Pre-Design Investigation Work Plan

Delaware Sand & Gravel Superfund Site

New Castle County, Delaware

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ACRONYMS AND ABBREVIATIONS

% LEL	percent lower explosive limit
°C	degrees Celsius
ACL	Army Creek Landfill
AoA	Area of Attainment
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
ASR	aquifer storage and recovery
AWC	Artesian Water Company
BCEE	bis (2-chloroethyl) ether
BRA	bioremediation area
BTEX	benzene, toluene, ethylbenzene, and xylenes
CBB	Cirillo Brothers' building
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Chemical of Concern
COPCs	Chemicals of Potential Concern
CSM	conceptual site model
DAA	Detailed Analysis of Alternatives
DCC	deposit control chemical
DDA	Drum Disposal Area
DNAPL	dense non-aqueous phase liquids
DNREC	State of Delaware Department of Natural Resources and Environmental Control
DO	dissolved oxygen
DS&G	Delaware Sand and Gravel Landfill
DQI	data quality indicators
DQO	data quality objective
EA	Environmental Alliance, Inc.
ELFExS	Enhanced Low Flow Extraction System
EPC	exposure point concentrations
ERP	Emergency Response Plan
ESI	Environmental Simulations, Inc.
EVS/MVS	Environmental Visualization System/Mining Visualization System
FDR	Final Design Report
FFS	Focused Feasibility Study
Final FS Rev 1	Final Feasibility Study Revision 1
FS	Feasibility Study
FSP	Field Sampling Plan
FSWP Rev 2	Feasibility Study Work Plan Revision 2
ft-bgs	feet below ground surface
FYR	five-year review
GMWs	gas monitoring wells
GMZ	groundwater management zone
gpm	gallons per minute
GVs	gas vents
GWV	Groundwater Vistas
HASP	Health and Safety Plan
HDPE	high-density polyethylene
HGVs	horizontal gas vents
HHRA	Human Health Risk Assessment
HI	hazard index
LEL	lower explosive limit
LFExS	low-flow extraction system

LFG	landfill gas
LNAPL	light non-aqueous phase liquid
LPA	Lower Potomac Aquifer
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/l	milligrams per liter
MGD	million gallons per day
MOA	Memorandum of Agreement
MPA	Middle Potomac Aquifer
MPCU	Middle Potomac Confining Unit
ng/l	nanograms per liter
NAPL	non-aqueous phase liquid
NBS	National Bureau of Standards
NCC	New Castle County
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System Program
OM&M	operation, maintenance and monitoring
OU	Operable Unit
PAHs	polynuclear aromatic hydrocarbons
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity
PDI	Pre-Design Investigation
PDI WP	Pre-Design Investigation Work Plan
PFAs	per- and polyfluoroalkyl substances
PFCs WP	Perfluorinated Compounds Work Plan
PFHpA	perfluoroheptanoic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PHE	Public Health Evaluation
PID	photoionization detector
POTW	publicly-owned treatment works
Ppmv	parts per million by volume
PRAP	Proposed Remedial Action Plan
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RD AOC	Administrative Settlement Agreement and Order on Consent for Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
ROD-A2	Record of Decision-Amendment 2
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SMCL	secondary maximum contaminant level
SOW	Statement of Work
ss-PRGs	Site-specific preliminary remediation goals
SSC Rev 2	Supplemental Site Characterization Report Revision 2
SSCR	Supplemental Site Characterization Report
SSDS	sub-slab depressurization system
SVE	soil vapor extraction

SVI	soil vapor intrusion
SVOC	semi-volatile organic compound
TCE	Trichloroethylene
ug/l	micrograms per liter
UPA	Upper Potomac Aquifer
UPCU	Upper Potomac Confining Unit
UPCUTZ	Upper Potomac Confining Unit Transition Zone
UPDC	Upper Potomac Dividing Clay
USEPA	United States Environmental Protection Agency
VAP	vertical aquifer profile
VBVS	Vertical Bioventing System
VOC	volatile organic compound
WMA	waste management area

1.0 INTRODUCTION

On behalf of the Delaware Sand & Gravel (DS&G) Remedial Trust (the Trust), Golder Associates Inc. (Golder) prepared this Pre-Design Investigation Work Plan (PDI WP) for the DS&G Superfund Site (Site) located approximately two miles south of New Castle, Delaware (see Figure 1).

The Final Feasibility Study Revision 1 (Final FS Rev 1; Golder, 2016d) was submitted to the United States Environmental Protection Agency (USEPA) on May 25, 2016. The USEPA approved the Final FS Rev 1 via letter dated July 5, 2016 (USEPA, 2016a), issued the Proposed Remedial Action Plan (PRAP) on September 7, 2016 (USEPA, 2016b) identifying Alternative C from the Final FS Rev 1 as the Selected Remedy, and held a public meeting on September 21, 2016 to present the PRAP. On December 12, 2017, the USEPA issued the Record of Decision-Amendment 2 (ROD-A2; USEPA 2017b) for the DS&G Site, and on May 22, 2018, the Trust and the USEPA signed an "Administrative Settlement Agreement and Order on Consent for Remedial Design" (RD AOC; effective date May 29, 2018). The Statement of Work (SOW) associated with the RD AOC "sets forth the procedures and requirements for implementing the Work, which consists of: (1) a Preliminary Design Investigation (PDI), and (2) a Remedial Design (RD) for the components of the Remedial Action (RA)". (USEPA, 2018f) The first step of the PDI process is the development of the PDI WP for review and approval by the USEPA.

This PDI WP includes the following:

- Current conceptual site model (CSM) and areas of uncertainty
- Summary of Site-specific FS information and description of the Selected Remedy
- Data quality objectives (DQOs) and the PDI scope of work
- Sampling and Analysis Plan (SAP; see Appendix A), Health and Safety Plan[1] (HASP; see Appendix B) and Emergency Response Plan (ERP; see Attachment A in Appendix B) for the PDI activities as well as for the ongoing groundwater monitoring performed at the Site.

This section of the PDI WP provides the following:

- Overview of this document including the purpose and organization
- Site background including brief Site history, Site description, and summary of aquifer use in the area

1.1 Document Overview

1.1.1 Purpose

As stated in Paragraph 3.3 of the SOW, "[t]he purpose of the Pre-Design Investigation (PDI) is to address data gaps identified in the *Supplemental Site Characterization Report – Revision 2* (Golder Associates, 2016) (SSCR[; Golder, 2016a]) and the *Final Feasibility Study – Revision 1* (Golder Associates, 2016) (FS) by conducting additional field investigations." (USEPA, 2018f). As such, this PDI WP was prepared to provide a detailed scope of work, methodologies and objectives to address the Conceptual PDI Scope that was included as Appendix N of the Final FS Rev 1 and any additional scope and/or sequencing information related to satisfying the requirements of the ROD-A2 and RD AOC SOW.

As stated in Paragraph 3.3(a) of the SOW (USEPA, 2018f):

[1] Golder's HASP is a Health, Safety and Environment Plan (HASeP).

Respondents shall submit a PDI Work Plan (PDI WP) for EPA approval. The scope of the PDI is described in Golder Associates' May 20, 2016 Technical Memorandum, included as Appendix N of the FS and Appendix A to the SOW, and Section 2.12.2 of ROD Amendment No. 2. The PDI WP must include:

(1) An evaluation and summary of existing data and description of data gaps;

(2) A sampling plan including media to be sampled, contaminants or parameters for which sampling will be conducted, location (areal extent and depths) and number of samples;

(3) Aquifer testing locations and methods, including;

(i) Installation of two groundwater extraction wells at locations and depths as determined during the PDI and approved by EPA.

(ii) Aquifer testing of each extraction well for a minimum of 72 hours.

(4) Planned updates to the groundwater flow model; and

(5) The following supporting deliverables described in ¶ 5.6 of the SOW (Supporting Deliverables): Health and Safety Plan; Emergency Response Plan; Field Sampling Plan; and Quality Assurance Project Plan. (USEPA, 2018f)

The PDI WP was prepared to include these items and the updated groundwater monitoring program that includes DS&G's routine semi-annual monitoring program as well as annual, monthly, bi-monthly and quarterly monitoring of groundwater performed by the Trust and the Artesian Water Company (AWC) at its Llangollen wellfield.

1.1.2 Organization

This document is divided into the following sections:

- Section 1 - Introduction including descriptions of the purpose and organization of document, and summaries of the Site background, RD AOC SOW, and updates to the groundwater monitoring program
- Section 2 - Existing and Ongoing Site Remedial Measures that are included in the Selected Remedy
- Section 3 - Updated CSM and Areas of Uncertainty identified in the Final FS Rev 1
- Section 4 - Summary of Site-specific FS Information and Description of Selected Remedy
- Section 5 - Data Quality Objectives
- Section 6 - PDI Scope of Work including methods for management and evaluation of data
- Section 7 - Project Organization, Next Steps, and Anticipated Schedule
- Section 8 - References for the materials cited

1.2 Site Background

This section provides a brief summary of the Site background as well as a brief description of the regional and local aquifer use, and the existing groundwater management zones (GMZs) associated with the Superfund Sites (i.e., DS&G and the adjacent Army Creek Landfill [ACL] Superfund Site) and other state-listed sites in the area. More

detailed information related to the Site description and history is included in the FS Work Plan Revision 2 (FSWP Rev 2; Golder, 2011).

1.2.1 Brief Site History and Description

The DS&G Site is approximately 27 acres in area, and is located in an area of residential and light-industrial use with many residential developments within one mile. The DS&G Site is bound to the north and northeast by the Norfolk Southern Railroad tracks and to the west by Army Creek that eventually discharges into the Delaware River.

Prior to 1968, the DS&G Site operated as a sand and gravel quarry, following which filling operations began. Between 1968 and 1976, the DS&G Landfill collected approximately 550,000 cubic yards of waste including about 13,000 drums[2] containing liquids and sludges from chemical production, manufacturing, and petroleum-refining processes (USEPA, 2005). The following presents a summary of the disposal area activities (see Figure 2) from the 1993 ROD Amendment for the DS&G Site:

- The Drum Disposal Area (DDA): "This area was originally a pit where drums containing liquids and sludges, including perfume, plastics, paint, and petroleum, from various industrial processes were disposed. The majority of drum contents were organics and inorganic solids." (USEPA, 1993)
- The Ridge Area: "...was used primarily for surface storage of drums and large storage tanks containing inorganic and organic sludges and solids. The drums and tanks have been removed, or emptied, and steam cleaned; however, contaminated surface soils remain." (USEPA, 1993)
- The Inert Disposal Area: "Field investigations suggest that nearly one half million cubic yards of construction rubble and scattered chemical wastes were deposited in this disposal area. The refuse was covered with a thin layer of soil. Abandoned cars, trucks, storage tanks, and other solid wastes currently occupy the surface of the Inert Disposal Area." (USEPA, 1993).
- The Grantham South Area: "An estimated 73,400 cubic yards of construction rubble and scattered chemical wastes were deposited in a layer nearly 35 feet thick. Pre-construction field investigations identified elevated levels of organic and inorganic contaminants within the refuse layer" (USEPA, 1993). Between 1988 and 1991, the US Army Corps of Engineers installed a cap on the Grantham South Area.

The ACL Site (see Figure 2) is located immediately west of the DS&G Site across Army Creek/Army Pond. The ACL Site is a 60-acre abandoned sand and gravel quarry that was operated by New Castle County (NCC) as an unlined landfill between 1960 and 1968 and received 1.9 million cubic yards of municipal and industrial wastes (USEPA, 1998).

1.2.2 Aquifer Use

As stated in the Remedial Investigation (RI) Report for the DS&G Site (Dunn, 1987), in NCC, the Potomac aquifers are used extensively for public and industrial water supply, especially the Upper Potomac Aquifer (UPA). As a result of the aquifer use activities in the area, the Site and surrounding area is considered a Delaware Wellhead Protection Area.

[2] The 1993 Amended ROD indicates "approximately 550,000 cubic yards of industrial wastes and construction debris, including at least 7,000 drums, were disposed of within four distinct disposal areas on the DS&G property" (USEPA, 1993).

A description of historical aquifer withdrawals is included in Section 3.1 of SSC Rev 2. Currently, the major withdrawals from the UPA in the vicinity of the DS&G and ACL Sites are associated with operation of the AWC wellfields, the closest of which is AWC's Llangollen wellfield. The current aquifer use and withdrawals are described below. Based on discussions with AWC and the State of Delaware Department of Natural Resources and Environmental Control (DNREC), future use of the UPA will be similar to its current use.

Between 2003 and 2014, withdrawal by AWC from its Llangollen wellfield averaged 1.6 million gallons per day (MGD) with a range of 0.0 to 3.4 MGD. Based on the current allocation permits for the wellfield and discussions with AWC, the future withdrawal from this wellfield will be between 0.5 and 2.2 MGD. A description of current aquifer withdrawals is included in Section 3.2 of SSC Rev 2, and in the updated CSM in Section 3 of the Final FS Rev 1.

As a result of the screen failures in early 2012 at wells AWC-K1 and AWC-G3, AWC installed replacement well AWC-G3R in the fall of 2012 (see additional discussion in the SSC Rev 2 and in Section 3.2). During startup testing of this well in early 2013, groundwater analytical samples indicated that 1,4-dioxane had the potential to exceed the proposed DNREC health advisory of 3.5 micrograms per liter (ug/l). Due to this potential exceedance, AWC discontinued connection of this well to their distribution system until further evaluation could be conducted. Based on their evaluation, AWC added a system for treatment of 1,4-dioxane to their existing treatment train. Per DS&G correspondence and meetings with AWC, the new system was brought on-line in October 2014, and well AWC-G3R is currently in use.

In August 2017, due to concerns related to increasing manganese concentrations upgradient and at its Llangollen wellfield, AWC performed pilot testing for manganese and iron treatment options. In the fall of 2017, AWC began design of a Pure-Flow® treatment system for reduction of the manganese (and iron) concentrations in their extracted groundwater. AWC anticipates the manganese treatment system will be brought on-line by June 2019. AWC also replaced well AWC-6 with well AWC-6R in the fall of 2017 due to evidence of impending screen failure and well AWC-6R was brought on-line in January 2018.

AWC's Llangollen wellfield also includes an aquifer storage and recovery (ASR) system. The purpose of the ASR system is to store the potable water in the UPA (aquifer storage) for withdrawal during periods of peak demand and/or low water/drought conditions in NCC. As described in Section 3.2.1 of the SSC Rev 2, operation of the ASR does not result in a net gain or net loss from the UPA.

In June 2006, the DNREC Division of Air and Waste Management and the DNREC Division of Water Resources entered into a "Memorandum of Agreement" (MOA) for "Army Creek & Vicinity, New Castle, Delaware" (DNREC, 2006). The MOA establishes two GMZs (see Appendix A of the Final FS Rev 1) to manage releases from ten state-listed sites in the vicinity of Army Creek "and to protect exposure of the public by way of potential groundwater contamination." In general, the GMZs were established to prevent installation of new public or domestic water supply wells without additional layers of State review.

2.0 EXISTING AND ONGOING SITE REMEDIAL MEASURES

Numerous remedial measures have been undertaken at the Site. Those measures that are part of the ongoing Site remediation and are part of the Selected Remedy for the Site are summarized in this section. Additional detailed descriptions of the previous and existing remedial measures are included in the FSWP Rev 2 (Golder, 2011) and in the SSC Rev 2 (Golder, 2016a).

2.1 Drum Disposal Area

The Trust previously performed removal and remedial measures (see FSWP Rev 2 and Final FS Rev 1) and there are several existing and ongoing remedial measures associated with the DDA (see Figures 2 and 3) that are considered part of the Selected Remedy. These remedial measures include containment (installation of slurry-wall system and cap), and two active remedial measures currently in operation at or near the DDA: 1) low-flow extraction system (LFExS), and 2) well PW-1(U) system.

2.1.1 Slurry-wall System and Cap

In 1994, the Trust constructed a slurry-wall system to enclose an area of about three acres, including the DDA and the surrounding soils affected by historical releases from the DDA. The slurry-wall system consists of a 3-foot thick, soil-bentonite slurry wall keyed into the underlying Upper Potomac Confining Unit (UPCU, clay unit), where present, and ranges in depth from 17 to 57 feet below ground surface (ft-bgs). (USEPA, 1997) Between 1995 and 1997, the Trust completed remedial activities for the DDA (including drum and soil removal, and construction of a bio-venting system within the slurry-wall system) and Ridge Area (implemented under operable units OU4 and OU5, which superseded OU2). (USEPA, 1997)

The area within the slurry-wall system is divided by a partition wall, which isolates the portion of the DDA with contaminated soils (containment area) from the area where the clay is thin, discontinuous or not present (partition area) (see Figure 3). Appendix B of the SSC Rev 2 provides additional information regarding the slurry-wall system. Around the partition area, the slurry wall is classified as a “hanging wall” because the UPCU is absent beneath this section of wall. The interpreted UPCU thickness in the DDA vicinity indicates that the UPCU is continuous beneath the containment area of the DDA, at thicknesses ranging from 5 to 18 feet (eastern corner of DDA), with the exception of the boring SS-2011-03 area located along the northern slurry wall. In the areas where the UPCU is absent, the Columbia Aquifer is in direct contact with the UPCU Transition Zone (UPCUTZ).

