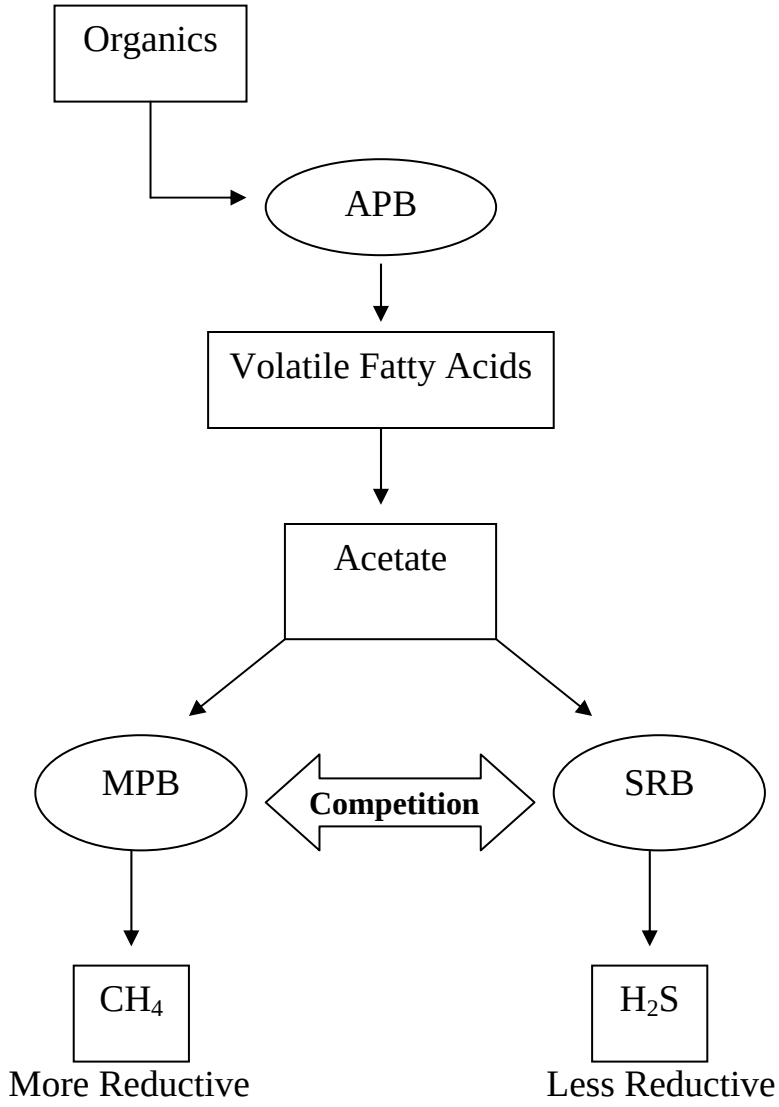
the prime substrate for SRB and MPB with the latter tending to dominate under the more reductive conditions.



The APB have now been recognized as a possible major cause of corrosion mainly because their fermentative activities will cause the pH particularly in the biofilms to drop into the acid range. Under these conditions, an acid-driven form of corrosion could occur, where the metals begin to dissolve and concrete structures lose integrity. This form of acid-corrosion can be viewed as an initiating, or alternating, event to SRB-initiated electrolytic corrosion. In the last two decades, industry has become more aware of the risks posed by the APB and have come to generally view the creation of acidic pH levels within the environment under reductive conditions to be predominantly driven by the APB. This heightens the corrosion risk to the engineered systems within the affected zone. To detect the APB, an APB-BART™ has been developed.

One of the major problems in establishing the APB-BART™ test has been to determine what level of acidic pH can be considered significant to increase the corrosion risk? A survey of the concern revealed a wide disparity in the pH values that would be considered threshold for an

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increased acid-induced corrosion risk. In general the range was from as low as 3.8 to as high as 6.2 with most moderating in the range of 4.4 to 5.8. In the development of the APB-BART™ it was decided to work with a range of produced and natural waters as well as ATCC bacterial strains to set a threshold pH value to act as a positive detection of APB. Initially, threshold values were set in the pH range of 4.4 to 4.8 but this was found to generate a high probability of false negatives. Examination of the normal pH operating range for the APB to generate acidic products was found to be much higher than the 4.4 to 4.8 range and, by experiment, it was found that the threshold range that would be triggered by APB would be in the 5.2 to 5.8 pH range. When this was selected as the target range to confirm the presence of APB there appeared to be a greater conformity between detectable (by the APB-BART™) and confirmed risk.

The next challenge related to the speed of the APB-BART™ in detecting the presence of acid producing bacteria in the water samples and pure cultures. It was found that, in the earlier configurations of the test, there was a slow and dispersed acidic generation that was resolved by modifications to the supporting culture medium. This medium can be seen as a crystallized deposit on the floor of the inner BART™ test vial. The approved medium causes acid formation along much of the water / medium column in the test and a positive reaction is now easy to determine by the clear shift in the color of the solution from purple to yellow during the incubation of the test at room temperature.

Comparative studies of the APB-BART™ against the standard American Petroleum Institute's standard test for acid producing bacteria conducted by an oil company in Alberta revealed that the APB-BART™ detected the APB faster in the water samples thought to have a problem than did the standard method. In addition, the APB-BART™ detected these bacteria being active in more samples than the standard method. It is recommended that in using the APB-BART™ comparisons be made with the standard methods and that some of the suspension from a positive BART™ test be applied to the standard test to confirm that the APB detected as present are confirmed as acid producing bacteria.

The medium selected for the detection of the APB is a glucose-peptone-based medium incorporating a pH indicator, bromocresol purple. This pH indicator shifts from a purple color under neutral to alkaline conditions to yellow under acid with the transition occurring between pH values of 5.2 and 5.8. While the medium is in the form of a crystalline pellet on the floor of the inner BART™ test vial, the pH indicator is impregnated into the inside of the cap. The test is initiated by adding the water sample (see notes 1 and 2 for constraints and limitations) to the inner test vial until the water reaches the fill line with the ball floating up to the surface. To charge the test, the inner test vial when sealed with the cap is inverted for thirty seconds to allow the pH indicator to mix with the water. This starts the test and the water sample in the test should have a purple color (see note 1 for more information if the water is either a yellow or golden orange color). It is recommended that the test be read daily for any significant change in color while being kept at room temperature away from direct sunlight.

9.1 Reaction Patterns, Acid Producing Bacteria

A positive reaction is indicated by a change of color within the test vial. The color of the fluid when the test is initiated is a deep purple. When the test has gone positive the purple color will have changed to an orange or yellow. This color change should be cloudy or followed by clouding within the test vial. Normally this reaction will appear at first in one or more zones down the test vial and these will gradually spread until more than 80% of the sample has turned from a purple to a yellow-orange color. Note the first time that this color change is occurring and calculate the number of days that the test was running before the positive indication of acid production (yellow-orange color) was noticed. This time, usually measured in days, becomes the time lag (TL) from which the aggressivity of the APB can be calculated.

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9.2 Time Lag (days of delay) to APB-BART™ Populations

There is only one reaction recognized in this test. This reaction is indicated when produced acid (PA) results in a change of color in the sample being tested. The TL gives a measure of the aggressivity of the test:

- TL of 3 days and less - HIGH AGGRESSIVITY
- TL of 4 to 6 days inclusive - MEDIUM AGGRESSIVITY
- TL of 7 to 10 days inclusive - LOW AGGRESSIVITY

TL can also be used to determine the population of APB using Table Seventeen.

Table Fifteen

The Relationship between Time Lag and the Population For Acid Producing Bacteria

Time Lag	Population cfu/ml
1	1,000,000
2	500,000
3	100,000
4	50,000
5	10,000
6	1,000
7	100

9.3 Hygiene Risk Considerations

Some of the APB belongs to the section five bacteria. Included in this section are the enteric bacteria within which the coliform bacteria form an important part. While the reductive conditions found in an environment generating acidic environments would not be likely to support the growth of the principal coliform species, *Escherichia coli*, some of the other species associated with coliform bacteria and hygiene risk could be present. In the event of a highly or moderately aggressive APB population being detected (with a TL<7days) it is recommended that a total coliform test be conducted on the sample to determine the hygiene risk with respect to coliform bacteria.