Following completion of the slurry-wall system, drum removal, soil excavation, and bio-cell construction activities (see below), the Trust covered the area within the slurry-wall system with a temporary soil and bentonite cap[3] that is more than 2-feet-thick and remains in place today. As part of the Selected Remedy, an enhanced cap system will upgrade the existing temporary cap and will be the permanent cap for the DDA to reduce infiltration into and through the contaminated soil and treatment materials[4] that remain within the DDA.

Between 1996 and 1997 the Trust installed the bioremediation area (BRA) that included two components: a bio-cell and a vertical bioventing system (VBVS), which treated the interval below the bio-cell. The bio-cell included the original 0.8-acre area where drums were disposed within the DDA, and the soils that were excavated and consolidated from the DDA and the Ridge Area. The Trust mixed the excavated soils with wood chips, sand, and di-ammonium phosphate to enhance the biodegradation of the soil contaminants prior to placement within the bio-cell. The Trust constructed and operated the bio-cell above the surface of the Columbia Aquifer water table (as influenced by operation of an extraction well to lower and maintain the water table beneath the bio-cell).

[3] The cap thickness includes 0.25 feet of topsoil, 1 foot of native low permeability soil, a geosynthetic clay layer, and 1 foot of crushed stone as a gas collection layer above the bio-cell materials.

[4] As discussed in Appendix C of the Final FS Rev 1, the Trust’s Remedial Action Report - Completion of Operable Unit 4 (Trust, 1996) indicates that the addition of amendments (sand, wood chips and di-ammonium phosphate) prior to placement in the bio-cell for treatment, increased the volume of impacted materials from 12,000 cubic yards to 30,000 cubic yards. It is important to note that the volume of amendments (18,000 cubic yards) mixed with the impacted soils exceeded the original volume of impacted soil (12,000 cubic yards).

2.1.2 Low-flow Extraction System

In May 2009, the Trust began operation of the LFExS that initially extracted groundwater from six extraction wells within the DDA (wells C-2D, C-19D, C-18D, BG-1, C-4D, and B-4D). The LFExS started temporary operation on May 4, 2009 and operated at a monthly average flow rate of approximately 2 to 5 gallons per minute (gpm) until the system was shut down for construction of the permanent system in December 2009. Operation of the permanent system started on February 23, 2010. In September 2010, the Trust completed construction of an additional extraction well within the DDA (well C-30) to extract groundwater from the Columbia Aquifer in the vicinity of piezometer PZ-6S. This extraction well was connected to the LFExS in early October 2010. In December 2012, the Trust brought well C-20D on-line as the eighth extraction well in the LFExS with the intent of removing dissolved-phase contaminant of concern (COC) mass detected in the vicinity of wells MHW-1S and MHW-1M. The LFExS discharges directly to the sanitary sewer system (i.e., publicly-owned treatment works [POTW]) under a permit with NCC.

The LFExS currently has eight operational extraction wells (wells C-2D, C-19D, C-18D, BG-1, C-4D, B-4DR, C-30 and C-20D as shown on Figure 3) that provide hydraulic containment within the DDA by inducing inward (horizontal) gradients in the Columbia Aquifer across the slurry walls, and upward (vertical) gradients between the UPA upper sand and the Columbia Aquifer (i.e., maintaining a lower potentiometric head within the DDA). Operation of the LFExS also removes volatile organic compounds (VOCs) and semi-VOCs (SVOCs, primarily bis (2-chloroethyl) ether [BCEE] and 1,4-dioxane) dissolved-phase contaminant mass from within the DDA containment area.

Routine preventative maintenance activities and startup of deposit control chemical (DCC) addition has improved the LFExS performance and increased the monthly average extraction rate to between 9 and 11 gpm since January 2013. Monitoring results indicate the LFExS is providing hydraulic containment and removing VOCs and BCEE contaminant mass from the DDA (Golder, 2012 and Golder, 2015f).

2.1.3 Extraction Well PW-1(U) System

In June 2004, NCC and the Trust worked together to install extraction well PW-1 in the vicinity of monitoring well DGC-7S to complete the groundwater divide between the DDA and AWC's Llangollen wellfield and to provide capture of UPA groundwater in the vicinity of the DDA. Wells PW-1(L) (screened in the lower sand of the UPA) and PW-1(U) (screened in the upper sand of the UPA) began operation in October 2004. Well PW-1(L) was operated until January 25, 2005, when the USEPA "approved termination of pumping from the lower zone [well PW-1(L)] because multiple rounds of chemical-quality data and hydraulic data demonstrated that the lower zone is generally free of contaminants and is hydraulically separated from the upper zone [well PW-1(U)]" (Ruth, 2007). On May 23, 2011, the portion of well PW-1 containing well PW-1(L) was grouted up to just below the base of well PW-1(U). (Ruth, 2013)

On October 15, 2012, the Trust assumed hands-on responsibility for the operation and maintenance of extraction well PW-1(U) from NCC. The well PW-1(U) system discharges directly to the NCC sanitary sewer system (POTW). The NCC sewer discharge permit was modified to include the discharge from both the LFExS and extraction well PW-1(U) with the total combined flow now permitted at 51 gpm. On October 3, 2013, the Trust began addition of Redux 620 to reduce iron fouling in the well. Since beginning Redux 620 addition to well PW-1(U), maintenance demands for this well have decreased significantly due to the decreased iron fouling, and more consistent extraction rates (i.e., average monthly extraction rates generally between 33 and 37 gpm) have been maintained. Figure 14 from the January to June 2015 Semi-Annual Monitoring Report (Golder, 2015f) illustrates this change.

As presented in the SSC Rev 2 Report, groundwater data (water quality and potentiometric data) indicate that extraction well PW-1(U) captures some contaminant mass within the UPA upper sand and contaminant mass migrating from the UPCUTZ groundwater to the UPA upper sand groundwater to the north and northwest of well PW-1(U). Based on the potentiometric surface and results of the Spring 2013 aquifer testing, the areas to the east and northeast of well PW-1(U) (eastern edge of the groundwater emanating from beneath the DDA), and to the west in the area of well DDA-16-US, appear to be outside the capture zone for well PW-1(U).

2.2 Grantham South, Inert Area and Ridge Area

Following the completion of an RI/FS (Dunn, 1988) in April 1988, the USEPA issued a ROD for the Site (USEPA, 1988a). This ROD presented USEPA's selected remedy for the Grantham South Area (OU1), the DDA and Ridge Area (OU2), and the Inert Disposal Area (OU3). Between 1989 and 1991, a multi-layer landfill cap, gas venting system, and perimeter fence were installed in the Grantham South Area (OU1). Between 1996 and 1997, the Trust constructed an 11-acre, multi-layer, landfill cap over the Inert Area (OU3). In the last five-year review (2015 FYR) for the DS&G Site, the USEPA indicated that the remedies at the Grantham South Area, Inert Area, and DDA (part of OUs 4 and 5) currently protect human health and the environment (USEPA, 2015f), and the remedy at the Ridge Area (part of OUs 4 and 5) is protective of human health and the environment. The 2015 FYR also indicates that additional response actions may be needed if it is determined that releases from Grantham South and/or the Inert Area are impacting groundwater in the UPA. (USEPA, 2015f)

2.2.1 Landfill Gas

Based on barhole probe assessment activities performed in 2014 and 2015, evidence of landfill gas (LFG) migration from Grantham South and the Inert Area toward potential receptors was observed. The following sections describe the ongoing mitigation of LFG migration at the Site.

2.2.1.1 Cirillo Brothers' Building Sub-Slab Depressurization System

Between November 18 and 19, 2014, a sub-slab depressurization system (SSDS) was installed beneath the building located at 761 Grantham Lane (Cirillo Brothers' building; CBB) near the Inert Area to mitigate the potential for migration of vapors including methane into the building. This work was completed in accordance with Golder's Work Plan for SSDS dated November 10, 2014. (Golder, 2014a) Confirmatory indoor air samples and an ambient air sample were collected on December 19, 2014 (30 days following SSDS installation). Indoor air samples were collected from the unfinished basement, first floor office space, and the garage office space. Based on evaluation of the confirmatory indoor air samples, Golder concluded that the SSDS is operating as designed and is inducing vacuum conditions beneath the slab to mitigate the potential for sub-slab vapors to enter the building. The SSDS Construction Completion Report was submitted to the USEPA on March 19, 2015. (Golder, 2015b) The USEPA reviewed the report and indicated via email dated April 2, 2015 that "VOCs that were detected in the indoor air while the system was in operation are within EPA's acceptable risk range." (USEPA, 2015c)

2.2.1.2 LFG Mitigation System

In June 2017, the Trust contracted Panther Technologies Inc. through Golder to construct the LFG Mitigation System for prevention of LFG migration beyond the perimeter of the Inert Area and Grantham South in the areas where potential receptors exist, and to reduce the lower explosive limit (LEL) of methane at the facility boundaries to below 25% LEL (performance goal). The primary components of the LFG Mitigation System consist of LFG extraction wells, conveyance piping, and a flare. The system began operation on September 21, 2017, and as a result, methane concentrations measured in the gas monitoring wells around the perimeter of the landfills have

dropped significantly. Because the current flare system cannot operate at these lower methane levels, the Trust will be removing the previously installed flare and replacing it with a direct-venting system.

Golder submitted the Operations Monitoring & Maintenance Plan (OM&M Plan) for the LFG Mitigation System dated June 18, 2018 (Golder, 2018c) to the USEPA for review and approval. The OM&M Plan details procedures to monitor and maintain the current flare LFG Mitigation System as well as the proposed direct-venting system. The USEPA agreed to the proposed direct venting system and the air permit is under review with DNREC at this time.

2.3 Ongoing Groundwater Monitoring Program

As documented in the semi-annual monitoring reports, groundwater monitoring is ongoing at the Site and is conducted under the FSWP Rev 2 (Golder, 2011) with monitoring wells added in 2012 and 2013 after performance of additional investigation activities. In addition, annual per- and polyfluoroalkyl substances (PFAS) monitoring began in 2016, and was performed in October 2016 and April 2017 under the Perfluorinated Compounds Work Plan (PFCs WP; Golder, 2016e) as approved by the USEPA on September 23, 2016 (USEPA, 2016g). On November 13, 2017, the USEPA requested via email addition of sampling and analysis of the Columbia Aquifer and Upper Potomac Confining Unit Transition Zone (UPCUTZ) locations to the PFCs WP. To address this request, the PFAS – Well Purging, Groundwater Sampling and Analysis Program For 2018 dated February 7, 2018 (PFAS 2018 WP; Golder, 2018a) was prepared and submitted to the USEPA for review and approval. The USEPA provided comments on the PFAS 2018 WP via letter dated April 26, 2018. These comments are addressed in the SAP.

As indicated above, the DS&G Site is adjacent to another Superfund site, the ACL Site, and the Sites are located upgradient of AWC's Llangollen wellfield (see Section 3 for additional information). There are ongoing monitoring activities at the adjacent ACL Site and AWC's Llangollen wellfield that overlap with the ongoing monitoring activities at the DS&G Site. Due to the proximity of the DS&G Site, ACL Site and the AWC wellfield, and the commingled nature of the plumes migrating from the Sites toward AWC's Llangollen wellfield, the USEPA requested addition of cations and anions to the DS&G monitoring program via email dated February 1, 2018 (USEPA, 2018c) consistent with its request for the ACL Site's monitoring program via email dated January 19, 2018 (USEPA, 2018a) with a subsequent letter dated January 24, 2018 (USEPA, 2018b).

As discussed with and agreed to by the USEPA via email dated May 18, 2018 (USEPA, 2018e), the revisions (PFAS 2018 WP comments) and additions (major cations and anions annually) to DS&G's ongoing groundwater monitoring program have been consolidated and are documented in the SAP for ease of review and consistency in methodologies. The SAP will be followed for DS&G's semi-annual monitoring program beginning in October 2018. The next PFAS and the major cation/anion monitoring event will be performed in April 2019.

2.4 Engineering and Institutional Controls, and Ongoing Activities

The 1993 Amended ROD issued by the USEPA established legal "institutional" and engineering controls intended to prevent or reduce exposure to hazardous substances associated with the Site, including perimeter fencing and deed restrictions. In accordance with the Amended ROD, a perimeter fence has been erected around the Site (Grantham South, Inert Area, and the DDA and Ridge Area) to prevent unauthorized access to the property. These chain-link fences are a minimum of 6 feet in height and are equipped with locking gates.

In addition, deed restrictions have been placed on portions of the Site to prevent any future uses of the property that could affect the remediation (USEPA, 1993). As described in Section 1.2.2, GMZs were established in June 2006 to prevent installation of new public or domestic water supply wells without additional layers of State review.

The Trust is conducting ongoing remedial and OM&M activities at the Site. These ongoing activities include the following:

- Quarterly shallow gas monitoring along the perimeters of the Inert Area and Grantham South.
- Quarterly inspection (and repair as necessary) of the cover systems or caps, gas venting systems, surface water controls, access roads, and perimeter fences at the DDA, the Inert Area and Grantham South.
- Site-wide groundwater monitoring of groundwater elevation, and sampling and analysis of VOCs, SVOCs, metals, and other parameters as described in Section 2.3.
- LFExS and well PW-1(U) system OM&M including monitoring of the system effluent. The effluent samples are collected semi-annually and analyzed for VOCs, SVOCs, metals, and parameters per the NCC discharge permit.

3.0 CONCEPTUAL SITE MODEL AND AREAS OF UNCERTAINTY

The CSM presented in this section was presented in the Final FS Rev 1 and approved by the USEPA via letter dated July 5, 2016 (USEPA, 2016e). This CSM is unchanged from the CSM presented in the Final FS Rev 1, with the exception of the following:

- Updates related to LFG mitigation activities at the Site
- Minor changes to Sections 3.5.1 and 3.7.1 due to revision of the Site-specific preliminary remediation goals (ss-PRGs) in October 2017 (Golder, 2017c)
- Additional discussion related to manganese concentrations in the UPA at and upgradient of AWC's Llangollen wellfield
- Discussion of PFAS detections in groundwater at the Site
- Acknowledgement of additional activities work plan for the ACL Site

As identified in the CSM, there are areas of uncertainty that exist at the Site that are relevant to remedy design. These areas were considered during preparation of the FS and will be addressed during PDI activities as discussed in this PDI WP.

3.1 Geology and Hydrogeology

Additional detail related to the geology and hydrogeology at the Site and regionally is presented in Sections 2.6, 2.7, 7.1, and 7.2 of the SSC Rev 2. Figure 4 provides the conceptual stratigraphic column described in this section, and the geologic contours and cross-sections provided in the SSC Rev 2 are included in Appendix C of this PDI WP.

3.1.1 Geology

Regionally, there are two aquifer units used for water supply, the Columbia Aquifer and the UPA. The Columbia Aquifer is a water table aquifer underlain and separated from the UPA by the UPCU, a regionally thick, competent clay unit. The top of the UPCU generally slopes to the north and northwest beneath the DS&G Site. There are occasional subcrop zones (zero-clay areas) where the UPCU has been eroded away and replaced by sands, gravels and cobbles as evidenced by the presence of the Columbia basal gravel unit in areas where paleochannels

exist(ed). As included in Appendix D, Slide 8 from Attachment 1 to Tetra Tech's numerical groundwater flow model memo (included in Appendix B of the Detailed Analysis of Alternatives [DAA; Golder, 2015c]) provides an illustration of the current understanding of the extent of the zero-clay areas. These areas represent locations where the UPCU is thin (less than 2 feet thick) or absent, based on review of available boring logs. Due to the presence of the fine-grained materials of the UPCUTZ between the Columbia Aquifer and the UPA upper sand (see discussion below), the Columbia Aquifer is not typically in direct contact with the UPA upper sand in these zero and/or thin clay areas. There may be other areas of zero and/or thin clay at and in the vicinity of the Sites that have not been encountered and/or identified.