9.3.1 Notes on Constraints and Concerns

Acidic Water Samples: Modification to the Testing Procedure.

Water samples that are acidic (i.e., have a pH<6.0) are likely to give an instant or premature positive reaction (PA). It is therefore necessary to correct the sample's pH by titrating the pH upward with sterile normal KOH. This will raise the pH up into the range of 6.9 to 7.2. This does create some trauma when the test is then performed. This is usually because the APB becomes stressed by the sudden upward shift in pH resulting from the addition of the KOH. It is therefore recommended that the TL obtained by this technique would need to be modified to correct for the trauma. This is done using the following formula:

$$TL_c = TL_r - 2$$

Where TL_r is the time lag actually observed for the sample in which the pH was amended using the sterile KOH and TL_c is the corrected TL that should be used to determine the aggressivity and population size.

High Saline Waters: Modifications to the Testing Procedure

Water samples containing greater than 6% salt is most likely to give false negatives. The high concentration of salt within these samples interacts negatively within the test vial, giving a negative reaction. This is not a definitive negative however, to rectify this problem, all samples over 6% salt concentration should be diluted. To determine the presence of APB in such waters it is recommended that the water sample be diluted with sufficient sterile distilled water to bring the salt concentration down to less than 6% before setting up the APB-BART™ test. The dilution of these types of samples to < 6% gives a much improved potential to detect the APB in highly saline waters (e.g., connate / produced waters).

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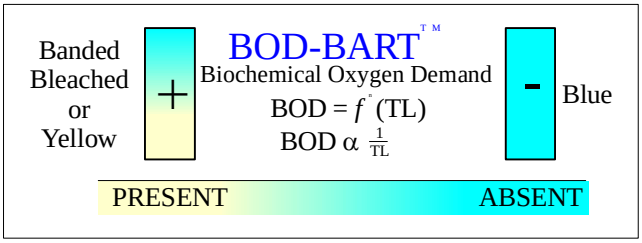
10.0 BIOCHEMICAL OXYGEN DEMAND, BOD-BART™



*TL Time Lag/Time to Positive Reaction

Biochemical Oxygen Demand (BOD) is the measure of oxygen consumption in water bodies due to the biological oxidation of organic matter. Presently, BOD is measured by using a five-day standard test based on dilution techniques. In comparison, the BOD-BART™ test provides an easy and rapid (< 24 hour) measurement of BOD based on enhanced respiration activity of heterotrophic aerobic bacteria. Accurate determination of the respiration rate of HAB (i.e. the rate of free oxygen uptake) in terms of time to positive reaction or time lag (TL) is the essence of the rapid determination of BOD or the concentration of biodegradable organic matter within a sample. Heterotrophic aerobic bacteria are able to biodegrade or consume organic matter in water bodies as their source of energy, using free available oxygen as an electron acceptor. By far, the majority of these heterotrophs function most effectively under aerobic conditions. Much of the biodegradation that occurs in aerobic environment is due to the activities of HAB. Since these bacteria are primarily responsible for oxygen demand in water bodies, their respiratory activity has serious implications on the quality of water within these bodies.

The unique feature of the BOD-BART™ test is the addition of a specific mineral and nutrient media and methylene blue, as a redox indicator. These additives enhance the respiration rate and its measurement as a function of time lag through time to initiation of bleaching (blue color changes to clear state). While there remains free oxygen in the sample, the methylene blue dye in the liquid medium remains blue. As soon as all of the oxygen has been consumed by bacterial respiratory activity, the methylene blue shifts from its observable form to a colorless form. In other words, in the BOD-BART™ test, when the liquid medium turns from blue to a colorless form, the heterotrophic aerobic bacteria have been sufficiently aggressive to have “respired off” the oxygen. At this time a methylene blue reductase enzyme becomes active and this starts reducing the methylene blue to its colorless form. Here the rate of bleaching action is correlated with the concentration of BOD in the sample. Note that the dried methylene blue present in the cap of each biodetector is dissolved in the liquid by inverting the BOD-BART™ three times up side down. During this process the FID traverses up and down the test vial six times. This allows for a head space oxygen saturation in the liquid.

Methylene blue is a basic dye that can bind readily to the negatively charged microbial cells. Traditionally, this dye has been used to stain microbial cells. The important property of methylene blue dye is that it changes from its original blue color in the oxidized state, to a clear in the reduced state with a progression of oxygen consumption. When methylene blue is added to a liquid medium with biodegradable organic concentration, due to microbial respiration, electrons are transformed to the dye carrying it to become reduced and eventually the blue color starts disappearing, depending upon rate of biological respiratory activity. The protocol has been based

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on the methylene blue reductase test that has been used in dairy industry for decades to determine the potential for bacterial spoilage of milk.

In the BOD-BART™ main objective is to provide an easy and rapid alternative system for determination of BOD in wastewater's as BOD is considered to be an important parameter for water pollution control activities.

10.1 Reaction Patterns, Biochemical Oxygen Demand

UP -Bleaching moves upwards from base

There is only one recognized reaction pattern (UP) for the BOD-BART™. There are different forms of clouding which follow the bleaching of methylene blue and these can be recognized using raw data from the BODSCAN™ system, although it is not important for BOD determination point of view.

UP- Bleaching moves upwards
Blue solution bleaches from the bottom up. The bleached zone may be clear or clouded. In the latter case, the medium tends to have a light to medium yellow color. Rarely does the bleaching extend beyond the equator of the ball so that a blue ring will remain around the ball with a width of 1 to 5 mm.

10.2 RPS (Reaction Pattern Signatures) for the BOD-BART™

- **UP** Strict aerobic bacteria is dominant with some facultative anaerobes often present

10.3 Time Lag (hours per second) to BOD-BART™ Concentration

The relationship between the approximately time lag (hours per second) to the probable BOD (mg/L) is given in Table Eighteen.

Table Sixteen

The Relationship between Time Lag and the Probable BOD

Time Lag (Hours)	Probable BOD (mg/L)	Time Lag (Hours)	Probable BOD (mg/L)
1.0	667	8.0	31
1.5	368	9.0	26
2.0	241	10.0	23
2.5	174	11.0	20
3.0	133	12.0	17
3.5	106	13.0	15
4.0	87	14.0	14
4.5	73	16.0	11
5.0	63	18.0	10
5.5	55	20.0	8
6.0	48	24.0	6
7.0	38	>24	Not Detected

10.4 Risk Potential Assessment-BOD-BART™

The BOD-BART is specifically designed to determine the biochemical oxygen demand within a sample. This BOD number determines the risk associated to the environment, in particular, water bodies. Regular and rapid monitoring of BOD data is critical to control pollution loads in receiving water bodies. BOD has serious implications on environmental quality of these water bodies. If not controlled properly, it adversely impacts the health and quality of aquatic systems, in turn, posing a health risk to humans. This is a result of reduced levels of dissolved oxygen in water bodies. This remains a demand for a rapid BOD forecasting system to cope with this type of environmental risk without delays. Besides rapid evaluation, BOD is also important in controlling unit operations in wastewater treatment plants. BOD-BART™ with BODSCAN™ would provide an attractive solution to above concerns and help in minimizing the pollution risks in water bodies.

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ATTACHMENT 2

EQuIS EDD REQUIREMENT

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Earthsoft - EDD Format Definition

Version UPDATE July 25, 2000
Provided by EarthSoft, Inc. and CDM.

This document defines the preferred format of the analytical electronic data delivery (EDD) to CDM. The data from the laboratory can be either a set of ASCII files as defined below or in the Excel spreadsheet template CHEM-LAB.xls as provided.

For each sample delivery group (SDG), the lab should submit either one two-tab Excel file or a pair of ASCII files. The Excel files should be renamed to sdgnum.XLS, where sdgnum is the SDG number. For the ASCII files, the first portion of the filenames must contain the SDG number plus the file code, either "-tes" or "-res". The ASCII filename extensions may be prn or txt:

Sdgnum-tes.prn for Lab Test Files
Sdgnum-res.prn for Lab Result Files

Dates should be entered as MM/DD/YY (month/day/year) and time as HH:MM (hour:minute). Time uses a 24-hour clock, thus 3:30 p.m. will be reported as 15:30. Data that is less than the maximum length should not be padded with spaces.