In the subcrop zones, the Columbia Aquifer is in direct contact with the generally fining-upward sequence that is present between the UPCU and the top of the UPA upper sand. This key hydrostratigraphic unit is referred to at this Site as the UPCUTZ. The UPCUTZ, while represented as a generally fining-upward sequence, displays evidence of bedding/discontinuous sandy layers (see discussion in Appendix E of the Final FS Rev 1). The understanding of the interaction between the sandy portions of the UPCUTZ and the underlying UPA upper sand is incomplete; however, groundwater modeling (Appendix B of the DAA) and water quality data for the UPCUTZ and UPA upper sand suggest ongoing mass flux from the UPCUTZ groundwater to the UPA upper sand groundwater at the Site.[5]

The underlying UPA is a thick sand unit, which is generally confined by the UPCU. Where the UPCU is absent (zero-clay areas), the UPA acts as a semi-confined aquifer. Within the UPA, there is an intermittent clay unit referred to as the Upper Potomac Dividing Clay (UPDC), which separates the UPA into two sand units - the upper sand of the UPA and the lower sand of the UPA.

3.1.2 Hydrogeology

In the area of the DS&G Site, the localized groundwater flow direction within the Columbia Aquifer is generally to the northwest toward Army Pond and Army Creek, which discharges to the Delaware River to the northeast of the DS&G and ACL Sites. The general groundwater flow direction in the UPA is to the south/southeast or southwest toward the AWC extraction wells. Regionally, the natural groundwater flow direction in the UPA is toward the Delaware River located to the east of the Site.

The head differences measured between wells screened in the Columbia Aquifer and the UPA generally indicate a downward vertical gradient between the Columbia Aquifer and the UPA, except within the containment area of the DDA due to the operation of the LFExS (see discussion in Appendix B of the Final FS Rev 1). Due to extraction by AWC at its Llangollen wellfield predominantly from the UPA lower sand, there is typically a downward vertical gradient from the UPA upper sand to the UPA lower sand between the wellfield and the DS&G Site. The UPA receives recharge directly from a subcrop zone immediately west and north of Army Creek and indirectly as vertical leakage from the overlying Columbia Aquifer and the underlying Middle Potomac Aquifer (MPA) and/or Lower Potomac Aquifer (LPA). (Dunn, 1987) Additional information regarding these units is provided in the SSC Rev 2.

[5] The mass flux from the UPCUTZ to the UPA upper sand is predominantly observed in the vicinity of extraction well PW-1(U). The top portion of the well PW-1(U) screen intersects the lower portion of the UPCUTZ; therefore, it is assumed that operation of well PW-1(U) is influencing flux from the UPCUTZ to the UPA upper sand between the DDA and well PW-1(U). Evidence of this influence is demonstrated by the isoconcentration contours for BCEE and 1,4-dioxane in the UPA upper sand (see Appendix C of the semi-annual monitoring reports [Golder, 2015f]). Modeling and evaluation of the well PW-1(U) capture zone indicates that this downward migrating dissolved-phase mass is captured by operation of well PW-1(U) at 40 gpm.

3.2 Current and Historical Aquifer Use

The UPA is used regionally as a drinking water supply. In the vicinity of the DS&G and ACL Sites, the groundwater within the UPA upper and lower sand units is withdrawn and treated by AWC at its Llangollen wellfield (located south and southwest of the DS&G Site) for use as drinking water. Additional detail related to the current and historic aquifer use in the vicinity of the Site is presented in Section 3 of the SSC Rev 2 as well as historic aquifer use presented in the RI by Dunn (Dunn, 1987).

Withdrawals from the UPA in the vicinity of the Sites for drinking water and industrial purposes began prior to disposal activities at the two Sites. In the vicinity of the Sites, the UPA has shown dramatic head declines since the 1950s due to preferential extraction from this unit. (Dunn, 1987) Groundwater extraction from the Potomac Formation (includes the UPA, MPA and LPA) in the vicinity of the DS&G and ACL Sites has been as high as 9 MGD (in the 1980s), and is currently about 2 MGD. In addition to extraction by AWC at its Llangollen wellfield, historic aquifer use in the vicinity of the Sites has included:

- Operation of production wells at the former Amoco and other industrial facilities to the east of the DS&G Site
- Extraction from the NCC recovery wells between 1973 and 2004 to extract leachate-contaminated water from the UPA and in an attempt to create a groundwater divide between the Sites (ACL and DS&G) and AWC's Llangollen wellfield

The extraction wells in use by AWC in the Llangollen wellfield have changed over time causing shifts in the groundwater flow direction. Prior to the 1980s, wells in the western portion of the wellfield (wells AWC-2, AWC-6, and AWC-7) were predominantly used. During the 1980s and 1990s, wells across the east-west extent of the wellfield were used (wells AWC-2, AWC-6, AWC-7, AWC-G3 and AWC-K1). Between the late 1990s through 2012, extraction shifted to the wells in the eastern portion of the wellfield (wells AWC-G3 and AWC-K1) with some contribution from well AWC-7 in the western portion of the wellfield. Since failure of the well screens on well AWC-K1 in January 2012 and well AWC-G3 in April 2012, withdrawal by AWC at its Llangollen wellfield shifted to wells AWC-7 and AWC-2 with a typical total withdrawal rate of 1 MGD. With AWC's use of well AWC-6 (and AWC-6R) since April 2014 and restart of well AWC-G3R in October 2014, the total withdrawal rates since April 2014 have increased to approximately 2 MGD. Based on the allocation permits for the wellfield and discussions with AWC, the future total withdrawal rate from this wellfield will be between 0.5 and 2.2 MGD.

The changes in withdrawal rates and extraction well locations over time have caused significant changes in head, horizontal and vertical gradients, and groundwater flow directions, thereby exerting a strong influence on the distribution of COCs observed within the UPCUTZ and UPA at this time. These influences are discussed in Section 3.4 as they relate to the release mechanisms at the Site. The resulting distribution of contaminants of potential concern (COPCs) within the UPCUTZ and UPA is discussed in Section 3.5.

Extraction from other wellfields in the region contributes to the background groundwater flow direction in the vicinity of the Site. The modeling memo (Appendix B of the DAA) discusses the aquifer use in the area, including extraction from AWC's Artisan's Village wellfield to the south of AWC's Llangollen wellfield, and its effect on groundwater flow direction at the Site.

3.3 Source Areas

There are three potential source areas associated with the DS&G Site: the DDA, Grantham South Area, and Inert Area. The DS&G Site is adjacent to another Superfund site, the ACL Site. Both the DS&G Site and the ACL Site landfilled industrial wastes and include capped landfills located within the Columbia Aquifer. Waste disposal

occurred between 1960 and 1968 at the ACL Site and between 1968 and 1976 at the DDA portion of the DS&G Site. Due to the contribution of dissolved-phase COC mass common to both Sites (DS&G and ACL) to the UPA in the area between these Sites and AWC's Llangollen wellfield, both Sites are included in the Site-wide CSM.

3.3.1 DS&G

As described in Section 4 of the SSC Rev 2, the DS&G Site includes three existing disposal or potential source areas (DDA [less than 3 acres], Inert Area [about 11 acres] and Grantham South [about 2 acres]), and one former disposal area (Ridge Area) in close proximity. A brief summary of the three existing disposal areas is provided below. Additional details related to the operational, regulatory, assessment and remedial history were presented in the FSWP Rev 2.

3.3.1.1 DDA

The DDA "… was originally a pit where drums containing liquids and sludges, including perfume, plastics, paint, and petroleum, from various industrial processes were disposed. The majority of drum contents were organics and inorganic solids." (USEPA, 1993) Disposal in this area occurred between 1968 and 1976. After removal of drums and placement of slurry walls around the DDA in the mid-1990s, the impacted soils associated with the original DDA (0.42 acres) were excavated from above the water table and combined with soils excavated from the Ridge Area (see Section 4.1 of the SSC Rev 2 and Appendix C of the Final FS Rev 1) for treatment in the BRA. Additional details regarding drum removal in 1984 by the USEPA and DNREC, and drum removal and excavation activities by the Trust in the 1990s are included in Section 2.1.1 of the Final FS Rev 1.

As part of the BRA (bio-venting system including a bio-cell constructed within the DDA containment area) construction within the DDA, amendments (wood chips, sand and di-ammonium phosphate) were added to the excavated soils before placement into the bio-cell. After construction of the BRA, a temporary bentonite-mat cap was constructed over the DDA. The bio-venting system operated within the DDA between 1997 and 2009. In 2009, the bio-venting system was shut down and a groundwater extraction system (LFExS) was constructed within the containment area of the slurry-wall system and is currently in operation to maintain inward and upward gradients within the DDA. Documentation illustrating the inward and upward gradients within the DDA containment area is included in Appendix B of the Final FS Rev 1.

3.3.1.2 Inert Area and Grantham South

The Inert Area contains "construction rubble and scattered chemical wastes" (USEPA, 1993), and was capped by the US Army Corps of Engineers between 1988 and 1991 (USEPA, 1993) with a Resource Conservation and Recovery Act (RCRA) Subtitle C cap (USEPA, 2005). The Grantham South Area contains "construction rubble and scattered chemical wastes", and both capped landfills have passive gas venting systems in place.

As discussed in Sections 6 and 7 of the SSC Rev 2, available data do not indicate that the Inert Area or Grantham South represent ongoing sources to the groundwater in the Columbia Aquifer, the UPCUTZ or the UPA; however, detections of inorganics in samples collected from temporary wells near these landfills in 2011 (wells GMW-GSNW and GMW-11) and inorganics and organics in the UPA upper sand wells near these landfills (wells MW-34, MW-18 and the P-6 area wells) indicate there is a potential for the Inert Area and/or Grantham South to contribute COC mass to the Columbia Aquifer and/or the UPA upper sand. The uncertainty associated with the source of impacts to the UPA in the vicinity of wells P-6/UPA-101-US (elevated concentrations of various VOCs and SVOCs) and MW-18 (elevated manganese concentrations) located near Grantham South, as well as the cause of the groundwater mounding observed in the well P-6/UPA-101-US area, will be addressed as appropriate as part of the PDI.

The Inert Area and Grantham South represent sources of vapors, primarily methane, to the subsurface as evidenced by data from the gas monitoring wells around the perimeter of the capped landfills (Golder, 2016a,b,c) and additional assessment activities performed in 2014 and 2015 (Golder, 2015e). Additional discussion is provided in Section 3.5.6.

3.3.2 Army Creek Landfill

The ACL Site is located immediately west of the DS&G Site across Army Creek/Army Pond. The ACL Site is a 60-acre abandoned sand and gravel quarry that was operated by NCC as an unlined landfill between 1960 and 1968 and received 1.9 million cubic yards of municipal and industrial wastes (USEPA, 1998). "As the [landfill operations] progressed, cover material and landfill space became depleted. This encouraged deeper excavation that may have removed much of the clay layer that separated the Columbia from the Potomac formations. This in turn, could have created direct access routes for leachate to the Potomac from the Columbia. Direct access routes may also have occurred naturally due to the non-continuous geometry of the Potomac clay." (USEPA, 1986)

As indicated in Section 3.1.2 of the SSC Rev 2, a groundwater recovery system was operated by NCC between 1973 and 2004 to extract contaminated groundwater from the UPA and in an attempt to create a groundwater divide between the Sites (ACL and DS&G) and AWC's Llangollen wellfield. A cap was constructed on the ACL between 1992 and 1993. Based on review of the available analytical data, it is apparent that the ACL Site represents an ongoing source of contaminant mass (primarily iron and manganese, which are also COCs at the DS&G Site) to the UPA. As stated by the USEPA in their comments dated December 19, 2014, "the Army Creek Landfill may be characterized as an indirect source of dissolved iron and manganese and a source of 1,2-dichloroethane in the UPA. Elevated total arsenic and cobalt are also found in groundwater downgradient of the Army Creek Landfill and appear to be site-related." (USEPA, 2014d)

As the USEPA states in the ROD-A2, "[b]ecause elevated dissolved metals concentrations within an area of the Upper Potomac Aquifer appear to be related to releases from both the DS&G Site and the Army Creek Landfill Site, groundwater contamination from both Superfund sites is addressed in the CSM." (USEPA, 2017c) Additionally, the USEPA states in the ROD-A2, "groundwater monitoring data indicates that the Army Creek Landfill is a source of 1,2-dichloroethane and dissolved metals, primarily iron, manganese and cobalt, in the Upper Potomac Aquifer." (USEPA, 2017c) "The Selected Remedy will restore groundwater in the Area of Attainment within the Upper Potomac Aquifer which has been impacted by releases from the DS&G Site and the eastern lobe of the Army Creek Landfill." (USEPA, 2017c) "EPA acknowledges, and ROD Amendment No. 2 reflects, that elevated concentrations of dissolved metals, particularly iron, manganese and cobalt, within a portion of the Area of Attainment are due, in part, to redox conditions in the Upper Potomac Aquifer caused by releases from the Army Creek Landfill." (USEPA, 2017c)

3.3.3 Source of UPA Impacts Observed in Wells MW-18/MW-34 and MW-26N

During the development of the ss-PRGs, the western extent of impacts associated with the DS&G Site was evaluated. The evaluation indicated that the western extent of the DS&G Site impacts overlaps with the eastern extent of impacts from the ACL Site. Both the DS&G and ACL Sites contribute iron and manganese mass to the area roughly located between wells MW-18 and MW-34 located south of Grantham South and wells BW-1 and MW-26N located in the northern portion of Llangollen Estates. Although subject to changes in regional aquifer withdrawals, impacts to the east of this area of combined mass would be primarily attributable to the DS&G Site, and the impacts to the west of this area of combined mass would be primarily attributable to the ACL Site.

As the USEPA states in the ROD-A2, "[r]eleases from additional source areas at the DS&G Site and the adjacent Army Creek Landfill Site have also resulted in elevated levels of inorganic solutes, particularly iron and manganese, in groundwater between the two Superfund sites and Artesian's Llangollen well field. … The western portion of the groundwater plume migrating from the DS&G Site overlaps the eastern portion of dissolved metals contamination in groundwater at Army Creek Landfill." (USEPA, 2017c)

The manganese concentration in well MW-26N (located approximately 1,500 feet upgradient of AWC's Llangollen wellfield) has been generally increasing since April 2011, and manganese was detected at 1.58 milligrams per liter (mg/l) in the April 2015 sample. A review of the data provided on the chembox figures (see Appendix F of the Final FS Rev 1) and trend plots included in the semi-annual monitoring reports indicates that manganese concentrations in the UPA are generally stable and below 2 mg/l for the wells located downgradient of extraction well PW-1(U), with exception of the following:

- Wells MW-34 and UPA-01 – concentrations fluctuate between 0.5 and 2.5 mg/l, potentially due to regional changes in aquifer withdrawals (concentrations in nearby wells P-6 and RT-1-UP are less than 1 mg/l)
- Well BW-1 - generally stable at concentrations around 2 mg/l
- Well MW-18 - generally stable at concentrations around 4 mg/l since 2012, and lower than historical concentrations of approximately 10 mg/l in 2005
- Wells UPA-02D, MW-26N and AWC-E2 – concentrations are below 2 mg/l, but demonstrate increasing trends

The source of manganese to the wells MW-18/MW-34 area and the well MW-26N area remains under evaluation.

3.3.4 Source of UPA Impacts Observed in Well BW-2

As indicated above, an area of combined mass exists between the DS&G and the ACL Sites and upgradient of AWC's Llangollen wellfield. There are conflicting lines of evidence regarding the potential source of the 1,4-dioxane concentrations detected at well BW-2 as described below.

Since March 2013, when a sample from well BW-2 was first analyzed for 1,4-dioxane, 1,4-dioxane concentrations between 84 and 120 ug/l have been detected. The groundwater flow direction upgradient of well BW-2 (which is located to the west of the area of combined mass) has been to the south from beneath the eastern lobe of the ACL to the NCC boundary well BW-2 since shutdown of the NCC system in 2004. Groundwater elevation contours for 2006, 2010, and 2013, along with interpreted groundwater flow directions upgradient of well BW-2, are presented in Appendix 5.6 of the SSC Rev 2. These contours suggest the source of groundwater to the area of well BW-2 likely emanates from beneath the ACL Site north of wells MW-28 and MW-29. As included in Appendix D, Slide 44 of Attachment 1 to Tetra Tech's numerical groundwater flow modeling memo (originally included in Appendix B of the DAA) provides an illustration of the capture zone for a proposed well in the well BW-2 area indicating that the source of water to the well BW-2 area extends to beneath the ACL Site. However, based on the low concentrations of 1,4-dioxane detected (approximately 3 ug/l in 2013, and between 1 and 2 ug/l in April 2015) in the limited set of samples collected from UPA wells MW-28, MW-29, and MW-31[6] (located between well BW-2 and the ACL Site), the USEPA has raised questions about ACL as the source of 1,4-dioxane to the well BW-2 area. Therefore, the

[6] UPA wells MW-28, MW-29 and MW-31 were installed by NCC for high-volume extraction of groundwater downgradient of the ACL site and as such have long screen intervals (80 feet, 79 feet, and 46 feet, respectively), are screened below the UPCUTZ, if present, across both the UPA upper and lower sand, and are widely spaced (three wells located over a 900-foot distance).

source of 1,4-dioxane to the well BW-2 area remains under evaluation as part of the PDI. Regardless, it is anticipated that the remedy would be the same whether the source was from the DS&G Site or the ACL Site, since the potential source areas are capped, the impacts are already in the UPA, and there are limited remedial options for 1,4-dioxane.