Fields with **Y** in the **Req.** column are required in database CDM uses to manage analytical data. These fields have a blue column heading in the template.

The ASCII file should use comma field separation. Each data field must be enclosed in double quotes (") and separated by columns. Data fields with no information should be represented by two commas. Each line must be terminated with a carriage return. Column headers with the names of the fields may be included. A second header line with the column numbers may also be included. The header lines are not required in the ASCII file but may be placed there if it of help to the lab. The two header rows must remain on both tabs in the spreadsheet file.

An Excel spreadsheet template is provided for this definition in CHEM-LAB.xls

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Lab Test

#	Field	DataType	Required	Definition
1	sys_sample_code	Text(20)	Y	Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. This must be consistent throughout the data.
2	lab_anl_method_name	Text(35)	Y	Laboratory analytic method name or description. This should be consistent throughout the data. See Appendix A for a list of valid codes.
3	analysis-date	Date/Time	Y	Date of sample analysis in MM/DD/YY format..
4	analysis-time	Text(5)	Y for reanalyses	Time of sample analysis in 24-hr (military) HH:MM format. Note that this field, combined with the "analysis_date" field, is used to distinguish between retests and reruns (if reported). Please ensure that retests have "analysis_date" and/or "analysis_time" different from the original test event (and fill out the test_type field as needed).
5	total-or-dissolved	Text(1)	N	If required, it must be either "T" for total [metal] concentration, "D" for dissolved or filtered [metal] concentration, or "N" for organic (or other) constituents for which neither "total" nor "dissolved" is applicable.
6	column-number	Text(2)	N	Use for indicating column from which result is reported.
7	test_type	Text(10)	Y	Type of test. Valid values include "initial", "reextract", and "reanalysis".
8	lab_matrix_code	Text(10)	N	Code which distinguishes between different types of sample matrix. I.E, soil versus leachate. See Appendix A for a list of valid codes.
9	analysis-location	Text(2)	N	If required, it must be "LB" for fixed-based laboratory analysis.
10	basis	Text(10)	N	If required, it must be either "Wet" for wet-weight basis reporting, "Dry" for dry-weight basis reporting, or "NA" for tests for which this distinction is not applicable.
11	container-id	Text(30)	N	Sample container identifier.
12	dilution-factor	Single	N	Effective test dilution factor.
13	prep_method	Text(35)	N	Laboratory sample preparation method name or description.
14	prep-date	Date/Time	N	Date of sample preparation in MM/DD/YY format.
15	prep-time	Text(5)	N	Time of sample preparation in 24-hr (military) HH:MM format.
16	leachate-method	Text(15)	N	Laboratory leachate generation method name or description.
17	leachate-date	Date/Time	N	Date of leachate preparation in MM/DD/YY format.
18	leachate-time	Text(5)	N	Time of leachate preparation in 24-hr (military) HH:MM format.
19	lab_name_code	Text(10)	N	Unique identifier of the laboratory.
20	qc-level	Text(10)	N	Data validation QC level.
21	lab-sample-id	Text(20)	Y	Laboratory LIMS sample identifier. Required. If necessary, a field sample may have more than one LIMS lab-sample-id (maximum one per each test event).

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#	Field	DataType	Required	Definition
22	percent-moisture	Text(5)	N	Percent moisture of the sample portion used in this test; this value may vary from test to test for any sample. Numeric format is "NN.MM", i.e., 70.1% could be reported as "70.1" but not as "70.1%".
23	subsample-amount	Text(14)	N	Amount of sample used for test.
24	subsample-amount-unit	Text(15)	N	Unit of measurement for sub-sample amount.
25	analyst-name	Text(30)	N	Name or initials of laboratory analyst.
26	instrument-id	Text(50)	N	Instrument identifier.
27	comment	Text(255)	N	Comments about the test as necessary.
28	Preservative	Text(50)	N	Type of preservative.
29	Final-volume	Text(15)	N	Final volume.
30	Final-volume units	Text(15)	N	Units of measurement for the final volume.

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Lab Result

#	Field	DataType	Required	Definition
1	sys_sample_code	Text(20)	Y	Unique sample identifier. Each sample must have a unique value, including laboratory spikes and duplicates. Laboratory QC samples must also have unique identifiers. This must be consistent throughout the data. This sample identifier must come from the chain-of-custody/traffic report. This sample identifier must be the same as used on the Lab-test tab for this sample.
2	lab_anl_method_name	Text(35)	Y	Laboratory analytic method name or description. This should be consistent throughout the data. See Appendix A for a list of valid codes.
3	analysis-date	Date/Time	Y	Date of sample analysis in MM/DD/YY format. This field is always required.
4	analysis-time	Text(5)	Y for reanalyses	Time of sample analysis in 24-hr (military) HH:MM format.. Note that this field, combined with the "analysis_date" field, is used to distinguish between retests and reruns (if reported). Please ensure that re-tests have "analysis_date" and/or "analysis_time" different from the original test event (and fill out the test_type field as needed).
5	total-or-dissolved	Text(1)	N	If required, it must be either "T" for total [metal] concentration, "D" for dissolved or filtered [metal] concentration, or "N" for organic (or other) constituents for which neither "total" nor "dissolved" is applicable.
6	column-number	Text(2)	N	If required, then it must be either "1C" for first column analyses, "2C" for second column analyses, or "NA" for analyses for which neither "1C" nor "2C" is applicable. However, if any "2C" tests are reported, then there must be corresponding "1C" tests present also.
7	test_type	Text(10)	Y	Type of test. Valid values include "initial", "reextract", and "reanalysis".
8	cas-rn	Text(15)	Y	Chemical Abstracts Registry Number for the parameter if available. See Appendix B - Substitute Analyte Codes for additional codes.
9	chemical-name	Text(60)	Y	Chemical name is used only in review of EDD. The cas-rn field is the only chemical identity information actually imported into EQuIS.
10	result-value	Text(20)	Y	Analytic result reported at an appropriate number of significant digits. May be blank for non-detects.
11	result-error-delta	Text(20)	N	Error range applicable to the result value; typically used only for radiochemistry results.
12	result-type-code	Text(10)	Y	Must be either "TRG" for a target or regular result, "TIC" for tentatively identified compounds, "SUR" for surrogates, "IS" for internal standards, or "SC" for spiked compounds.
13	reportable-result	Text(10)	Y	Must be either "Yes" for results which are considered to be reportable, or "No" for

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#	Field	DataType	Required	Definition
				other results. This field has many purposes. For example, it can be used to distinguish between multiple results where a sample is re-tested after dilution. It can also be used to indicate which of the first or second column results should be considered primary. The proper value of this field in both of these two examples should be provided by the laboratory (only one result should be flagged as reportable).
14	detect-flag	Text(2)	Y	May be either "Y" for detected results or "N" for non-detects.
15	lab-qualifiers	Text(7)	Y	Qualifier flags assigned by the laboratory.
16	organic-yn	Yes/No	N	If required, then it must be either "Y" for organic constituents or "N" for inorganic constituents.
17	method-detection-limit	Text(20)	Y	Method detection limit.
18	reporting-detection-limit	Text(20)	N	Detection limit that reflects conditions such as dilution factors and moisture content. Required for all results for which such a limit is appropriate.
19	quantitation-limit	Text(20)	N	Concentration level above which results can be qualified with confidence.
20	result-unit	Text(15)	Y	Units of measurement for the result.
21	detection-limit-unit	Text(15)	Y	Units of measurement for the detection limit(s).
22	tic-retention-time	Text(8)	N	Retention time in seconds for tentatively identified compounds.
23	result-comment	Text(255)	N	Result specific comments.
24	qc-original-conc	Text(14)	N	The concentration of the analyte in the original (unspiked) sample.
25	qc-spike-added	Text(14)	N	The concentration of the analyte added to the original sample.
26	qc-spike-measured	Text(14)	N	The measured concentration of the analyte.
27	qc-spike-recovery	Text(14)	N	The percent recovery calculated as specified by the laboratory QC program.
28	qc-dup-original-conc	Text(14)	N	The concentration of the analyte in the original (unspiked) sample.
29	qc-dup-spike-added	Text(14)	N	The concentration of the analyte added to the original sample.
30	qc-dup-spike-measured	Text(14)	N	The measured concentration of the analyte in the duplicate.
31	qc-dup-spike-recovery	Text(14)	N	The duplicate percent recovery calculated as specified by the laboratory QC program.
32	qc-rpd	Text(8)	N	The relative percent difference calculated as specified by the laboratory QC program.
33	qc-spike-lcl	Text(8)	N	Lower control limit for spike recovery
34	qc-spike-ucl	Text(8)	N	Upper control limit for spike recovery.
35	qc-rpd-cl	Text(8)	N	Relative percent difference control limit.
36	qc-spike-status	Text(10)	N	Used to indicate whether the spike recovery was within control limits.
37	qc-dup-spike-status	Text(10)	N	Used to indicate whether the duplicate spike recovery was within control limits.
38	qc-rpd-status	Text(10)	N	Used to indicate whether the relative percent difference was within control limits.