3.4 Release Mechanisms

The following discussion on the original release mechanisms describe likely conditions at the time of, or shortly after, disposal activities that occurred over 40 years ago (in the late 1960s and early 1970s). Investigations of environmental conditions near the DS&G disposal areas did not occur until the mid-1980s, nearly 10 years after the disposal activities ended. As such, portions of the following discussion describe the conceptual release mechanisms at the time of the original release, and are not representative of current conditions. For example, free-phase migration is discussed below and may have occurred historically, but recent data suggest that the potential for the presence of non-aqueous phase liquid (NAPL) in the Columbia Aquifer and the UPCUTZ is low.

The following conceptual discussion of the release mechanisms provides the basis for the nature and extent of contamination described in Section 3.5.

3.4.1 Overview of Conceptual Release Model

The original release occurred due to the disposal of drums and liquid wastes to the unsaturated soil of the Columbia Aquifer at the original DDA. Once in the unsaturated soils, the free-phase and dissolved-phase (caused primarily by infiltration of precipitation through disposed wastes) impacts would have migrated downward due to gravity through the unsaturated Columbia Aquifer (vadose zone) to the top of the UPCU. Dissolution of any free-phase constituents would have begun immediately upon entering the saturated zone. Upon encountering the UPCU, the impacts likely migrated horizontally along the surface of the competent clay and followed the downward sloping surface of the UPCU to the zero-clay areas located north and northwest of the DDA. Vertical migration of impacts into the underlying UPCUTZ would have been spatially limited to the zero-clay areas. Migration within the UPCUTZ would have occurred preferentially within sandier portions of the unit, with a portion of the impacts sorbing onto or diffusing into finer-grained materials encountered in the Columbia Aquifer and the UPCUTZ. Due to the nature of the UPCUTZ (fine-grained materials with horizontal bedding), vertical migration of potential free-phase impacts into the UPA would have been unlikely.

Due to the age of the release, a high degree of NAPL attenuation has occurred through natural processes. Observation and evaluation of current data indicate that the potential for the presence of NAPL in the Columbia Aquifer and the UPCUTZ is low.

Upon encountering the saturated zone within the UPCUTZ and/or the UPA, dissolved-phase impacts would have migrated and spread more widely in the direction of groundwater flow along preferential pathways (i.e., sands) and diffused into the interspersed lower permeability materials (i.e., silts and clays). The distribution of the dissolved-phase impacts has been strongly influenced by local and regional extraction in the UPA.

Available data suggest the historic release mechanisms within the DDA containment area have been mitigated by remedial measures including installation of the DDA slurry-wall system, removal and off-Site disposal of drums and impacted soils, construction and operation of the BRA, DDA dewatering, construction of the temporary bentonite-mat cap, and installation and operation of the LFExS. After construction of the slurry-wall system, secondary “release” mechanisms (primarily back diffusion from less permeable materials) developed that have been mitigated within the DDA containment area of the slurry-wall system through installation and operation of the LFExS.

Additional details related to the original release mechanisms and secondary release mechanisms (including aquifer resaturation and implementation of remedial activities) are presented below.

3.4.2 Discussion of Release Mechanisms

The original source area associated with the DDA received drums containing liquids and sludges (USEPA, 1993). This original pit area (approximately 0.42 acres [Dunn, 1987]) represents the original release area for COPCs associated with the DS&G Site. At the time of the release, the mechanism within the original DDA included the release of free-phase impacts from the disposal of drums and liquid waste, and release of dissolved-phase impacts caused primarily by infiltration of precipitation through the disposed wastes. This original release occurred more than 40 years ago and continued until performance of remedial actions in the 1980s (removal of surficial drums) and 1990s (removal and off-Site disposal of buried drums, construction of the slurry-wall system, removal and off-Site disposal of impacted soil, construction and operation of the BRA, DDA dewatering, and construction of the temporary bentonite-mat cap). Once released into the Columbia Aquifer, the dissolved-phase groundwater impacts likely migrated as discussed above in Section 3.4.1.

The original release mechanism was likely accentuated during operation of the NCC extraction system as well as other regional withdrawals (AWC's Llangollen wellfield and the former Amoco production wells). More specifically, at the time of the original release, the Columbia Aquifer was dewatered in this area such that the potentiometric surface was located within or possibly below the UPCUTZ during the period of greatest extraction (mid-1980s) by the NCC system, by AWC at its Llangollen wellfield and the former Amoco production wells (see Appendix G of the Final FS Rev 1). These withdrawals lowered the potentiometric surface of the UPA such that the groundwater within the Columbia Aquifer was drawn to the zero-clay areas and into the UPCUTZ. Due to the low permeability of the UPCUTZ, there was a limited degree of vertical groundwater flow from the Columbia Aquifer to the UPA upper sand.

Construction of the DDA slurry-wall system and treatment activities in the 1990s mitigated the release from the DDA containment area and mitigated the flux of COPCs from the Columbia Aquifer to the UPCUTZ and UPA upper sand; however, flux of COPCs continued, albeit to a lesser extent, from the following:

- Partition area that parallels the edge of the zero-clay area within the DDA slurry-wall system
- Columbia Aquifer external to the DDA northern slurry wall along the railroad tracks
- UPCUTZ to the UPA upper sand

After construction of the slurry-wall system, contaminants continued to back diffuse from the lower permeability aquifer materials into the more permeable materials of the Columbia Aquifer within the DDA, and from the finer-grained layers in the UPCUTZ into the coarser-grained layers of the UPCUTZ and UPA upper sand. Limited migration of dissolved-phase impacts through advective transport from the DDA containment area through more transmissive portions of the UPCU and into the UPCUTZ and UPA upper sand likely occurred due to the downward vertical gradient between the DDA and the UPA upper sand. However, this advective transport was mitigated by installation and operation of the LFExS starting in 2009, which created inward and upward gradients within the DDA containment area (see Appendix B of the Final FS Rev 1).

Despite the treatment efforts at the DDA, the back diffusion of contaminants from the finer-grained layers in the UPCUTZ into the coarser-grained layers of the UPCUTZ and UPA upper sand is ongoing at this time. Appendix H of the Final FS Rev 1 includes figures illustrating decreasing BCEE trends in UPA wells DGC-7S and MHW-1D from 2000 through present that demonstrate the beneficial effects of the remedial activities in the 1990s, changes in local

pumping in 2004, and operation of the LFExS starting in 2009. Appendix B of the Final FS Rev 1 also presents information pertaining to the inward and upward gradients established by the LFExS.

Since 1986 (period of lowest documented groundwater elevations in the DDA vicinity), a rise of up to 20 feet[7] in the UPA and Columbia Aquifer potentiometric surface elevations has been observed (see Appendix G of the Final FS Rev 1). This rise was the result of decreases in area groundwater withdrawal rates including:

- Decreases in the NCC extraction well withdrawal rates between the late 1980s and 2004
- Shutdown of the NCC extraction wells in 2004
- Reduction in the withdrawal rates by AWC at its Llangollen wellfield in 2005 to 2006

The drawdown of the potentiometric surface into the UPCUTZ and associated vertical fluctuations (dewatering of portions of the UPCUTZ followed by resaturation) and horizontal changes (east-west variations in groundwater flow direction) may have assisted in distributing contaminants within the UPCUTZ (beneath the UPCU) between the time of the original release (initiation of dumping at the DS&G Site in 1968) and the installation of the slurry-wall system in 1994. Additional discussion is provided in Section 3.5.

The dewatering system within the DDA was shut down in April 1998 and restarted in July 2001. While the slurry-wall system still provided lateral containment of the soil and impeded lateral migration of the groundwater when the dewatering system was shut down, it is likely that the shutdown of this system allowed contaminants to be released from the DDA to the UPCUTZ and the UPA upper sand. The UPA upper sand BCEE concentration trends at wells MHW-1D and DGC-7S (see Appendix H of the Final FS Rev 1) demonstrate that despite this shutdown, BCEE concentrations in the UPA upper sand beneath and immediately downgradient of the DDA continued to decline prior to 2004 when the NCC extraction system was shut down and extraction from well PW-1(U) began. These continued declining concentrations during this period suggest effectiveness of the drum and soil removal, and BRA operation in treating contamination and reducing the contaminant flux from the DDA.

3.5 Nature and Extent of Contamination

This section summarizes the nature and extent of soil and groundwater contamination and addresses the findings of surface water and gas migration assessments. As demonstrated by the list presented in the beginning of Section 3, there are areas of uncertainty associated with the extent of groundwater contamination in the UPCUTZ and in the UPA. These areas are identified in this section, where appropriate.

3.5.1 Chemicals of Concern

As discussed in Section 3.7, a human-health risk assessment (HHRA) was performed and ss-PRGs were developed. As such, the existing remedial measures, investigation activities, and data evaluations presented in the SSC Rev 2 refer to the COCs as identified in the HHRA. As presented in the Revised Addendum to Development of ss-PRGs - Revision 2 (ss-PRGs Rev 2 Addendum; Golder, 2017c) and summarized on Table 1, the COCs in groundwater at the Site include VOCs (benzene; four alkylbenzenes [ethylbenzene; xylenes; 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene]; and N,N-dimethylaniline), SVOCs (BCEE and 1,4-dioxane),

[7] The rise in Columbia groundwater elevation between 2003 and 2005 was most pronounced at NCC well C-5 (~17-foot-rise in groundwater elevation) and DDA well BG-1 (approximately 15-foot-rise in groundwater elevation). For most of the Columbia Aquifer wells within the DDA, groundwater elevations rose approximately 5 to 8 feet between 2000 and 2005.

and metals[8] (arsenic, cobalt, iron and manganese). Iron and manganese are also documented COCs in groundwater associated with the ACL Site. (USEPA, 2014d) The USEPA also references cobalt and 1,2-DCA as COCs for the ACL Site in the ROD-A2.

PFAS, primarily perfluorooctanoic acid (PFOA), has been detected in Site-wide groundwater as well as in groundwater at listed-sites upgradient of the DS&G and ACL Sites. PFAS compounds have not been identified as COCs; however, these compounds will continue to be monitored.

3.5.2 Soil

The FSWP Rev 2 submitted in October 2011 provided a discussion of the nature and extent of soil impacts associated with the DDA. The results of additional soil sampling in December 2011 and between September 2012 and December 2013 are presented in Section 7.3 of the SSC Rev 2. The analytical results for the soil samples collected within the DDA in 2011 do not change the conclusions related to the nature and extent of impacts within the DDA as presented in the FSWP Rev 2.

Based on investigations and removal and remedial measures performed at the Site since the 1980s, there is no evidence that significant impacts exist in unsaturated soils outside the bio-cell of the DDA. As such, the extent of unsaturated impacted soils is limited to the former bio-cell (located above the water table by design; see description in Appendix B of the Final FS Rev 1) within the containment area of the DDA. Results of these same investigations indicate that impacted saturated soils are primarily located beneath the former bio-cell located within the containment area of the DDA and above the UPCU.

In 2003, the Trust performed a Columbia soil investigation at the DS&G Site, outside the limits of the disposal areas, by advancing 19 soil borings in the vicinity of the DDA and the Inert Area. (Golder, 2003) The soil analytical results from this investigation indicated the following:

- Detections of BCEE in soil in two borings: GSB-4 (outside of the slurry-wall system and between the DDA and monitoring well DGC-7S) at 2.6 micrograms per kilogram (ug/kg); and GSB-9 (about 25 feet west of the Inert Area) at an estimated concentration of 1.6 ug/kg.
- Limited detections of VOC and SVOC compounds, with the exception of polynuclear aromatic hydrocarbons (PAHs) in samples from borings GSB-10[9] (advanced along the northern portion of the Inert Area west of well DGC-7S) and GSB-19 (advanced to the west of the Inert Area near well DGC-8C). The PAHs detected in these borings are not Site-related COCs.

There were also estimated low-level detections of toluene and total xylenes in soil samples from various borings.

A limited investigation of soils in the Columbia Aquifer was conducted at locations both within (borings SS-2011-01 through SS-2011-05) and outside (boring GAI-101) of the DDA as part of the FS to evaluate whether there are elevated soil concentrations coincident with areas of higher groundwater concentrations within the DDA (see Section 4.2 in the FSWP Rev 2). The results of the soil analyses indicate that COPCs, including but not limited to, benzene, toluene, ethylbenzene, and xylenes (BTEX), BCEE, phthalates and phenols, are present in both saturated and unsaturated soils (bio-cell only) within the containment area of the DDA. The elevated COPC concentrations

[8] As presented in Appendix J of the Final FS Rev 1, low-level analysis of hexavalent chromium for groundwater samples collected from 21 wells at the Site did not identify the presence of hexavalent chromium in groundwater.

[9] Boring DDA-11-US was advanced in this area in October 2012. Observations during boring advancement did not indicate visual or olfactory evidence of impacts. Columbia sands (and silt) were noted as 'wet' from 31 to 37.8 ft-bgs. Photoionization detector (PID) readings ranged from 0 to 3.6 (just above the UPCU) parts per million by volume (ppmv) in the Columbia Aquifer.

detected in the 2011 soil samples are located in areas with elevated concentrations observed in groundwater near LFExS extraction wells. Additional discussion regarding soil samples collected during the FS is included in Section 7.3 of the SSC Rev 2.

With the exception of borings GSB-4 and GSB-9 (2003 investigation) and boring GA-101 (2011 investigation), evidence of COCs in the Columbia Aquifer have not been detected in borings advanced in locations outside the DDA. Analytical results for the soil sample collected from boring GA-101, located outside the northern wall of the slurry-wall system, and groundwater samples collected from well GA-101 indicate the presence of impacts including primarily BTEX, styrene, and phthalates outside of the northern wall of the slurry-wall system. The exterior soil and groundwater concentrations are less than those observed within the slurry-walled area of the DDA and are not considered a significant source to the UPA groundwater. The extent of these impacts has not been evaluated, but based on the current and historic analytical data from wells outside the northern slurry wall of the DDA (wells DGC-5 and PZ-5-EXT), these impacts do not extend a significant distance beyond the northern slurry wall of the DDA.

During the September to December 2012 investigation, soil samples were also collected from the UPCUTZ beneath and downgradient of the DDA. During the November-December 2013 investigation, soil samples were collected from the UPCUTZ in the area of well P-6. Analytical results for these soil samples and the co-located monitoring well indicate that COPCs, including but not limited to, BTEX, BCEE, and chlorinated compounds, are present in the UPCUTZ; however, the concentrations detected were much lower than those detected in the DDA[10]. The full extent of soil and groundwater impacts in the UPCUTZ in the vicinity of well P-6 remains an area of uncertainty.

3.5.3 NAPL

A conservative analysis of the soil analytical results from samples collected in the DDA, UPCUTZ and the UPA since 2011 was performed consistent with the USEPA guidance on screening for the presence of NAPL (see Section 8.1.1 of the SSC Rev 2). The results of the analysis indicate that the potential for residual NAPL in the DDA is low. No evidence of residual NAPL was identified in the UPCUTZ and UPA soils collected.

Results of conservative NAPL screening of Columbia Aquifer, UPCUTZ and UPA groundwater data (see Section 8.1.2 of the SSC Rev 2) suggest it is possible that residual NAPL exists in the Columbia Aquifer within the DDA, in the UPCUTZ groundwater in the vicinity of the DDA, and in several wells downgradient of extraction well PW-1(U); however, the screening methodology used is extremely conservative and is not a definitive analysis as to the presence of NAPL. Neither light NAPL (LNAPL) nor dense NAPL (DNAPL) have been observed in the Columbia Aquifer or within the UPCUTZ or elsewhere at the Site in more than 10 years of monitoring and investigation activities.[11]

3.5.4 Groundwater

At the DS&G Site, the groundwater impacts extend vertically from the Columbia Aquifer along the northern Site boundary to the UPA upper sand. Downgradient of extraction well PW-1(U), the groundwater impacts extend vertically from the UPCUTZ into the UPA upper sand and lower sand, and at AWC's Llangollen wellfield, the groundwater impacts are observed in both the UPA upper and lower sand. Changes over time in the extent and location of downgradient impacts for VOCs detected in the UPA (e.g., benzene and ethylbenzene) follow a similar

[10] Analytical results for 1,4-dioxane in DDA soil are not available because 1,4-dioxane was not included on the target analyte list at the time when DDA soil samples were being collected for analysis.

[11] LNAPL determined to be weathered No. 4 fuel oil via analysis was identified in an unused well drilled for water supply purposes. (Golder, 2015a) This well was located in the basement of the Cirillo Brothers' building adjacent to an aboveground fuel oil storage tank. This well was decommissioned via grouting to grade on April 16, 2015.

trend to changes in the extent and location of the BCEE impacts; however, most VOCs (not including 1,4-dioxane) typically attenuate prior to reaching wells MW-26N or AWC-G3 (see FSWP Rev 2 and Section 3.6).

3.5.4.1 Columbia Aquifer

3.5.4.1.1 DDA

Impacts associated with the DDA in the Columbia Aquifer are encompassed by the slurry-wall system, with the exception of the area outside the northern DDA slurry wall along the railroad tracks as discussed below. The nature of impacts observed within the DDA varies with location, but the COCs include VOCs (primarily benzene), SVOCs (primarily BCEE and 1,4-dioxane), and metals (primarily iron and manganese). A discussion of groundwater analytical results and trends is presented in Section 7.4 of the SSC Rev 2.

Results for groundwater samples collected from the LFExS extraction wells are indicative of the groundwater concentrations in the most impacted portions of the Columbia Aquifer within the containment area of the DDA. The LFExS extraction well concentration trend plots indicate generally decreasing concentrations at the DDA extraction wells (with the exception of well BG-1 which is generally stable), between initiation of LFExS extraction (May 2009) and the March-April 2015 semi-annual monitoring event. (This observation does not include the 1,4-dioxane concentrations due to the limited data set available.) As demonstrated by the concentration trend plots for the DDA monitoring wells (see Appendix B of the Final FS Rev 1), concentrations of COCs in the DDA groundwater have decreased significantly since startup of the LFExS. In addition, the concentration trend plots for wells located within the partition area indicate that VOC and SVOC concentrations in that portion of the DDA have decreased since 2004.

As discussed in Section 7.4.1 of the SSC Rev 2, COC-impacted groundwater is observed in the Columbia Aquifer outside the northern DDA slurry wall along the railroad tracks. As shown by the trend plots for these wells, the concentrations in wells PZ-11-EXT and GA-101 have remained stable over time. The extent of these impacts outside the northern DDA slurry wall represents an area of uncertainty; however, there is no evidence to suggest that these impacts extend a significant distance beyond the northern slurry wall of the DDA.

3.5.4.1.2 Grantham South and Inert Area

As presented to the USEPA on August 6, 2013 (see Appendix 5.1 of the SSC Rev 2) and as discussed in Sections 7.2.5, 7.3.1.2 and 7.4.1.3 of the SSC Rev 2, there is no evidence of significant impacts to the Columbia Aquifer in the vicinity of Grantham South or the Inert Area, or any direct evidence of impacts from Grantham South or the Inert Area to the UPA. It is noted that in the December 2011 groundwater samples from temporary wells GMW-GSNW and GMW-11, an elevated manganese concentration was detected for the temporary well GMW-GSNW sample, and elevated concentrations of arsenic, chromium, lead, iron, and manganese were detected for the temporary well GMW-11 sample. These wells were not developed prior to sampling and were sampled the day after installation. While it is understood that these wells were purged and sampled using low-flow techniques, it is likely these samples were not representative of ambient groundwater conditions in that portion of the Columbia Aquifer.

3.5.4.2 UPCU Transition Zone

As shown on the isoconcentration contour plots included as Figures 5.1B through 5.3B and 5.4A through 5.6A of the SSC Rev 2, the COC impacts within the UPCUTZ extend from east to west beyond the footprint of the DDA slurry walls and extend from north of the DDA (along the railroad tracks) to the south in the vicinity of extraction well PW-1(U). It is likely that the extent and associated dissolved-phase COC mass extends to the west of the DDA to the area of well DGC-2S and to the east in the vicinity of well DDA-10-US (no UPCUTZ present); however, no monitoring wells are currently located in this area to allow verification of this assumption. Upgradient of extraction

well PW-1(U), the majority of the primary COC (1,4-dioxane, BCEE and benzene) dissolved-phase mass is in the UPCUTZ groundwater (see Section 4.4 of the Final FS Rev 1).

With the exception of well UPA-101-TZ installed in the vicinity of well P-6 in December 2013, UPCUTZ wells do not exist to the south and west of extraction well PW-1(U). Vertical aquifer profile (VAP) groundwater samples collected in November-December 2013 in boring UPA-101-TZ and subsequently in monitoring well UPA-101-TZ suggest that the COC impacts within the UPCUTZ are located in the area of well P-6. Based on the results of the groundwater flow model, it is anticipated that the dissolved-phase mass in the UPCUTZ downgradient of extraction well PW-1(U) is localized to the well P-6 area. Groundwater samples collected in the UPCUTZ during installation of downgradient wells UPA-01, UPA-02S, UPA-02D, and UPA-03D did not indicate evidence of groundwater impacts in the UPCUTZ along the UPA-01 to UPA-03D well transect.

The source of impacted groundwater observed in the UPCUTZ at well P-6, the extent of impacted groundwater in the UPCUTZ to the west of wells PW-1(U) (and south of well DDA-16-TZ) and P-6, the extent of the COC-impacted groundwater in the UPCUTZ to the east of well PW-1(U) (and south of well DDA-10-US), and the extent of the COC-impacted groundwater in the UPCUTZ to the south of well P-6 represent current areas of uncertainty.

3.5.4.3 Upper Potomac Aquifer

As shown on the isoconcentration contour plots for the UPA groundwater (see Figure Group 5 of the SSC Rev 2), BCEE and 1,4-dioxane impacts in the UPA extend from the DDA in the northern area of the Site to the wells in AWC's Llangollen wellfield located to the south. As shown on the isoconcentration contour plots included as Figures 5.1C, 5.2C, 5.3C, 5.4B, and 5.6B of the SSC Rev 2, the COC impacts within the UPA groundwater between the DDA and extraction well PW-1(U) are lower in concentration and cover a smaller east-to-west extent than the extent observed for the UPCUTZ groundwater impacts in that area. Despite migration within the UPCUTZ and into the UPA upper sand groundwater from the UPCUTZ, COC concentrations in the UPA upper sand groundwater between the DDA and extraction well PW-1(U) have been decreasing with time since:

- Installation of the slurry-wall system, removal of drums and soil, operation of the BRA, and installation of the temporary bentonite-mat cap, as evidenced by decreased concentrations in wells MHW-1D and DGC-7S (see Section 5.2.3 of the SSC Rev 2 and Appendix H of the Final FS Rev 1).
- Shutdown of the NCC system followed by startup of the well PW-1(U) system, as evidenced by decreased concentrations in wells DGC-7S and MHW-1D (see Section 5.2.3 of the SSC Rev 2 and Appendix H of the Final FS Rev 1). Decreased concentrations are also observed in wells DGC-2S and DGC-8S and are assumed to be due to the shutdown of the NCC system and the resulting eastward shift of the plume.

The extent of UPA impacts reflects the influence of historic local and regional withdrawals from the UPA as discussed in Section 3.4.1. The extent of the COC-impacted groundwater in the UPA upper sand to the east of extraction well PW-1(U) (area between wells DDA-10-US and DDA-12-US) and to the south-southwest of wells DGC-2S and DDA-16-US represent areas of uncertainty.

Downgradient of extraction well PW-1(U), the eastern extent of impacts attributable to the DS&G Site is interpreted to be just west of well pairs DGC-10S/D and DGC-11S/D. The western extent of the impacts related to the DS&G Site, particularly with respect to iron and manganese, is uncertain due to the proximity to the ACL Site and the contribution of mass from the ACL Site to the UPA, which combines with the dissolved-phase mass migrating from the DS&G Site. The dissolved-phase mass migrating from the Sites has created an area of combined mass between the two Sites. This area of combined mass is roughly located between Grantham South and wells BW-1

and MW-26N located in the northern portion of Llangollen Estates. Furthermore, as discussed in Section 3.3.4, the source of 1,4-dioxane detected at well BW-2 has been identified as an area of uncertainty (see Section 3.8).

There is also uncertainty associated with the potential for the presence of 1,4-dioxane and BCEE groundwater impacts in the UPA downgradient of the eastern portion of AWC's Llangollen wellfield due to shutdown of wells AWC-G3 and AWC-K1 in 2012. These wells were replaced by well AWC-G3R which has been in operation since October 2014. Based on Tetra Tech's numerical flow model, operation of well AWC-7 would have captured COCs in the eastern portion of the wellfield. Furthermore, in discussions with AWC's hydrogeologist and groundwater modeler, he stated that data from the operation of the ASR well shows that migration of the eastern portion of the plume beyond AWC's Llangollen wellfield will not occur as long as operation of the Llangollen wellfield continues close to the allocated volumes, even without the operation of well AWC-G3R.

3.5.5 Surface Water

As discussed in Section 7.5 of the SSC Rev 2, surface water samples collected in the area of ponded water near the toe of Grantham South indicated that low levels of VOCs, SVOCs, and metals were detected; however, the detections in the ponded water samples were below the ss-PRGs developed for the Site. In addition, surface water samples collected as part of the semi-annual monitoring program for the ACL Site do not indicate evidence of impacts in surface water in Army Creek located between the Sites. There are no known or documented surface discharge points for the impacted UPA groundwater associated with the ACL and DS&G Sites, and based on the strong downward gradients between the Columbia Aquifer and the UPA, discharge of UPA groundwater to the Columbia Aquifer and/or surface water is unlikely. Due to the overall regional extraction from the UPA, operational changes by AWC at its Llangollen wellfield are not anticipated to alter the downward gradient between the Columbia Aquifer and the UPA.

3.5.6 Gas Monitoring and Vapor Intrusion

3.5.6.1 DDA

The Trust suspended operation of the VBVS portion of the system in 2005, due to high water levels in the extraction wells that followed shutdown of the NCC system. The Trust subsequently suspended active operation of the bio-cell in 2009. Shutdown of these systems represented a data gap with respect to understanding the presence and behavior of the soil gas within the DDA. In the fall of 2013, the Trust performed a 10-week study related to the generation of vapors in the DDA. While measured oxygen levels during this study suggested ambient air infiltration into the extraction piping, the results of the air analyses suggested the presence of vapors (methane and VOCs [primarily benzene and toluene]) in the DDA. Due to the presence of the slurry-wall system including the temporary cap, there is no potential for substantial vapor migration from within the DDA to structures beyond the footprint of the DDA.

3.5.6.2 Grantham South and Inert Area

A discussion of the shallow groundwater assessment performed to address the data gap associated with the potential for vapor intrusion at Grantham South and the Inert Area is presented in Section 7.6.2 of the SSC Rev 2. The following provides information related to the presence of methane associated with the two areas and the potential for LFG migration and/or vapor intrusion into nearby buildings.

As presented in the Landfill Gas Monitoring and Inspection Activities – First Quarter 2016 Report, Delaware Sand & Gravel Superfund Site, New Castle, Delaware dated May 24, 2016 (Golder, 2016c), it is Golder's opinion that LFG migration is occurring at both the Inert Area and Grantham South. Based on its Site-specific knowledge and

experience at other sites, Golder believes that the LFG is trapped by the capped area and is migrating (by diffusion) laterally in coarser-grained units to areas beyond the capped landfills. Minimal levels of LFG were observed at the interior monitoring points (gas vents [GVs] and horizontal GVs [HGVs]) at both the Inert Area and Grantham South, while significant concentrations were observed at the perimeter monitoring points (gas monitoring wells [GMWs]). Based on the existing data, it appears that passive venting has a limited effect on releasing the LFG from beneath the cap and reducing the LFG migration. Evidence of LFG migration from both the Inert Area and Grantham South during the March 2016 monitoring event is consistent with prior quarterly LFG monitoring performed since 2012 and with prior LFG migration assessments performed in 2014 and 2015. Based on Tier III monitoring results, methane has not migrated to adjacent structures at levels greater than or equal to 1% of the lower explosive limit (LEL).

Due to the age of the landfilled materials (greater than 40 years) in both Grantham South and the Inert Area, it is unlikely that substantial quantities of methane continue to be generated within the landfill, but rather the LFG is trapped beneath the capped area and is migrating (by diffusion) laterally in coarser-grained units to areas beyond the capped landfill. Based on the existing data, it appears that passive venting of the LFG from within the landfill is likely limited to shallow areas; therefore, the passive venting has limited effectiveness in reducing migration of LFG from the landfill.

To assess the potential for LFG migration in the vicinity of the Inert Area and Grantham South, utility corridor and barhole probe surveys were conducted along Grantham Lane, on the Cirillo Brothers' property and on the DS&G Site between Grantham Lane, the northern portion of the Inert Area and the vicinity of the DS&G treatment building. Additional assessment of LFG migration between the Inert Area and the CBB (761 Grantham Lane), and between the Inert Area and the Dell'Aversano residence was performed in 2014 and 2015. The results of these assessment activities were summarized and submitted to the USEPA in a technical memorandum titled Assessment of Landfill Gas Migration dated July 6, 2015 (Golder, 2015e). Based on the results of these assessments, there is evidence of LFG migration from the Inert Area to the following locations:

- Onto the Cirillo Brothers' property
- Across Grantham Lane in the vicinity of the Cirillo Brothers' driveway
- Along Grantham Lane adjacent to the Dell'Aversano property
- Beyond well PW-1(U) toward the DDA

Observations during the 2014 assessment identified the potential for vapor intrusion associated with migration of LFG and resulted in the Trust's installation of a SSDS in the basement of the CBB to mitigate the potential for migration of vapors including methane into the building. The Trust monitors this system quarterly.

In addition, it is likely that LFG has migrated from Grantham South and/or the Inert Area onto the Dell'Aversano residential property. The Trust extends the offer to the property owner (Mr. Dell'Aversano) for building monitoring when quarterly gas vent monitoring triggers a Tier III monitoring event (i.e., sustained, elevated methane concentrations in gas monitoring wells exist near occupied structures warranting monitoring of indoor air). Access is not typically granted by Mr. Dell'Aversano. According to the First Quarter 2015 Monitoring and Inspection Report by Environmental Alliance, Inc. (EA), "Mr. Dell'Aversano's basement was last monitored during the Second Quarter 2014 (June 19, 2014) and all LEL measurements were recorded as 0% LEL." (EA, 2015)

As included in the July 2015 technical memorandum (Golder, 2015e), it was recommended that options for mitigation of LFG migration in the vicinity of the Inert Area and Grantham South be evaluated. To address this

recommendation, the Trust submitted the Proposed Scope for Landfill Gas Mitigation Pilot Study (Revision 1) dated September 3, 2015 (Golder, 2015g) to the USEPA for approval. The USEPA approved the work plan on September 17, 2015. (USEPA, 2015g) In November 2015, Golder initiated a soil vapor extraction (SVE) pilot test for LFG mitigation on the Cirillo Brothers' property in accordance with the Landfill Gas Mitigation Pilot Study-Work Plan (Golder, 2015g). A report summarizing the results of the SVE pilot test was submitted to the USEPA on February 19, 2016 (Golder, 2016b). The USEPA provided approval of the report with recommendations via email on April 4, 2016 (USEPA, 2016b).

On February 10, 2017, Golder submitted to the USEPA for review and approval the Final Design Report (FDR; Golder, 2017a) for the LFG Mitigation System. The purpose of the LFG Mitigation System is to prevent LFG migration beyond the perimeter of the Inert Area and Grantham South in the areas where potential receptors exist and to reduce the LEL of methane at the facility boundaries to below 25% LEL (performance goal). On March 15, 2017, the USEPA provided comments on the FDR and conditional approval (USEPA, 2017b). Golder submitted FDR - Addendum No. 1 to the USEPA on June 19, 2017 (Golder, 2017b), and construction of the LFG Mitigation System commenced on June 25, 2017. The primary components of the LFG Mitigation System constructed consist of LFG extraction wells, conveyance piping, and a flare. The system began operation on September 21, 2017, and as a result, methane concentrations measured in the gas monitoring wells around the perimeter of the landfills have dropped significantly (Golder, 2018b).

The evaluation and implementation of mitigation measures for LFG migration is being performed as an additional response action associated with the operation and maintenance of the Inert Area and Grantham South Area. (USEPA, 2015h)

3.6 Fate and Transport

This section describes the Site-specific fate and transport processes (Section 3.6.1) and the dissolved-phase contaminant migration pathways (Section 3.6.2) associated with the DS&G Site.

3.6.1 Site-specific Processes

The Site-specific fate and transport processes occurring at the DS&G Site are presented based on hydrostratigraphic unit to be consistent with the format for the presentation of information in this report.