Field and Lab Sample and Analytical Data Import

Appendix A

– Lab Analysis Method Codes

Lab_anl_method_code	Lab Analysis Method Description
SW8021B	GC volatile organics
SW8260B	GCMS volatile organics

- Lab Matrix Codes

lab_matrix_code	Lab Matrix Code Description
GW	Groundwater
SB	Subsurface Soil
SED	Sediment
Soil	Soil
SG	Soil Gas
SS	Surface Soil
SW	Surface Water
Water	Water

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Field and Lab Sample and Analytical Data Import

Appendix B - Substitute analyte codes

CAS_RN	Chemical Name
ALK	CaCO3 - Alkalinity
ATOC	Total Organic Compounds - Aqueous
BOD	Biological Oxygen Demand
Fe2+	Ferrous
(Sieve size)	Grain Size Analysis – use sieve size description
HARD	Hardness - EPA 130.1 or 130.2
NO3/NO2	NO3/NO2
PH-A	pH - Aqueous
PH-S	pH - Soil
SO4	SO4 - Sulfate 375.3 or 375.4
STOC	TOC - Soil - L. Kahn
TDS	Total Dissolved Solids
TKN	TKN - 351.3 or 351.4
TPO4	Phosphate, total
TSS	Total Suspended Solids

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APPENDIX C

HEALTH AND SAFETY PLAN

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FINAL
HEALTH AND SAFETY PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
GARVEY ELEVATOR – OU1 AND OU2 SITES
HASTINGS, NEBRASKA

Prepared for:

U.S. Environmental Protection Agency Region 7
901 North 5th Street
Kansas City, KS 66101

Architect and Engineering Services Contract EP-S7-05-05
Task Order: 0033 and 0034

Prepared by:

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CDM Federal Programs Corporation
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Kansas City, MO 64114

May 2009

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Health and Safety Plan Form	**Environmental Protection Agency --Region 7--**	**HydroGeoLogic, Inc.**
		Project Name: Garvey Elevator—OU1 and OU2
		Task Order No.: 0033 and 0034

Job Site Address:	[redacted]: [redacted]
2315 West Highway 6, Hastings, Adams County, Nebraska	**WBS Work Area:** RI
Site Contact: NA	**EPA TOPO:** Brian Zurbuchen, TOPO
Telephone: NA	**Telephone:** 913-551-7101
	e-mail:zurbuchen.brian@epamail.epa.gov

☐ **Revision No. 0**

Objectives of Field Work: HGL has been tasked by EPA Region 7 to conduct a remedial investigation/feasibility study at the Garvey Elevator OU1 and OU2 Sites in Hastings, Nebraska. This field effort will consist of: direct push technology (DPT) in conjunction with electroconductivity (EC) downhole logging and subsurface soil and groundwater sampling; surface soil sample collection; surface water and sediment sample collection from on-site drainage ditches and pond; subslab soil gas sample collection; indoor and outdoor air sample collection; installation and development of monitoring wells; installation, development, and dipole flow testing at one hydraulic test well; slug testing; and monitoring well sampling.

Type: Check as many as applicable

☒ Active	☐ Landfill	☐ Unknown
☐ Inactive	☐ Uncontrolled	☐ Military
☐ Secure	☒ Industrial	☐ Enclosed space
☒ Unsecure	☐ Recovery	☐ Well Field
☐ Other **specify:**		

Description and Features: Summarize below. Include principal operations and unusual features (containers, buildings, dikes, power lines, hills, slopes, river).

The Garvey Elevator Site (site) is located in the NW1/4 of Section 23, T7N, R10W, approximately 7 miles west of the Adams County/Clay County line in the southwest portion of the City of Hastings, Nebraska. The site is bounded on the north by U.S. Highway 6/34, on the east by the Burlington Northern and Santa Fe (BNSF) railroad track, on the west by Marion Road, and on the south by farmland owned by the Walter Family Trust. The site is an area of soil and groundwater contamination that consists of the Garvey Elevator property at 2315 West Highway 6, Hastings, Nebraska (OU1), and the associated contaminated ground water plume that extends approximately three (3) miles east of the site (OU2).

The site is the location of an active 8-million bushel capacity grain storage facility which consists of a concrete elevator head house and elevator, a flat storage building, and steel bins. It was constructed in 1958 and originally owned and operated by Garvey Elevators, Inc., of Fort Worth, Texas. The facility is currently owned and operated by AGP Grain marketing, LLC.

The site is located within the Loess Plains, a portion of the Great Plains physiographic province. The topography of the area is relatively flat, with a slight slope to the east-southeast. The Platte River valley lies 15 miles north of the site and flows to the northeast, and the Little Blue River valley lies 10 miles to the south and flows toward the east.

Surface soils in the vicinity of the site consist of silt-loam. The elevation is approximately 1,930 feet above mean sea level (amsl). The Hastings area is underlain by approximately 200 to 240 feet of unconsolidated Pleistocene Age deposits lying unconformably on Upper Cretaceous Age Niobrara Formation, an argillaceous chalk and limestone formation containing interbedded layers of chalky shale. Ground water is generally encountered at depths between 100 and 130 ft below the ground surface.

Surrounding land use is primarily agricultural with a mixture of urban and industrial use to the north and east. Land use along the Highway 6 corridor north of the site is primarily zoned commercial and industrial. The nearest residential developments are approximately 1 mile to the northeast and east. However, isolated residences lie within ½ or ¾ of a mile from the site.

Hastings is situated within the Little Blue Natural Resources District. Under the provisions of the Rules and Regulations for Enforcement of this district, the site is within a Wellhead Protection Area; therefore, no wells can be installed without first being permitted. Though there are expected to be some private wells in use within the affected area, businesses and residences having wells that are known to be contaminated have been placed on alternative water supplies.

Surrounding Population: ☒ Residential ☒ Industrial ☒ Rural ☐ Urban ☒ Other: Commercial

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Site History: Summarize below. In addition to history, include complaints from public, previous agency actions, known exposures or injuries, etc.

A fumigant, Liquid 80-20, which was composed of 80 percent carbon tetrachloride and 20 percent carbon disulfide, was applied to grain in all upright grain storage areas. In 1960, Garvey Elevator installed a 3,000-gallon aboveground storage tank that was used for storage of the liquid grain fumigant. The fumigant was transferred through a delivery pipe that connected the storage tank to piping mounted on the side of the elevator and then up the side of the elevator to the distribution gallery. A buried portion of this delivery pipe was found to be leaking and was replaced, sometime before 1986 when the tank was removed. The exact date of the repair and the amount of fumigant that leaked are unknown. The facility ceased use of the liquid fumigant in 1985.

Garvey Elevator was first identified as a source of carbon tetrachloride contamination in 1994 when an on-site water sample revealed the presence of carbon tetrachloride at 199 micrograms per liter (μg/L). During past investigations, 36 monitoring wells were installed to define the extent of groundwater contamination. Soil and soil vapor samples collected in 1994 documented the presence of extensive carbon tetrachloride contamination in on-site soils. Contamination in the soils extended from the ground surface to the water table at a depth of more than 100 feet bgs. It was estimated that 55 million cubic feet of contaminated soil existed at the site. These contaminated soils represented a continuing source of groundwater contamination as contaminants were dissolved with infiltrating precipitation. In 1996, the groundwater contaminant plume was estimated to be 6,500 feet long by 3,200 feet wide in the principal regional sand and gravel aquifer. The maximum carbon tetrachloride concentration in groundwater was observed in an on-site monitoring well at approximately 29,000 μg/L.