3.6.1.1 Columbia Aquifer – DDA Vicinity

The processes occurring in the Columbia Aquifer within the containment area of the DDA are primarily leaching of COCs from unsaturated soils and desorption of COCs from finer-grained materials to the groundwater. The processes occurring in the Columbia Aquifer within the partition area of the DDA and along the northern slurry wall outside the DDA are primarily desorption of COCs from finer-grained materials to the groundwater, advection and dispersion. This section provides additional detail regarding these processes within the Columbia Aquifer in the vicinity of the DDA.

The DDA is capped with a temporary bentonite-mat cap, but some precipitation continues to percolate into the underlying soil and leach VOCs and SVOCs from the treatment residuals within the bio-cell. Beneath the water table, VOCs and SVOCs continue to leach from contaminated soils and from the interstitial space of finer-grained materials into the more permeable (coarser-grained) materials of the Columbia Aquifer. All these soils, groundwater and any leached impacts are contained by the DDA slurry-wall system, and captured and removed from the DDA by operation of the LFExS.

BCEE and 1,4-dioxane are highly soluble and fully miscible, respectively, in water. As such, these compounds will leach from the unsaturated DDA soils during percolation of precipitation and enter the groundwater. These compounds are not likely to sorb to soils, but in areas where previously high concentrations have caused diffusion of COCs, such as 1,4-dioxane, into the interstitial space of finer-grained materials, then back diffusion over time is significant to the fate and transport of these COCs. Given the age of the source at the DDA and the tendency of 1,4-dioxane and BCEE to not sorb to soils, back diffusion is a key consideration with regard to the fate and transport of these COCs.

In the saturated zone, dissolved-phase VOCs and SVOCs migrate horizontally and vertically in response to hydraulic gradients. The existing slurry-wall system and operation of the LFExS creates localized inward and upward gradients that mitigate the potential for migration horizontally or vertically out of the DDA into the underlying UPCUTZ. By contrast, groundwater within the partition area and external to the DDA migrates from the Columbia Aquifer to the UPCUTZ and UPA upper sand.

The overall decrease in concentrations of biodegradable compounds in DDA monitoring wells since the 1990s (e.g., BTEX, acetone or 2-butanone), as well as the presence of the trichloroethylene (TCE) breakdown products in the DDA groundwater (e.g., cis-1,2-dichloroethylene and vinyl chloride) suggests that some level of biodegradation is occurring within the DDA. In addition, the BTEX compounds detected within the partition area and outside the northern DDA slurry wall attenuate within a relatively short distance from the DDA (as compared to more conservative COCs such as BCEE); therefore, biodegradation of BTEX compounds appears to be occurring within the Columbia Aquifer. There is no evidence that biodegradation of BCEE and 1,4-dioxane is occurring in the Columbia Aquifer.

Volatilization of VOCs from impacted Columbia Aquifer groundwater occurs at the Site; however, volatilization (and a complete vapor intrusion pathway) is expected to be limited due to the enclosed nature (clay base, slurry-wall sides and bentonite cap) of the DDA. Previous operation of the vapor extraction system associated with the BRA reduced the level of volatile compounds within the DDA. While some volatilization of COCs is still occurring based on the DDA vapor monitoring performed between 2009 and 2013, volatilization of COCs does not play a significant role with regard to fate and transport in the DDA, especially for relatively soluble COCs like BCEE and 1,4-dioxane.

3.6.1.2 UPCU Transition Zone from DDA to Well P-6 Area

The fate and transport processes occurring in the UPCUTZ are primarily advection and desorption of COCs from finer-grained materials to groundwater. Historically, COCs migrated with groundwater from the DDA into the UPCUTZ and into the UPA upper sand. Currently, due to operation of the LFExS and installation of the slurry walls, little, if any, groundwater from within the DDA is migrating into the UPCUTZ and/or UPA upper sand. However, Columbia Aquifer groundwater with much lower level impacts is migrating from the area along the northern slurry wall outside the DDA and from the partition area into the UPCUTZ.

As discussed in Section 3.1 and Appendix E of the Final FS Rev 1, the UPCUTZ, while represented as a generally fining-upward sequence, displays evidence of bedding/discontinuous sandy layers that cause this unit to show a preference for horizontal migration/flow (i.e., the horizontal hydraulic conductivity of this unit is much greater than the vertical hydraulic conductivity). Because the UPCUTZ is comprised of interbedded sandy layers within a silt or clay matrix, historically high concentrations within the sandy layers have caused diffusion of COCs such as 1,4-dioxane into the interstitial space of finer-grained materials, and back diffusion of these COCs over time is likely to be significant to the fate and transport of these COCs at the Site.

Impacted groundwater in the UPCUTZ migrates horizontally and vertically in response to hydraulic gradients, which are generally to the south toward extraction well PW-1(U) in the vicinity of the DDA. Limited attenuation of COCs through dilution or dispersion is expected to occur in the UPCUTZ because this unit is finer grained than the Columbia Aquifer and UPA and there is less influx of groundwater from areas outside the contaminant plume than observed within the Columbia Aquifer and UPA.

The presence of the TCE breakdown products in the UPCUTZ groundwater suggests that some level of biodegradation is occurring within the Columbia Aquifer and/or the UPCUTZ. In addition, the TCE and breakdown products detected in the Columbia Aquifer and the UPCUTZ attenuate within a relatively short distance from the DDA (as compared to more conservative COCs such as BCEE); therefore, biodegradation appears to be occurring within the UPCUTZ. However, there is no evidence that appreciable biodegradation of BCEE and 1,4-dioxane is occurring in the UPCUTZ.

Due to the location of the UPCUTZ beneath a confining unit (UPCU), volatilization of VOCs from the UPCUTZ groundwater is not expected to be a significant fate and transport process at the Site.

3.6.1.3 UPA from DDA to AWC Wellfield

Historically, impacted groundwater from the DDA migrated into the UPCUTZ, into the UPA upper sand, and then into the UPA lower sand. Currently, due to operation of the LFExS and installation of the slurry walls, little, if any, groundwater from within the DDA containment area is migrating into the UPCUTZ and/or the UPA upper sand in the vicinity of the DDA (see Appendix B of the Final FS Rev 1 for supporting discussion and figures). Little, if any, low-level impacted groundwater is migrating from the area along the northern slurry wall outside the DDA and from the partition area into the UPCUTZ and/or the UPA.

As described above, BCEE and 1,4-dioxane are not likely to sorb to soils, but in areas where previously high concentrations have caused diffusion of COCs such as 1,4-dioxane into the interstitial space of finer-grained materials, then back diffusion of these COCs over time is significant to the fate and transport of these COCs to the UPA as well as within the UPA.

Impacted groundwater in the UPA upper sand migrates horizontally and vertically in response to hydraulic gradients induced by operation of well PW-1(U), and the impacted groundwater within the UPA upper and lower sand migrate in response to operation by AWC of its Llangollen wellfield and other wellfields in the area that induce downward vertical gradients from the UPA upper sand to the UPA lower sand. Horizontal gradients at the Site are generally from the DDA in the north toward extraction well PW-1(U) and AWC's Llangollen wellfield in the south.

As presented in Section 8.9 of the SSC Rev 2, extraction well PW-1(U) captures some contaminant mass within the UPA upper sand and contaminant mass migrating from the UPCUTZ groundwater to the UPA upper sand groundwater to the north and northwest of well PW-1(U). Based on the potentiometric surface and results of the Spring 2013 aquifer testing, the areas to the east and northeast of extraction well PW-1(U) (eastern edge of the groundwater emanating from beneath the DDA), and the area to the west in the area of well DDA-16-US appear to be outside the capture zone for well PW-1(U). Results of the numerical groundwater flow modeling in the DDA area (see Appendix B of the DAA) generally support the observations in SSC Rev 2. More specifically, the results indicate the following:

- Particles released near the DDA since shutdown of the NCC system in 2004 have been generally captured by extraction well PW-1(U)[12] operation (see Slides 18 to 21 in Appendix D of the SSC Rev 2)
- The capture zone for extraction well PW-1(U) at a simulated extraction rate of 40 gpm encompasses more than the entire width of the DDA (see Slide 28 in Appendix D of the SSC Rev 2)

Beyond extraction well PW-1(U), the processes of dispersion and biodegradation have the greatest effect on the fate of COCs in the UPA. Dispersion of VOCs in groundwater is typically a first order reaction and is dependent on compound and Site-specific properties.

Benzene and other alkylbenzenes are not typically detected above the ss-PRGs downgradient at well MW-26N, suggesting that significant attenuation of benzene and other alkylbenzenes is occurring in the UPA, upgradient of well MW-26N. Reduced dissolved oxygen (DO) concentrations upgradient of this point suggest that biodegradation is an important attenuation mechanism upgradient of well MW-26N. Additionally, metals impacts to UPA groundwater currently attenuate significantly prior to reaching AWC's Llangollen wellfield.

Relative to other VOCs and SVOCs at the Site, 1,4-dioxane and BCEE are conservative compounds because of their low affinity for organic carbon and relative stability in the aquifer. There is evidence that BCEE is susceptible to biodegradation under certain aerobic conditions (McClay et al, 2007), whereas 1,4-dioxane has not been demonstrated to be susceptible to biodegradation. There is no evidence that biodegradation of BCEE[13] and 1,4-dioxane is resulting in attenuation of these compounds in the UPA.

Due to the location of the UPA beneath a confining unit (UPCU), volatilization of VOCs from the UPA groundwater is not a significant fate and transport process at the Site.

3.6.2 Dissolved-phase Contaminant Migration Pathways

3.6.2.1 Columbia Aquifer to the UPCU Transition Zone

Within the DDA, there is likely back diffusion occurring from finer-grained materials into the Columbia Sand and/or leaching from unsaturated materials to the water table. However, as discussed in Section 3.4, the installation of the slurry-wall system and the subsequent installation and operation of the LFExS has mitigated migration of dissolved-phase impacts from the containment area of the DDA to the Columbia Aquifer. The inward and upward gradients measured within and around the DDA (as discussed in Appendix B of the Final FS Rev 1) indicate that there is very little, if any, mass flux across the slurry walls to the Columbia Aquifer outside the DDA or vertical flux from the Columbia Aquifer in the DDA to the UPCUTZ or UPA upper sand (see Appendices B and I of the Final FS Rev 1). As discussed in Section 3.5, little, if any, dissolved-phase impacts in the Columbia Aquifer within the partition area and external to the DDA along the northern slurry wall migrate from these areas into the UPCUTZ through the areas of more transmissive UPCU and the zero-clay areas.

3.6.2.2 UPCU Transition Zone to UPA in DDA Vicinity

The UPCUTZ represents a key hydrostratigraphic unit in the area of the Sites, and has been impacted at and downgradient of the DDA by historic migration of COCs from the DDA. As observed in the vicinity of the DDA, this

[12] As noted above, the particle capture in the groundwater model was simulated with well PW-1(U) operating at 40 gpm to approximate current conditions. Based on the operational history of well PW-1(U), NCC generally operated the well at less than 30 gpm between 2005 and 2012. Figure 14 of the January to June 2015 Semi-Annual Monitoring Report (Golder, 2015f) illustrates the well PW-1(U) extraction rates and changes over time.

[13] Microcosm studies performed by Shaw Environmental, Inc. on behalf of the USEPA indicate that Site conditions would be conducive to BCEE biodegradation in areas where DO is 3 mg/l or greater in the aquifer.

unit is characterized by potentially discontinuous beds of sandy clay, silt and silty sand, and is of a variable thickness across the Site. The hydraulic properties of the UPCUTZ are such that groundwater and thus dissolved-phase mass migration are impeded, most significantly in the vertical direction, within this unit in comparison to migration of the dissolved-phase COC mass within the UPA upper sand. Further, due to the fine-grained nature of the UPCUTZ, back diffusion from the interstitial spaces associated with these materials plays an important role in continued migration of the COC mass through the UPCUTZ and into the UPA upper sand.

Dissolved-phase COCs in the UPCUTZ below and outside of the DDA migrate generally to the south toward extraction well PW-1(U). In the area between the DDA and extraction well PW-1(U), there does not appear to be substantial contaminant mass migration from the UPCUTZ to the UPA upper sand, except:

- In areas where the UPCUTZ pinches out (e.g., between well DDA-15-TZ and well DDA-10-US); and/or
- Areas of the UPCUTZ under the strongest influence of extraction well PW-1(U) (e.g., wells DDA-02, DDA-12-US, and DDA-17).

Upward hydraulic gradients between the UPCUTZ and UPA in this area under well PW-1(U) pumping conditions and decreasing BCEE and benzene trends in UPA wells upgradient of well PW-1(U) generally support this finding.

Once COCs migrate into the UPCUTZ and the UPA, the difference in hydraulic properties between the two units allows for the COCs within the UPA upper sand to migrate more quickly from the area of the DDA to areas to the southwest, south and southeast of the DDA depending upon the extraction rates of the wells within the UPA downgradient of the Site.

Since shutdown of the NCC system and installation and initiation of extraction at well PW-1(U) in 2004, well PW-1(U) has removed COCs from both the UPCUTZ and UPA, thus decreasing the migration of COCs within the UPA upper sand from the DDA vicinity to areas downgradient of extraction well PW-1(U). However, based on the elevated COC concentrations (as compared to nearby wells) at well P-6 and the results of the November-December 2013 investigation in the area of well P-6 (see Sections 6.2.4 and 7.4 of the SSC Rev 2, and Section 3.6.2.3 below), it appears that there may have been migration of COCs within the UPCUTZ and/or UPA upper sand outside the influence of well PW-1(U). Additional discussion regarding observations and uncertainty related to well PW-1(U) capture is presented in Sections 5.3, 7.2.3 and 7.4.3.1 of the SSC Rev 2, and in Section 3.8 of this document.

3.6.2.3 UPCU Transition Zone from Extraction Well PW-1(U) Vicinity to AWC Wellfield

Areas of uncertainty exist relative to the migration of COCs in the UPCUTZ both to the east and west of extraction well PW-1(U) as well as to the south. Despite the preference for the groundwater and COPCs to migrate horizontally within the relatively coarser-grained layers of the UPCUTZ rather than migrate vertically through relatively finer-grained layers out of the UPCUTZ into the UPA upper sand, it is assumed that the groundwater and COPCs eventually migrate out of the UPCUTZ and into the UPA upper sand. This downward migration may be facilitated by a downward vertical hydraulic gradient downgradient of well PW-1(U), pinching out of the UPCUTZ, and/or the coarser-grained layers within the UPCUTZ connecting with the UPA upper sand. The specific areas where mass transfer occurs from the UPCUTZ to the UPA upper sand is uncertain. Elevated COPC concentrations at wells P-6 and UPA-101-US as well as the absence of COPC detections in the UPCUTZ in the well UPA-02S/D location suggest that contaminant mass transfer from the UPCUTZ to the UPA upper sand occurs between extraction well PW-1(U) and wells UPA-02S/D.

Results of the 2013 investigation in the well P-6 area suggest that COCs are present within the UPCUTZ and UPA upper sand in the area of well P-6. The source of contamination to well P-6 remains under evaluation. The

numerical modeling was able to simulate the groundwater mounding observed at well P-6 by including a U-shaped silt feature in the UPA upper sand and establishing a hydraulic connection between the Columbia Aquifer, UPCUTZ, and UPA upper sand in that localized area. Based on the upward vertical gradient between the UPA upper sand and the UPCUTZ in the well P-6 area, it appears that the UPCUTZ impacts detected in this area are caused by the localized upward migration of contaminants from the UPA upper sand to the UPCUTZ. The conceptual model for the impacts and mounding observed in the well P-6 area remains an area of uncertainty that will be evaluated during PDI (see Section 3.8).

3.6.2.4 UPA from Extraction Well PW-1(U) Vicinity to AWC Wellfield

In the area between well extraction PW-1(U) and AWC's Llangollen wellfield, the COCs migrate with groundwater within the UPA based on the hydraulic gradient and resulting groundwater flow direction. The overall flow direction in the UPA is to the south toward AWC's Llangollen wellfield. However, the groundwater flow direction can vary from southwest to southeast depending on which wells AWC is operating and their withdrawal rates. Additionally, regional withdrawals are contributing to the lowered potentiometric surface observed within the UPA downgradient of extraction well PW-1(U), and the southward groundwater flow direction.

COCs follow an overall downward flow path starting in the Columbia Aquifer at the disposal areas (DS&G and ACL Sites), then migrating downward with distance from the source areas into the UPCUTZ (identified at the DS&G Site in the vicinity of the DDA, suspected at the ACL Site) and UPA upper sand near the disposal areas, and eventually into the UPA lower sand. While it appears that the UPDC, located between the UPA upper sand and the UPA lower sand, is continuous between wells UPA-01 and UPA-03D, detection of COCs in both the upper and lower sand of the UPA downgradient of wells UPA-01 and DGC-8D suggests that COCs were previously drawn down into the UPA lower sand either by operation of the NCC system or by AWC's operation of its Llangollen wellfield or both. Because significant UPA lower sand impacts existed at the time of NCC shutdown and there is a limited UPA lower sand monitoring network, it is difficult to determine if COCs continue to migrate into the UPA lower sand since shutdown of the NCC system. It is possible that COCs migrate into the UPA lower sand from the UPA upper sand within the western portion of the Site due to operation by AWC at its Llangollen wellfield and potential discontinuous portions of the UPDC in that area. Figure 3.8 and Table 10 of the SSC Rev 2 provide information on vertical gradients observed at the Site.

3.6.3 Gas Monitoring and Vapor Intrusion

3.6.3.1 DDA

As indicated in Section 3.5.6.1, the generation of vapor within the DDA since shutdown of the BRA represents an uncertainty with respect to understanding the presence and behavior of the soil gas within the DDA. However, a complete shallow groundwater to indoor air pathway does not exist in the vicinity of the DDA due to the presence of the slurry-wall system.

3.6.3.2 Grantham South and Inert Area

3.6.3.2.1 Shallow Groundwater

As presented in Section 7.6.2 of the SSC Rev 2, a complete shallow groundwater to indoor air pathway does not exist in the vicinity of Grantham South and the Inert Area. This finding is based on the low detections in the shallow groundwater samples (wells DGC-8C, GMW-GSNW and GMW-11) collected and the general lack of groundwater above the UPCU in the Columbia Aquifer in several areas around Grantham South and the Inert Area (i.e., groundwater was not encountered above the UPCU during drilling along the northern and eastern boundaries of

Grantham South in borings GMW-13, GMW-14, GMW-16, GWM-17, GMW-18, UPA-101-US and UPA-101-TZ or along the southeastern boundary of the Inert Area in borings GMW-5 through GMW-9).

The groundwater quality within saturated portions of the Columbia Aquifer near the Inert Area and Grantham South was evaluated to assess whether volatilization via the soil vapor intrusion (SVI) pathway is an issue at the Site. As described in Sections 6.1.3, 7.2.5 and 7.4.1.3 of the SSC Rev 2, groundwater in the Columbia Aquifer was only encountered in two locations. Based on the analytical results from these two locations (temporary wells GMW-11 and GMW-GSNW) and from existing well DGC-8C, there is a very low potential that the SVI pathway is an issue at the Site.

3.6.3.2.2 Combustible Gas (Methane)

There is evidence of combustible gas (methane) migration from Grantham South and the Inert Area. According to the Landfill Gas Monitoring and Inspection Activities – First Quarter 2016 report (Golder, 2016c), LFG migration from Grantham South and the Inert Area is occurring; however, methane monitoring in occupied buildings (when access is granted) in the vicinity of Grantham South and the Inert Area suggests that methane is not migrating into occupied structures at levels equal to or above 1% of the LEL. In November 2014, an SSDS was installed beneath the building located at 761 Grantham Lane (CBB) near the Inert Area to mitigate the potential for migration of vapors including methane into the building. As indicated in Section 3.5.6, an LFG Mitigation System was installed to address LFG migration to potential receptors along the Inert Area and Grantham South.

3.7 Evaluation of Risk

A Public Health Evaluation (PHE) for the Site was prepared by Tetra Tech Richardson, Inc. in February 1988 and included in the FS prepared by Dunn, also dated February 1988. The PHE attempted to qualitatively and quantitatively characterize the risk posed to human health for the contaminants detected in soil and groundwater during the RI for the Site. More specifically, the PHE evaluated the potential risk posed by:

- Groundwater ingestion
- Soil ingestion, inhalation and dermal contact
- Leaching of organics from soils in or near the DDA

During performance of the FS, a combined HHRA was performed using tap water regional screening levels (RSLs) and preliminary remediation goal (PRG) calculation for UPA groundwater within the preliminary Area of Attainment (AoA) for the DS&G Site. This information was presented in the Technical Memorandum titled Development of ss-PRGs – Rev 2 dated December 22, 2014 (Golder, 2014b), approved by the USEPA via email on February 12, 2015 (USEPA, 2015a), then subsequently revised in October 2017 at the USEPA's request. Golder prepared and submitted the Revised Addendum to Development of ss-PRGs - Revision 2 (ss-PRGs Rev 2 Addendum; Golder, 2017c) to the USEPA on October 4, 2017 (see Table 1 for COCs and ss-PRGs). Additional discussion is provided in the Sections 3.7.1 through 3.7.4 regarding COCs, impacted media, receptors and potential exposure pathways, and the risk summary, respectively. The following summarizes the previous SVI evaluations.

In 2006, ENSR evaluated the potential inhalation risk associated with the vapor intrusion pathway (ENSR, 2006). The purpose of the SVI evaluation was to determine whether VOCs and SVOCs in the subsurface at the DS&G Site have the potential to pose risks above the USEPA's target risk levels assuming exposure to indoor air via the inhalation pathway. Based on the results of the SVI evaluation, ENSR concluded that soil vapor at the DS&G Site does not pose an unacceptable potential carcinogenic or non-carcinogenic risk to residents or workers in buildings

on the Site via the SVI inhalation pathway. This evaluation was representative of a conservative, worst-case scenario. It is likely that the potential risks to residents and workers in buildings on the DS&G Site are lower than those potential risk estimates presented in this evaluation; therefore, no further evaluation of the potential SVI pathway was recommended. However, the USEPA noted in their letter approving the report that "[s]hould saturation of additional areas within the Columbia aquifer occur in the future…, additional evaluation of the [groundwater] to indoor air pathway may be required." (USEPA, 2007a)

As described in Sections 6.1.3, 7.2.5 and 7.4.1.3 of the SSC Rev 2, the groundwater quality within saturated portions of the Columbia Aquifer near the Inert Area and Grantham South was evaluated to assess whether volatilization via the SVI pathway is an issue at the Site. Groundwater in the Columbia Aquifer was only encountered in two locations during installation of additional monitoring points. Based on the analytical results from these two locations (temporary wells GMW-11 and GMW-GSNW) and from existing well DGC-8C, there is a very low potential that the SVI pathway is an issue at the Site.

As discussed in Sections 3.5.6.2 and 3.6.3, additional assessment of LFG migration was performed in 2014 and 2015 (Golder, 2015e). While there is the potential for LFG migration and vapor intrusion into structures near the Inert Area and Grantham South, these are considered incomplete exposure pathways due to the operation of the SSDS in the CBB and the slab-on-grade construction of the occupied portion of Mr. Dell'Aversano's residence (there is an attached portion of the residence that has a basement, but the structure is not able to be occupied). Based on the analysis of indoor air samples from the CBB after installation and during operation of the SSDS, the USEPA concluded (and provided via email dated April 2, 2015) that "VOCs that were detected in the indoor air while the system was in operation are within EPA's acceptable risk range". (USEPA, 2015c)

3.7.1 COPCs, COCs and ss-PRGs

As indicated above, an HHRA was performed and the list of COPCs, exposure point concentrations (EPCs), COCs and ss-PRGs for the Site were developed (ss-PRGs Rev 2 Addendum; Golder, 2017c). As the ss-PRGs – Rev 2 Addendum presents in greater detail, the Trust re-evaluated the COC list using the same methodology requested by the USEPA for the screening performed as part of the FSWP Rev 2 groundwater and monitoring data for April 2012 through October 2013 for both the DS&G and ACL Sites. The updated list of COCs is provided as Table 1. The COCs at the Site include VOCs (benzene, and four alkylbenzenes [ethylbenzene; xylenes; 1,2,4-trimethylbenzene; and 1,3,5-trimethylbenzene]), SVOCs (BCEE; 1,4-dioxane[14]; naphthalene; and N,N-dimethylaniline), and metals[15] (arsenic, cobalt, iron and manganese) in groundwater.

Additional sampling and analysis since submittal and approval of the ss-PRGs memo demonstrated that hexavalent chromium is non-detect at reporting limits below the ss-PRG for a representative subset of wells at the Site. Additional information is provided in Appendix J of the Final FS Rev 1. These data indicate that hexavalent and total chromium in Site groundwater do not meet the criteria to be considered COPCs; therefore, hexavalent and total chromium should not be carried forward as COCs in either the HHRA process or the development of ss-PRGs. The ss-PRG for hexavalent chromium is not included on Table 1, and will not be considered in remedial actions for the Site.

[14] 1,4-dioxane is detected using a VOC analytical method and is presented as a VOC in Appendix B of the Final FS Rev 1.

[15] As presented in Appendix J of the Final FS Rev 1, low-level analysis of hexavalent chromium for groundwater samples collected from 21 wells at the Site did not identify the presence of hexavalent chromium in groundwater.

The COCs include both carcinogens and non-carcinogens. BCEE and benzene are known human carcinogens, and 1,4-dioxane is a probable human carcinogen. BCEE and 1,4-dioxane are particularly mobile in the subsurface, and do not readily adsorb to soil. Benzene and alkylbenzenes are less mobile and have a greater tendency to sorb to soil. Unlike benzene and alkylbenzenes, BCEE and 1,4-dioxane are not readily degraded by microbial processes.

The primary COCs at the Site are considered to be 1,4-dioxane, BCEE and benzene because they are probable (1,4-dioxane) or known (BCEE and benzene) human carcinogens, are relatively mobile, and occur in both soil and groundwater at the Site. There are additional COPCs, including but not limited to toluene, methylbenzenes, chlorinated compounds, and metals; but they are not detected Site-wide primarily due to attenuation (e.g., toluene) and/or transport properties that have limited their migration (e.g., phthalates).

As indicated in Section 3.5.1, PFAS, primarily PFOA, has been detected in Site-wide groundwater as well as in groundwater at listed-sites upgradient of the DS&G and ACL Sites. PFAS compounds have not been identified as COCs; however, these are considered COPCs and will continue to be monitored on an annual basis.

3.7.2 Impacted Media

The Site has documented impacts to subsurface soil and groundwater, and the potential to impact indoor air. The impacted soils in the Ridge Area have been removed, thereby eliminating risks associated with the soils in that area. Caps and fences placed on and around the DDA, Grantham South and the Inert Area have removed the exposure pathways for direct contact with impacted surficial soils in these areas. GMZs and treatment by AWC at its Llangollen wellfield have removed the exposure pathways for direct contact with impacted groundwater. Impacts to surface water[16] and sediments have not been identified previously, and are not anticipated for this Site. The USEPA acknowledges, "contaminated groundwater within the Upper Potomac Aquifer does not pose an unacceptable risk to occupants of nearby buildings via the vapor intrusion pathway." (USEPA, 2010) However, LFG migration assessment activities performed in 2014 and 2015 indicate that LFG has migrated beyond the perimeter of the Inert Area and Grantham South. Operation of the SSDS in the CBB has mitigated the exposure pathway for vapor intrusion into the CBB. In the 2015 FYR, the USEPA stated "Institutional controls addressing

[16] Army Creek/Army Pond was sampled between 2004 and 2012 (quarterly from October 2004 through April 2007, then annually from October 2009 through October 2012, after which the sampling frequency was reduced to every 5 years. The last sampling event was performed in October 2017) as part of the monitoring program for the adjacent ACL Site. The samples were analyzed for VOCs between 2004 and 2007, and SVOCs, metals and herbicides/pesticides between 2004 and 2012. In the 2014 FYR for the ACL Site (USEPA, 2014b), the USEPA states the following on pages 23 and 25, respectively:

> For the purpose of this five-year review, test results for water were compared with Delaware Water Quality Criteria for Protection of Aquatic Life and Delaware Water Quality Criteria for Protection of Human Health (based on fish ingestion). Delaware Water Quality Criteria for contaminants with concentrations exceeding the standards are presented in Table 4a. The test results that exceeded water quality standards at each sampling location are presented in Table 4b. The metal beryllium was detected in surface water at each of the seven sampling locations at concentrations exceeding the Delaware Water Quality Criterion for protection of human health in 2012, only. Bis(2-ethylhexyl)phthalate was detected at concentrations exceeding the standard for protection of human health in two samples collected from sample location F. The pesticides aldrin, beta-BHC, methoxychlor and toxaphene were sporadically detected in surface water at levels which exceed Delaware Water Quality Criteria for protection of human health and/or aquatic life. Pesticide contamination is consistent with what would be expected in an area formerly used for agriculture and in the vicinity of wetlands which were likely historically treated for mosquito control, and it does not appear that the exceedances are associated with the Site. Storm water run-off is a likely contributor of these contaminants to the surface water in Army Creek.
>
> EPA completed a screening level risk assessment for human exposure to surface water and sediment in Army Creek based on test results for samples collected from the stream in October 2012. No unacceptable risks were found for this exposure scenario.

potential vapor intrusion for new construction need to be developed and implemented for those areas beyond the perimeters of the Inert Area and Grantham South Area where landfill gas may be migrating." (USEPA, 2015f)

The impacted media at the Site associated with the potential exposure pathways include groundwater and subsurface soils, and potentially indoor air.

3.7.3 Receptors and Potential Exposure Pathways

To understand the risk posed by the COCs associated with the Site, the receptors and the potential pathways for human and ecological exposure to the COCs must be evaluated. Based on the current nature and extent of impacts, and the current and anticipated future remediation and use of the DS&G Site, the potential receptors and exposure pathways include the following:

- Industrial/Commercial Workers
  - Dermal contact and ingestion of impacted Columbia Aquifer and/or UPA groundwater via tap water
  - Inhalation of soil vapor and/or LFG due to migration into structures
  - Explosion hazard due to LFG migration into structures
- Construction/Excavation Workers
  - Dermal contact, ingestion and inhalation (particulates) of impacted subsurface soils
  - Dermal contact and ingestion of impacted Columbia Aquifer and/or UPA groundwater
  - Inhalation of VOCs and/or LFG that may accumulate in trench air during excavation activities
  - Explosion hazard due to LFG migration into trenches
- Residential
  - Dermal contact, ingestion and inhalation of impacted Columbia Aquifer and/or UPA groundwater via tap water
  - Inhalation of soil vapor and/or LFG due to migration into structures
  - Explosion hazard due to LFG migration into structures

Due to the presence of caps (engineered barriers) over the impacted soils in the landfilled areas, there are no exposure routes (direct contact, inhalation or ingestion) associated with potential ecological receptors that would result in a complete exposure pathway.

As stated in the FSWP Rev 2, potential exposure pathways associated with the discharge of potential shallow groundwater impacts to surface water downgradient of the DS&G and ACL Sites include dermal contact and ingestion by aquatic organisms of sediments and surface water impacted by groundwater discharge to surface water bodies. However, based on potentiometric surface elevations for the UPA, Columbia Aquifer and Army Creek/Army Pond, groundwater within the Columbia Aquifer and UPA at the DS&G Site do not discharge to surface water (see SCC Rev 2); therefore, the exposure pathway is incomplete.

3.7.4 Risk Summary

The primary potential human-health exposure pathway to Site-related COCs would be direct exposure of adults and children to groundwater via tap water from water supply wells. This pathway would include ingestion of impacted groundwater, direct contact with impacted groundwater through hand washing and bathing, and inhalation of vapors from impacted groundwater while showering. Additional potential human-health exposure pathways exist as described above. BCEE, 1,4-dioxane and benzene are the primary COCs associated with the ingestion of potentially-impacted groundwater exposure pathway; therefore, this is considered the risk driver for the Site.

Table 2 of the Final FS Rev 1 summarizes the impacted media, exposure points, receptors, and the exposure route for the receptors with addition of receptors and potential exposure pathways associated with LFG migration. These receptors and routes constitute the potential exposure pathways remaining at the Site. Because additional receptors and/or potential exposure pathways have not been identified, further evaluation of the receptors and the potential exposure pathways was not performed as part of this report.

The USEPA has indicated that the remedial activities at the Grantham South, Inert Area, and the DDA are currently protective of human health and the environment. (USEPA, 2015f) For the remedy to be protective of human health and the environment in the long term, the USEPA has indicated that additional response actions are needed at the DDA, and corrective measures may be needed at the Grantham South Area (USEPA, 2015f).

3.8 Areas of Uncertainty

As indicated above, there are areas of uncertainty that exist at the Site and will be addressed during PDI activities. This section provides a summary of these areas and Appendix N of the Final FS Rev 1[17] provides a discussion of proposed PDI activities to address the uncertainties. The areas of uncertainty include:

- The target capture zone in the area to the west and east of the DDA and extraction well PW-1(U) in the UPCUTZ and UPA upper sand associated with the following:
  - Area to the southwest of well pair DDA-16-TZ and DDA-16-US
  - Area to the south of well DDA-10-US and southeast of well pair DDA-12-TZ and DDA-12-US
- Area of well P-6 in the Columbia Aquifer, the UPCUTZ, and the UPA upper and lower sand associated with the following:
  - Nature/orientation of the “feature” used in the groundwater flow model to simulate the localized hydraulic mounding in the well P-6 area
  - Elevated manganese concentrations detected in temporary Columbia Aquifer well[18] GMW-11
  - UPCUTZ characterization[19]

[17] Appendix N of the Final FS Rev 1 was not part of the Final FS and is referenced out of sequence in the text of the Final FS Rev 1 to maintain the cross-references to the Final FS appendices included in other documents such as the SSC Rev 2.