Garvey Elevator initiated remedial activities under the NDEQ's VCP, including installation of a soil vapor extraction (SVE) system to treat contaminated vapor in soils beneath the facility, and installation/operation of a groundwater extraction and treatment (GET) system to treat contaminated groundwater. The SVE began operation in January 1999. The GETS consisted of eight extraction wells and an air stripper to remove contaminants from extracted water. The treated groundwater is re-injected to the aquifer. Within the first approximately two years of operation, the combined SVE and GETS removed more than 10,000 lbs of carbon tetrachloride from the soil and groundwater. Garvey Elevator continues to operate the SVE and GET systems.

The first survey/sampling of residential and business wells was conducted by Garvey Elevator in late 1994. Of the 13 private wells sampled, 5 were found to be contaminated with carbon tetrachloride at levels above the EPA maximum contaminant level (MCL) of 5 μg/L. Subsequent sampling events also have identified additional impacted residential/business wells. According to NDEQ records, alternate water provisions of bottled water and/or carbon filtration systems were made available to impacted residents.

The NDEQ completed a Preliminary Assessment/Site Inspection (PA/SI) of the Site in April 2003. The PA/SI detected carbon tetrachloride in groundwater wells located more than 3 miles downgradient from the site. In August 2003 Garvey Elevators indicated they would not conduct cleanup of the entire contaminated groundwater plume within the framework of the RAPMA program. Concerned about the ability of Garvey Elevator to address the on- and off-site contamination, NDEQ requested EPA assistance on December 9, 2003.

EPA entered into an Administrative Order on Consent (AOC) with the Potentially Responsible Party (PRP) on October 7, 2005. In the AOC, the PRP agreed to conduct investigation and source area treatment activities at the Garvey Elevator Site. In a separate Agreement with AGP Grain Marketing, LLC (AGP), AGP funded an escrow account to continue response actions at the site. The AOC and Agreement were issued pursuant to Sections 104, 106(a), 107, and 122 and to Section 102(h)(1) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA).

Garvey filed Chapter 7 bankruptcy in March 2008. The EPA took over ongoing removal activities to address the immediate threats posed by contamination from the site. These removal efforts include providing alternate water to impacted private wells and operation and maintenance of the ground water extraction wells, packed tower air stripper, soil vapor extraction wells, soil vapor extraction blowers and catalytic oxidation unit.

Several other potential sources of contamination associated with the grain elevator have been identified during past investigations but have not been assessed. These potential source areas are as follows:

- Ground mounted electrical transformers exhibiting oil stained surfaces and lacking clear labeling regarding polychlorinated biphenyl (PCB) content of dielectric oil.
- A pesticide storage building. Malathion, glyphosate (i.e. Roundup®), and 2,4-D are known to have been stored on the site.
- Three locations where various containers of roofing materials, paints, and petroleum products are stored (shop building, machine room, and outdoor drum storage area).

Waste Types: ☒ Liquid ☒ Solid ☐ Sludge ☐ Gas ☐ Unknown ☐ Other **Specify:**

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Waste Characteristics: Check as many as applicable.

- ☐ Corrosive
- ☒ Toxic
- ☐ Inert Gas
- ☐ Other **Specify:**
- ☐ Flammable
- ☒ Volatile
- ☐ Unknown
- ☐ Radioactive*
- ☐ Reactive
- ☒ Carcinogenic

* Contact Regional HSO for further project planning

Work Zones: Describe the Exclusion, Contamination Reduction, and Support Zones in terms on-site personnel will recognize.

Exclusion, contamination reduction, and support zones will be independently established around each sample point. Zones will consist of physical boundaries. Access by unauthorized personnel will dictate work zone delineation. Unauthorized personnel will be removed a safe distance from work areas.

Hazards of Concern:

Indoors

- ☐ Exhaust
- ☐ Inorganic Chemicals
- ☒ Organic Chemicals
- ☐ Motorized Traffic
- ☒ Heavy Machinery
- ☒ Slips, Trips, and Falls
- ☒ Noise
- ☐ Explosive/Flammable
- ☐ Radiological
- ☐ Other Specify

Outdoors

- ☒ Noise
- ☐ Inorganic Chemicals
- ☒ Organic Chemicals
- ☒ Motorized Traffic
- ☒ Slips, Trips, and Falls
- ☒ Biological: stinging insects, venomous reptiles
- ☒ Cold Stress
- ☒ Heat Stress
- ☒ Heavy Machinery

Note here any incidents at this site that will affect any and all standard operating procedures:

Principle Disposal Methods and Practices for investigation derived waste. Summarize below:

IDW soil will be containerized in 55-gallon drums and/or roll-off bins and staged on site prior to testing. After testing the drums will be disposed of by a qualified waste hauler.

IDW water will be containerized in either 55-gallon drums or poly tanks on site prior to testing. After testing the water will be transported to the POTW or disposed of by a qualified waste hauler as needed.

All other IDW will be disposed of in opaque heavy duty trash bags. Hastings municipal waste will remove these bags from the site on a weekly basis.

Project Specific Hazardous Material Summary: Check waste type and media in which the material is contained, estimate quantity if material exists in bulk quantities.

Chemicals Amounts/Units:	***Solids Amounts/Units:***	***Sludges Amounts/Units:***	***Solvents Amounts/Units:***	***Oils Amounts/Units:***	***Other Amounts/Units:***
☐ Acids	☐ Flyash	☐ Paint	☒ Halogenated (chloro, bromo)	☐ Oily Wastes	☐ Laboratory
☐ Pickling Liquors	☐ Asbestos	☐ Pigments	☒ Solvents	☐ Gasoline	☐ Pharmaceutical
☐ Caustics	☐ Milling/Mine Tailings	☐ Metal Sludges	☐ Hydrocarbons	☐ Diesel Oil	☐ Hospital
☒ Pesticides	☐ Ferrous Smelter	☐ POTW Sludge	☐ Alcohols	☐ Lubricants	☐ Radiological
☐ Dyes/Inks	☐ Non-ferrous Smelter	☐ Aluminum	☐ Ketones	☒ PCBs	☐ Municipal
☐ Cyanides	☐ Metals:	☐ Distillation Bottoms	☐ Esters	☐ Polycyclic Aromatics	☐ Construction
☐ Phenols	☐ Other	☐ Other	☐ Ethers	☐ Other	☐ Munitions
☐ Halogens	**Specify:**	**Specify:**	☐ Other	**Specify:**	☐ Other
☐ Dioxins			**Specify:** carbon tetrachloride, chloromethane, dichloromethane, chloroform, ethylene dibromide, carbon disulfide		**Specify:**
☐ Other					
Specify: Malathion, Glyphosate, 2,4-D (2,4-Dichlorophenoxy Acetic Acid)					

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Overall Hazard Evaluation: ☐ High ☐ Medium ☒ Low ☐ Unknown (Where tasks have different hazards, evaluate each. Attach additional sheets if necessary.)

Justification: Exposure routes are through ingestion and inhalation of VOC contaminated soil and water, dermal contact, and/or inhalation of particulates entrained in air. Toxicity of CCL is the same for exposure by either dermal or inhalation routes. Proper personal hygiene (i.e., laundering, showering, and washing hands) after field activities will minimize ingestion of contaminants.

Fire/Explosion Potential: ☐ High ☐ Medium ☒ Low ☐ Unknown

Background Review: ☒ Complete ☐ Incomplete Additional information to be collected in this and future investigations.

Known Contaminants	*Highest Observed Concentration (specify units and media)*	*TLV ppm or mg/m³ (specify)*	*IDLH ppm or mg/m³ (specify)*	*STEL/ Ceiling Limit*	*Symptoms/Effects of Acute Exposure*	*Photo-ionization Potential*
Carbon Tetrachloride CAS: 56-23-5	29,000 µg/L in groundwater [1] 884 µg/kg in soil 79,900 µg/m in soil gas	5 ppm -Skin-	200 ppm (CA)	10 ppm -Skin-	Irritate eyes and skin; central nervous system depression; nausea, vomiting; liver, kidney damage; potential carcinogen	11.47 eV
Chloroform CAS: 67-66-3	120 J µg/L in groundwater Nondetect in soil 2,350 µg/m³ in soil gas	10 ppm	500 ppm	2 ppm	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion; headache, weakness, exhaustion; anesthesia; enlarged liver; (potential occupational carcinogen)	11.42 eV
Carbon Disulfide CAS: 75-15-0	4.7 µg/L in groundwater Nondetect in soil Nondetect in soil gas	5,000 ppm	500 ppm	NE	Dizziness, headache, poor sleep, weakness, exhaustion, anxiety, anorexia, weight loss; psychosis; polyneuropathy; Parkinson-like syndrome; ocular changes; coronary heart disease; gastritis; kidney, liver injury; eye, skin burns; dermatitis; reproductive effects	10.08 eV
Ethylene Dibromide (1,2-Dibromoethane) CAS: 106-93-4	Nondetect in groundwater 130 mg/kg in soil 770 µg/m³ in soil gas	NE	100 ppm (CA)	NE	Irritation eyes, skin, respiratory system; dermatitis with vesiculation; liver, heart, spleen, kidney damage; reproductive effects; (potential occupational carcinogen)	9.45 eV
Dichloromethane (Methylene chloride) CAS: 75-09-2	Nondetect in groundwater Nondetect in soil Nondetect in soil gas	25 ppm	2300 ppm (CA)	125 ppm	Mental confusion, light-headedness, fatigue, nausea, vomiting and headache	11.32 eV
Chloromethane (Methyl Chloride) CAS: 74-87-3	Nondetect in groundwater Nondetect in soil Nondetect in soil gas	50 ppm	NE (CA)	100 ppm	Irritation eyes, skin, mucous membrane, respiratory system; pulmonary congestion, edema; corneal damage, necrosis; decreased pulmonary function, cough, breathing difficulty, wheezing; blood-stained sputum, bronchial secretions; (potential occupational carcinogen)	Undefined

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Known Contaminants	*Highest Observed Concentration (specify units and media)*	*TLV ppm or mg/m³ (specify)*	*IDLH ppm or mg/m³ (specify)*	*STEL/ Ceiling Limit*	*Symptoms/Effects of Acute Exposure*	*Photo-ionization Potential*
Malathion CAS: 121-75-5	Unknown	1 mg/m³	250 mg/m³	NE	Irritation eyes, skin; aching eyes, blurred vision, discharge of tears; salivation; nausea, vomiting, abdominal cramps, diarrhea, dizziness, confusion; headache; chest tightness, wheezing	Undefined
Glyphosate (Roundup®) CAS: 1071-83-6	Unknown	NE	NE	NE	Unknown	Unknown
2,4-Dichlorophenoxy Acetic Acid (2,4-D) CAS: 94-75-7	Unknown	1 mg/m³ (German MAK, inhalable fraction)	100 mg/m³	NE	Lassitude (weakness, exhaustion), stupor, hyporeflexia, muscle twitching; convulsions; dermatitis; in animals: liver, kidney injury	Undefined
PCBs CAS: 11097-69-1	Unknown	0.5 mg/m³	5 mg/m³ (CA)	NE	Irritation eyes, chloracne; liver damage; reproductive effects; (potential occupational carcinogen)	Undefined

ACGIH = American Conference of Government Industrial Hygienists
CA = Human carcinogen
CAS = Chemical Abstract Service
IDLH = Immediately Dangerous to Life and Health (NIOSH standard enforced by law)
LEL = Lower Explosive Limit
mg/m³ = milligrams per cubic meter
NE = Not established
NIOSH = National Institute for Occupational Safety and Health
OSHA = Occupational Safety and Health Administration
ppm = parts per million
STEL = Short Term Exposure Limit (15 minute TWA)
TLV = Threshold Limit Values (Recommended by ACGIH)
TWA = Time-Weighted Average (Average concentration for a normal 8-hour working day or 40-hour working week)
µg/kg = micrograms per kilogram
µg/L = micrograms per Liter
mg/m³ = milligrams per cubic meter

[1] Measured in 1995. The concentration at the same well had decreased to 280 µg/L in 2004.

Activity Hazard Analysis – Complete Corresponding Detailed PPE Section for each task

Task Number/Activity Description/ Site Location	*Potential Hazards*	*Controls*	*Primary /Secondary PPE Level*	*Exposure Monitoring Required/ Frequency*
1 Groundwater sampling during drilling. Groundwater samples will be collected using DPT.	Machinery, Chemical exposure, Heat/Cold stress, noise	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities.	**Modified Level D**/ Exit Area	PID, wellhead and breathing zone. Screen at start of activities; additional monitoring if VOCs are detected.
2 Subsurface soil sampling during drilling. Subsurface soil samples will be collected using a DPT rig along with a PID to screen the soil cores.	Machinery, Chemical exposure, Heat/Cold stress, noise	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities.	**Modified Level D**/ Exit Area	PID, wellhead and breathing zone. Screen at start of activities; additional monitoring if VOCs are detected.
3 DPT borehole logging/ EC logging.	Machinery, Chemical exposure, Heat/Cold stress, noise	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities.	**Modified Level D**/ Exit Area	PID, wellhead and breathing zone. Screen at start of activities; additional monitoring if VOCs are detected.

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Task Number/Activity Description/ Site Location	*Potential Hazards*	*Controls*	*Primary /Secondary PPE Level*	*Exposure Monitoring Required/ Frequency*
4 Monitoring well and hydraulic test well installation (including drilling, well installation, and well development).	Machinery, Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities	**Modified Level D**/ Exit Area	PID, breathing zone. Screen at start of activities; continuous monitoring if VOCs are detected.
5 Groundwater sampling. Groundwater samples will be collected from monitoring wells using nondedicated submersible pumps.	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather	**Modified Level D**/ Exit Area	PID at wellhead, and breathing zone at the opening of each well. Continuous monitoring of breathing zone if VOC levels are detected
6 Water level measurements will be taken from all monitoring wells used in the study prior to each sampling event.	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather	**Modified Level D**/ Exit Area	PID at wellhead, and breathing zone at the opening of each well.
7 Dipole flow testing of hydraulic test well.	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather	**Modified Level D**/ Exit Area	PID at wellhead, and breathing zone at the opening of the well.
8 Boring Abandonment/Grouting of Soil Borings.	Machinery, Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities	**Modified Level D**	PID, breathing zone. Screen at start of activities; continuous monitoring if VOCs are detected.
9 Equipment decontamination associated with groundwater sampling and drilling will use detergent, deionized water, and potable water. Power washer will be used to steam clean drilling and DPT equipment.	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather	**Modified Level D**	None
10 Surveying. Monitoring wells and sample locations will be surveyed for horizontal and vertical location.	Traffic, Heat/Cold Stress	Appropriate PPE, schedule breaks according to weather, cones or other traffic controls as needed	**Modified Level D**	None
11 Slug Testing will be completed at select monitoring wells	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather	**Modified Level D**	PID at wellhead, and breathing zone at the opening of each well.
12 Surface water and sediment sampling. Surface water and sediment samples will be collected at drainage ditches and a pond.	Chemical exposure, Heat/Cold stress, drowning	Appropriate PPE, schedule breaks according to weather, use the Buddy system	**Modified Level D**	None
13 Surface soil sampling. Surface soil samples will be collected prior to DPT drilling.	Chemical exposure, Heat/Cold stress	Appropriate PPE, schedule breaks according to weather, locate support equipment away from mechanical activities.	**Modified Level D**/ Exit Area	PID, breathing zone. Screen at start of activities; additional monitoring if VOCs are detected.
14 Vapor intrusion/indoor air investigation.	Chemical exposure; hand tools; heavy machinery; slips, trips and falls; and noise	Appropriate PPE	**Modified Level D**/ Exit Area	PID, breathing zone. Screen at start of activities; additional monitoring if VOCs are detected.

PPE Levels = A, B, C, D – definitions of these levels available in Corporate H&S Manual.
Exposure Monitoring = PID, PDR (dust monitor), CGI, O2 meter, etc.

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Does the project require continuous air monitoring during the project?
☐ Yes ☒ No If Yes, Contact the Regional Health and Safety Coordinator for additional project safety planning.

Protective Equipment: Specify by task. Indicate type and/or material as necessary. Use copies of this sheet if needed.

Task Number: 1-14 ☒ **Primary**
PPE Level: D - Modified ☐ **Contingency**

Respiratory: ☒ Not Needed
☐ SCBA, Airline
☐ APR Full face
☐ Cartridge
☐ Escape Mask
☐ Other

Prot. Clothing: ☐ Not Needed
☐ Encapsulated Suit
☐ Splash Suit
☐ Apron
☒ Saranex Coverall: where potential splash exposure exists
☐ Cloth Coverall
☐ High Visibility Vests

Head & Eye: ☐ Not Needed
☒ Safety Glasses (as needed)
☐ Face Shield (optional, as needed)
☐ Goggles
☒ Hard Hat (as needed)
☒ Hearing Protection (as needed)
☐ Other

Gloves: ☐ Not Needed
☐ Undergloves
☒ Gloves; StanzSolve Nitrile, or Viton
☐ Overgloves

Boots: ☐ Not Needed
☒ Boots: Leather steel-toed safety boots
☐ Overboots
☐ Rubber

☒ Other – specify below:

Exit area and reevaluate personnel protection if unexpected conditions arise.

Task Number: 1-8, 11, 13, 14 ☐ **Primary**
PPE Level: C ☒ **Contingency**

Respiratory: ☐ Not Needed
☐ SCBA, Airline
☒ APR Full face: MSA Advantage or 3M 6000
☒ Cartridge:
☐ Escape Mask
☐ Other

Prot. Clothing: ☐ Not Needed
☐ Encapsulated Suit
☐ Splash Suit
☐ Apron
☒ Saranex Coverall
☐ Cloth Coverall
☐ High Visibility Vests
☐ Other

Head & Eye: ☐ Not Needed
☒ Safety Glasses (as needed)
☐ Face Shield (optional, as needed)
☐ Goggles
☒ Hard Hat (as needed)
☒ Hearing Protection (as needed)
☐ Other

Gloves: ☐ Not Needed
☐ Undergloves
☒ Gloves; StanzSolve Nitrile, or Viton
☐ Overgloves

Boots: ☐ Not Needed
☒ Boots: Leather steel-toed safety boots
☐ Overboots
☐ Rubber

☒ Other – specify below:

Note**: Upgrade to Level C is not anticipated. Level C is included for informational purposes only. If action guidelines are exceeded during exposure monitoring stop work and contact PHSM for requirements for level C upgrade.**

Task Number: ☐ **Primary**
PPE Level: ☐ **Contingency**

Respiratory: ☐ Not Needed
☐ SCBA, Airline
☐ APR Full face
☐ Cartridge
☐ Escape Mask
☐ Other

Prot. Clothing: ☐ Not Needed
☐ Encapsulated Suit
☐ Splash Suit
☐ Apron
☐ Saranex Coverall
☐ Cloth Coverall
☐ High Visibility Vests
☐ Other

Head & Eye: ☐ Not Needed
☐ Safety Glasses
☐ Face Shield
☐ Goggles
☐ Hard Hat
☐ Hearing Protection
☐ Other:

Gloves: ☐ Not Needed
☐ Undergloves
☐ Gloves
☐ Overgloves:

Boots: ☐ Not Needed
☐ Boots: Leather steel-toed safety boots
☐ Overboots
☐ Rubber

☐ Other – specify below:

☐ Other – specify below:

Task Number: ☐ **Primary**
PPE Level: ☐ **Contingency**

Respiratory: ☐ Not Needed
☐ SCBA, Airline
☐ APR Full face
☐ Cartridge: MSA GMC-H
☐ Escape Mask
☐ Other:

Prot. Clothing: ☐ Not Needed
☐ Encapsulated Suit
☐ Splash Suit
☐ Apron
☐ Saranex Coverall
☐ Cloth Coverall
☐ High Visibility Vest
☐ Other

Head & Eye: ☐ Not Needed
☐ Safety Glasses
☐ Face Shield
☐ Goggles
☐ Hard Hat
☐ Hearing Protection
☐ Other:

Gloves: ☐ Not Needed
☐ Undergloves
☐ Gloves
☐ Overgloves:

Boots: ☐ Not Needed
☐ Boots: Leather steel-toed safety boots
☐ Overboots
☐ Rubber

☐ Other – specify below:

☐ Other – specify below:

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Personnel and Responsibilities ***(Include subcontractors)***

Name	Firm/Region	Medical Monitoring Clearance* (yes/no)	Responsibilities	On-site Involvement
[redacted]	HGL/KC	Yes	TOM	
[redacted]	HGL/KC	Yes	Field Team Leader	All Tasks
[redacted]	HGL/KC	Yes	SSHO	All Tasks
CDM Personnel	CDM	Yes	Field/sampling support	Field Support
DPT Drilling Subcontractor	TBD			DPT Drilling
Well Drilling Subcontractor	TBD			Well Drilling
Surveying Subcontractor	TBD			Surveying

*Health clearance meets all the medical surveillance requirements of 29 CFR 1910.120. Medical surveillance certification for on-site personnel is presented in HGL Policy 3.1. Subcontractors are required to meet the medical requirements of 20 CFR 1910.120, if applicable

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Does the project have any permit required confined spaces that will need to be entered to accomplish the identified project tasks?
☐ Yes ☒ No If Yes, Attach the Permit Required Confined Space Entry Checklist (available via the Intranet) and contact the regional HSC for additional project safety planning.

Health and Safety Monitoring Equipment: Specify by task. Indicate type as necessary. Attach additional sheets as necessary.

Instrument	*Task*	*Action Guidelines*		*Comments (Include schedules of use)*
Combustible Gas Indicator LEL/O_2 Meter		0-10% LEL **>10% LEL** 21.0% 02 <21.0% 02 **<19.5% 02**	No explosion hazard **Explosion hazard; interrupt task/evacuate** Oxygen normal Oxygen deficient; notify SHSC **Interrupt task/evacuate**	☒ Not Needed
Multi-gas Meter (CO_2/CO) Type _____		**Specify: Monitor CO levels**	If CO >25 ppm and/or CO_2 >5,000 ppm stop work and re-evaluate the ventilation design.	☒ Not Needed
Photoionization Detector Type ____■ 11.7 eV	1–8, 11, 13, 14	**Specify: Exit area and contact PHSM for requirements for level C upgrade**	**If > 10 ppm is detected in the breathing zone and sustained for 15 minutes, exit site and reevaluate conditions.** **Detectable Odor: If odor of any kind is detected, cease work and move to fresh air.**	☐ Not Needed **NOTE: CCL4 has an odor threshold of about 50 ppm.**
Sound level Meter Type _____		**Specify:**		☒ Not Needed
Detector Tubes/Monitor Type _____ Type _____		**Specify:**		☒ Not Needed
Respirable Dust Monitor (Digital) Type _____ Type _____		**Specify:**		☒ Not Needed Dusty conditions are not expected.
Other **Specify: Visible or nuisance dust and/or unusual vapors (odors)**	all	**Specify: If team notices unusual odors, heavy dust, or irritation of the eyes or throat, they will exit area and reevaluate personnel protection.**		
Other **Specify:**		**Specify:**		☐ Not Needed

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Decontamination Procedures

Personalized Decontamination	***Sampling Equipment Decontamination***	***Heavy Equipment Decontamination***
Wash well before hand-to-mouth contact is made. A shower will be taken as soon as possible after leaving the field. Workers will remove protective clothing in this order: Wet or dry decontamination procedures will be selected per project. **Dry Decon Procedure** Place all disposable PPE in a garbage bag as removed in the following order: (1) Brush off work boots, remove disposable over boots, or booties (2) remove gloves (3) remove safety glasses (4) remove Tyvek or cloth coverall, if used (5) remove respirator, if used (6) remove inner gloves (7) wash hands/face before eating/drinking **Wet Decon Procedure** ☐ **Not Needed** (1) wash overboots in soapy water and rinse (2) remove overboots or booties (3) remove gloves (4) remove safety glasses (5) remove Tyvek or cloth coverall, if used (6) remove respirator, if used (7) remove inner gloves (8) wash hands/face before eating/drinking	All sampling equipment will be thoroughly decontaminated as follows: (1) wash and scrub with low phosphate detergent (2) potable tap water rinse 1 (3) potable tap water rinse 2 (4) thoroughly rinse with deionized water, if specified by the Work Plan (5) thoroughly rinse with solvent (e.g., hexane and/or methanol), as specified by the Work Plan (6) air dry (7) wrap in aluminum foil for transport , if specified by the Work Plan ☐ Not Needed	See HGL HSP Policy 6.6 for pressure washing protocols. All heavy equipment and tool parts that contact subsurface soil are constructed of heavy gauge steel and have no natural or synthetic components that could absorb and retain most soil-borne organic contaminants. Prior to removal from the work site, potential contaminated soil/groundwater will be scraped or brushed from the exterior surfaces. The drill rig, augers and any other large equipment in the exclusion zone will be taken to a decon pad and steam cleaned. Rain suits to protect from water spray and runoff will be used if necessary ☐ Not Needed
Containment and Disposal Method	***Containment and Disposal Method***	***Containment and Disposal Method***
All disposable PPE will be double-bagged prior to disposal. Decon water to be contained on site for bulk disposal. ☐ Not Needed	Decon water to be contained on site for bulk disposal. ☐ Not Needed	All disposable PPE will be double-bagged before disposal. Decon water to be contained on site for bulk disposal. ☐ Not Needed

Hazardous Materials Inventory (MSDSs for Investigation-Associated Substances available on HGL Corporate Intranet)

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Spill Response: The following materials will be kept on site for spill response (check all appropriate materials)

☒ Absorbent Pads ☐ Granular absorbent material(non flammable) ☒ Polyethylene Sheeting ☒ Waste Container ☐ Shovels or assorted hand tools

If a hazardous waste spill or material release to the air, soil, or water at the site is observed, the EPA site representative and the local Fire Department will be immediately notified. An assessment will be made of the magnitude and potential impact of the release. If it is safe to do so, site personnel will attempt to locate the source of the release, prevent further release, and contain the spilled and/or affected materials.

Emergency Contacts		*Emergency Contacts*	*Name*	*Phone*
Facility Management	1-402-462-2189	[redacted] Manager	[redacted]	913-317-8860
Dig/Utility Clearance	1-800-331-5666	Site Health & Safety Officer	Steve Holmes	913-317-8860
Additional Utilities		EPA TOPO	Brian Zurbuchen	1-913-551-710
Health Department		HGL [redacted] H[redacted]	[redacted]	913-317-8860 W 913-909-2411 Cell
Sheriff's Department	1-402-461-7181	HGL [redacted]	[redacted], CIH [redacted], CIH, CSP	916-614-8770 W 916-833-3553 Cell 303-946-1774 Cell
Fire Department	911	HGL [redacted]	[redacted]	303-250-7753 Cell
		CDM RHSC	[redacted]	816-444-8270 W 913-481-8506 Cell
Police Department	911	CDM Corporate HSO	[redacted]	703-968-0900 W 571-216-7004 Cell
Highway Patrol/State Police	1-402-370-3456	Occupational Physician	Washington Occupational Health Associates	1-800-777-WOHA
Poison Control Center	1-800-525-5042			
State Spill Line	1-402-471-2186			

Contingency Plans **Summarize below:**

Evacuate site if any unexpected hazardous conditions are encountered. If staff observes hazards for which they have not been prepared, they will withdraw from the area and call their regional health and safety coordinator.

Health and Safety Plan Approvals

Prepared by: Phyllis Chase	Date: 5/20/2009
HGL SSHO Signature: Steve Holmes	Date:
[redacted]ture:	Date: 5/26/09

Site: Garvey Elevator, OU1 & OU2 Sites, Hastings, Nebraska

Medical Emergency

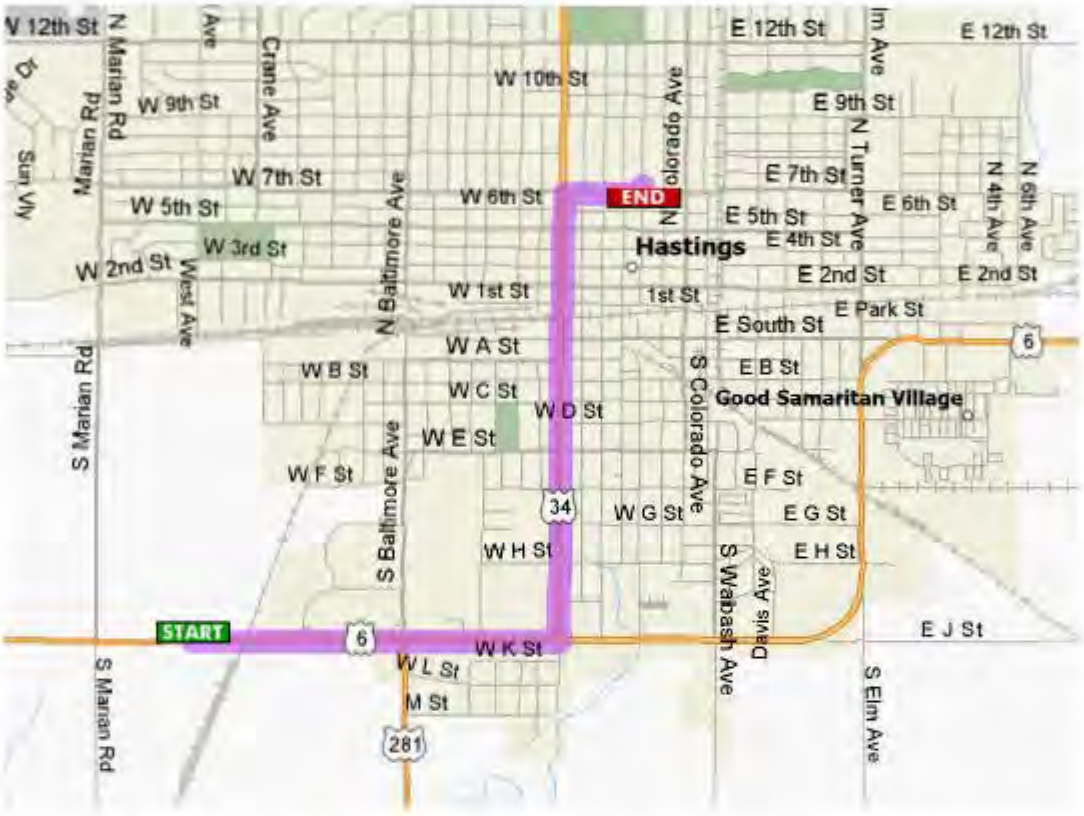
Hospital Name: Mary Lanning Memorial Hospital	
Hospital Address: 715 N. Saint Joseph Avenue	1-402-463-4521
Name of Contact at Hospital: NA	
Name of 24-Hour Ambulance:	911

Route to Hospital (See Figure 2)

Follow the attached map (Page 12) to the hospital. Become familiar with location of hospital prior to any site activities.

1. Head east on US 6/US 34 (0.8 mile)
2. Turn left (north) and stay on US 34 N / US 281 E / S. Burlington Ave (1.5 mile)
3. Turn right (east) onto W 6th St. (0.3 mile)
4. Turn left (north) onto N Saint Joseph Ave. ending at 715 N. St. Joseph Ave.

Distance to Hospital: 2.6 miles



US EPA ARCHIVE DOCUMENT

Health and Safety Plan Form	Environmental Protection Agency --Region 7--	HydroGeoLogic, Inc. Project Name: Garvey Elevator—OU1 and OU2 Task Order No.: 0033 and 0034

The following personnel have read and fully understand the contents of this Health and Safety Plan and further agree to all requirements contained herein.

Site: Garvey Elevator, OU1 & OU2 Sites, Hastings, Nebraska	**Project No.: EPA009-033/034**

Name and Responsibility	Affiliation	Date	Signature

US EPA ARCHIVE DOCUMENT