[18] Wells GMW-11 and GMW-GSNW were not developed prior to sampling and were sampled the day after installation. While it is understood that these wells were purged and sampled using low-flow techniques, it is likely these samples were not representative of ambient groundwater conditions in that portion of the Columbia Aquifer.

[19] The visual and olfactory observations during drilling and the results of the VAP samples collected from the UPCUTZ in borings UPA-01, UPA-02, and UPA-03 located between extraction well PW-1(U) and AWC’s Llangollen wellfield did not indicate evidence of dissolved-phase impacts in the UPCUTZ.

  - Modeled extraction rate and target capture zone for the potential extraction well
- Area of wells RT-1-UP and UPA-01 in the UPA upper and lower sand associated with the following:
  - Modeled extraction rate and target capture zone for the potential extraction well
  - Potential for connection between the UPA upper and lower sand
- Area of wells MW-18 and MW-34 in the Columbia Aquifer, the UPCUTZ, and the UPA upper and lower sand associated with the following:
  - Manganese impacts in the Columbia Aquifer and the UPA upper and lower sand upgradient of the wells MW-18 and MW-34
  - Manganese impacts in the UPA upper and lower sand downgradient of the wells MW-18 and MW-34
  - Modeled extraction rate and target capture zone for the potential extraction well
- Area upgradient of well BW-2 in the UPCUTZ and the UPA upper and lower sand associated with the following:
  - Assess the impacts (e.g., 1,4-dioxane and manganese) to the well BW-2 area
  - Assess the potential presence of impacts in the upper sand upgradient of the well BW-2 area
  - Modeled extraction rate and target capture zone for the potential extraction well

Additional uncertainties considered in development of the CSM and completion of the FS include:

- Extent of impacted soil and groundwater in the Columbia Aquifer along the northern DDA slurry wall
- Presence of UPDC and connection between the UPA upper and lower sand between the ACL Site and the well P-6 area and the UPA-series well transect (wells UPA-01, UPA-02S/D and UPA-03D) running from the DDA to AWC's Llangollen wellfield
- Interaction between UPCUTZ and UPA upper sand including the area of greatest contaminant mass flux from the UPCUTZ to the UPA

4.0 SUMMARY OF SITE-SPECIFIC FS INFORMATION AND DESCRIPTION OF SELECTED ALTERNATIVE

4.1 Remedial Action Objectives

The Trust used proposed remedial action objectives (RAOs) in the evaluation of alternatives for the DS&G Site as provided in the Final FS Rev 1 (Golder, 2016d). The USEPA modified the RAOs and included them in the ROD-A2 as follows:

- Prevent direct contact with contaminated soil enclosed within the slurry wall at the DDA.
- Prevent migration of contaminants from the DDA that would cause contaminant concentrations in the groundwater of the Columbia Aquifer outside the DDA or the Upper Potomac Aquifer within the Area of Attainment [AoA] (as defined below) to exceed MCLs [maximum contaminant levels], nonzero maximum contaminant level goals (MCLGs) or acceptable risk- and health-based concentrations.

- Prevent direct contact with groundwater containing contaminants from the DS&G Site at levels that exceed MCLs, non-zero MCLGs or acceptable risk- and health-based concentrations.
- Restore groundwater within the Area of Attainment (throughout the contaminant plume, at and beyond the boundary of the Waste Management Area [WMA][19[20]]) to its beneficial use in a reasonable time frame. The Waste Management Area and the current approximation of the Area of Attainment are shown in Figure 5.
- Prevent contaminant migration from subsurface vapor intrusion into indoor air that would result in unacceptable levels of risk. [(i.e., prevent exposures that would present a cumulative excess lifetime cancer risk greater than one in one million (1 x 10-6) or result in a hazard index (HI) greater than 1.0.)] (USEPA, 2017c)

4.2 Waste Management Area and Area of Attainment

The WMA and the AoA for the DS&G Site, as referenced in two of the RAOs presented above, are defined below.

As described in Section 1.2, the DS&G Site includes three existing disposal areas (DDA [less than 3 acres], Inert Area [about 11 acres] and Grantham South [about 2 acres]), and one former disposal area (Ridge Area) in close proximity. The existing DS&G disposal areas (three capped landfills), the Ridge Area (former disposal area) and the areas between the boundaries of the DS&G capped landfills and the Ridge Area constitute the WMA at the DS&G Site (see Figure 5).

The AoA includes the entire contaminant plume originating from the DS&G Site, at and beyond the edge of the WMA associated with the Site. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) preamble states that "[f]or ground water, remediation levels should generally be attained throughout the contaminated plume, or at and beyond the edge of the waste management area when waste is left in place" 55 Federal Register (FR) 8713 (March 8, 1990; USEPA, 1990). The groundwater directly beneath the WMA is generally not within the AoA (NCP Preamble and Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (USEPA Office of Solid Waste and Emergency Response [OSWER] Directive 9283 1-2, December 1988, [USEPA, 1988c]). At the DS&G Site, groundwater cleanup goals will be achieved throughout the AoA. The AoA for the DS&G Site is shown on Figure 5. The source of UPA groundwater impacts detected in the area of wells MW-18/MW-34 and MW-26N and in the area of well BW-2 will be evaluated as part of the PDI activities.

4.3 COCs and ss-PRGs

As discussed in the Revised Addendum to Development of Site-Specific Preliminary Remediation Goals – Revision 2 (Golder, 2017c), and summarized in Sections 3.5.1 and 3.7.1 and on Table 1, the COCs in groundwater at the Site include VOCs (benzene, and four alkylbenzenes [ethylbenzene; xylenes; 1,2,4-trimethylbenzene; and 1,3,5-trimethylbenzene]), SVOCs (BCEE; 1,4-dioxane[21]; naphthalene; and N,N-dimethylaniline), and metals[22] (arsenic, cobalt, iron and manganese). BCEE, 1,4-dioxane, benzene, iron and manganese were considered in the DAA because they are the primary risk drivers at the Site, and they are detected in the DDA groundwater as well as in groundwater within the AoA.

[20] The DS&G Site includes three areas where wastes are being managed on-site (DDA, Inert Area and Grantham South Area) and one former waste storage area (Ridge Area) in close proximity. These areas and the small parcels that connect them constitute the Waste Management Area at the Site.

[21] 1,4-dioxane is detected using a VOC analytical method and is presented as a VOC in Appendix B of the Final FS Rev 1.

[22] As presented in Appendix J of the Final FS Rev 1, low-level analysis of hexavalent chromium for groundwater samples collected from 21 wells at the Site did not identify the presence of hexavalent chromium in groundwater.

Iron and manganese are also documented COCs associated with the ACL Site. (USEPA, 2014b) Additional metals (arsenic and cobalt) as well as VOCs and SVOCs, while not COCs for the ACL Site, are present in groundwater at and downgradient of the ACL Site.

4.4 Selected Remedy

Details regarding Alternative C which was ultimately chosen by the USEPA as the Selected Remedy are included in the Final FS Rev 1. The Selected Remedy includes the proposed extraction well locations shown on Figures 6 and 7. As stated by the USEPA in the ROD-A2:

> The Selected Remedy will provide reliable containment of contamination remaining at the DDA through enhancements to the LFExS which is currently operating within the slurry wall and installation of a composite barrier cap. This alternative would also include the installation and operation of groundwater recovery wells in the Upper Potomac Aquifer, including the UPCUTZ, and extraction and *ex-situ* treatment of Upper Potomac Aquifer groundwater utilizing existing and potentially additional treatment systems at the Llangollen well field in order to restore groundwater to its beneficial use. In addition, this alternative would employ institutional controls to prevent potential future exposure to Site-related contaminants in indoor air at levels that would present unacceptable risks.
>
> The Selected Remedy addresses the three remediation targets enumerated below and includes the following remedial components:
>
> 1) DDA/Columbia Aquifer soil and groundwater
>
> - Existing slurry-wall system;[24][23]
> - Enhanced LFExS (ELFExS) pumping at an estimated 25 gallons per minute (gpm)[25][24] and equipped with a backup generator and instrumentation and telemetry for real-time containment monitoring to maintain inward and upward hydraulic gradients;
> - A groundwater monitoring program to ensure that the ELFExS is operating as designed;
> - A composite barrier cap to minimize infiltration of precipitation through contaminated soil contained within the slurry wall surrounding the former DDA; and
> - Institutional controls to prevent direct contact with contaminated soil, the installation of drinking water wells on the Site property and other future uses of the Site property which could compromise the effectiveness of the remedial action.
>
> 2) Upper Potomac Aquifer
>
> - Installation and operation of extraction wells in areas determined to optimize capture and remove contaminant mass from the more highly-impacted areas of the Upper Potomac Aquifer, including the UPCUTZ. The anticipated locations of the proposed new extraction wells are shown in Figures 7 and 8. The actual configuration of the groundwater recovery well network and groundwater extraction rates would be determined by EPA, in consultation with DNREC, during the remedial design.

[23] Costs associated with the slurry wall are not included in the cost estimate for the Selected Remedy.
[24] The LFExS currently operates at a rate of 8 to 10 gpm.

- Discharge of groundwater pumped from the DS&G Site extraction wells to the Wilmington Wastewater Treatment Plant.
- Continued groundwater extraction at Artesian's Llangollen well field with treatment utilizing existing systems for BCEE and 1,4-dioxane and, if necessary, additional treatment systems targeting other COCs, such as manganese.
- A program to monitor performance of the groundwater extraction wells, confirm they are preventing migration of the groundwater contaminant plume and evaluate progress toward the attainment of long-term groundwater remediation goals.
- Institutional controls to prevent future use of the Site property which could compromise the effectiveness of the remedial action and the installation of drinking water wells on the Site property.[26][25]

3) Potential vapor intrusion

There are several nearby buildings located within 300 feet of the on-site waste management areas. There may also be future construction within several hundred feet of those sections of the Inert Area and Grantham South Area where a landfill gas mitigation system is not being operated. Due to the documented migration of landfill gas beyond the perimeters of the Grantham South Area and the Inert Area, and the potential for vapor intrusion into nearby buildings and any future construction, the Selected Remedy includes use restrictions to prevent potential future exposure to Site contaminants in soil vapor and landfill gas that have the potential to migrate into indoor air. The use restrictions would be implemented through an enforceable institutional control such as a judicial consent decree, an administrative order or an environmental covenant, and would ensure that all new habitable buildings constructed on or adjacent to the Site property in areas potentially impacted by landfill gas have, at a minimum, a foundation vapor barrier and subsurface piping for a SSDS. The institutional controls would require testing of indoor air in any buildings subject to the controls prior to occupancy and, should indoor air concentrations equal or exceed EPA risk-based criteria, activation and operation of a SSDS until such time that EPA determined that landfill gas migration no longer posed a vapor intrusion risk. The areas subject to these use restrictions would be determined prior to the remedial design. (USEPA, 2017c)

As stated by the USEPA in the ROD-A2, "[t]he Selected Remedy will restore groundwater in the Area of Attainment within the Upper Potomac Aquifer which has been impacted by releases from the DS&G Site and the eastern lobe of the Army Creek Landfill." (USEPA, 2017c) The RD AOC requires preparation of the design for the Selected Remedy after performance of the PDI WP.

4.5 Compliance with ARARs

The Selected Remedy was chosen for its ability to achieve compliance with chemical-specific applicable or relevant and appropriate requirements (ARARs)[26], most specifically, the ss-PRGs (risk- and health-based groundwater cleanup standards) established for the UPA groundwater within the AoA. The Selected Remedy will meet the ss-PRGs in the AoA through installation of a mass removal and robust migration control system for purposes of capturing contaminated groundwater at and upgradient of the AoA. As stated by the USEPA in the

[25] Additional groundwater use restrictions have been in effect in the area surrounding the Site since June 2006, when DNREC established a groundwater management zone encompassing several hazardous waste disposal facilities near the Site. The groundwater management zone places restrictions on the installation of new water supply wells throughout the known extent of the Upper Potomac Aquifer contaminant plume.
[26] Location- and action-specific ARARs, such as the Delaware Regulations Governing Construction of Water Wells or the Delaware Regulations Governing Hazardous Waste, will be addressed later through design and permitting considerations.

ROD-A2, “groundwater extraction wells will continue to be operated after the risk- and health-based groundwater cleanup standards, MCLs, and non-zero MCLGs are met to prevent degradation of water quality downgradient of the Waste Management Area.” (USEPA, 2017c)

In addition, extraction and treatment of groundwater by AWC at its Llangollen wellfield assists with achieving the ss-PRGs within the AoA, and “treatment at the Llangollen well field shall provide an additional degree of protectiveness.” (USEPA, 2017c)

4.5.1 DDA/Columbia Aquifer Soil and Groundwater

As stated by the USEPA in the ROD-A2:

> The Selected Remedy will comply with State standards for owners and operators of hazardous waste landfills and federal and State standards governing discharges to publicly owned treatment works (POTWs) which accept and treat sewage and industrial wastewater. In particular, the design, construction and O&M of the composite barrier cap to be installed at the DDA would meet federally authorized State requirements for closure and post-closure care of hazardous waste landfills [7 DE Admin. Code 1302 Regulations Governing Hazardous Waste, subsections 264.310(a) and (b)(1) and (5)] and for monitoring and inspection during the installation of the cover system [7 DE Admin. Code 1302 Regulations Governing Hazardous Waste, subsection 264.303(a)]. Groundwater extracted from the Columbia Aquifer and discharged to the Wilmington Wastewater Treatment Plant would comply with effluent limitations established by New Castle County and the City of Wilmington to meet the requirements of Delaware’s National Pollutant Discharge Elimination System Program ([NPDES;]7 DE Admin. Code 7201 Regulations Governing the Control of Water Pollution, Section 6.0) and would meet any pretreatment standards established by New Castle County and the City of Wilmington in accordance with the NPDES General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403). (USEPA, 2017c)

4.5.2 UPA

As stated by the USEPA in the ROD-A2:

> The MCLs for primary drinking water contaminants and non-zero MCLGs for public drinking water supplies established under the Safe Drinking Water Act are considered to be relevant and appropriate standards for groundwater remediation under the Superfund program. The Selected Remedy will achieve MCLs and non-zero MCLGs for groundwater contaminants within the Area of Attainment in a reasonable time frame. Groundwater extracted from the Upper Potomac Aquifer and discharged to the Wilmington Wastewater Treatment Plant would comply with effluent limitations established by New Castle County and the City of Wilmington to meet the requirements of Delaware’s National Pollutant Discharge Elimination System Program (7 DE Admin. Code 7201 Regulations Governing the Control of Water Pollution, Section 6.0) and would meet any pretreatment standards established by New Castle County and the City of Wilmington in accordance with the NPDES General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403). Any pretreatment of groundwater discharged to the POTW, and treatment to remove COCs from groundwater extracted from the Llangollen well field, may result in the generation of hazardous waste. Generated hazardous waste would be managed in accordance with Delaware’s standards applicable to generators of hazardous waste, including storage and manifesting of hazardous waste (7 DE Admin. Code 1302 Regulations Governing Hazardous Waste, subsections 262.11-42). (USEPA, 2017c)

5.0 DATA QUALITY OBJECTIVES

The DQOs presented in this section have been developed based on the USEPA's "Guidance on Systematic Planning Using the Data Quality Objectives Process" (QA/G-4) (USEPA/240/B-06/001, February 2006). The DQOs for the PDI activities described in the PDI WP and the SAP are summarized in Appendix A - Table A-1 and the Decision Thresholds/Action Levels are presented in Appendix A - Table A-2. The DQO process as it relates to the Measurement Performance Criteria is described in Section 3 of the SAP.

5.1 Introduction

The SAP (see Appendix A) and the incorporated quality assurance plan describe the measures specified to produce data of known and sufficient quality and to characterize the impacts to environmental media at the Site, which will be used to determine the appropriate extent of the remedial action at the Site. As part of the evaluation component of the quality assurance (QA) program, results will be compared to data quality indicators (DQIs) that are part of the overall DQOs for the project. The QA program objectives for the analytical laboratory are presented in the laboratory's QA Plan. DQOs are qualitative and/or quantitative statements that:

- Define the degree and extent of releases to the environment
- Support the development and evaluation of the remedial action

The DQO Guidance document uses an iterative, seven-step, systematic-planning approach "to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study" (USEPA, 2006). The seven steps are as follows:

- State the Problem – Define the problem, identify the planning team, and examine the budget and schedule
- Identify the Goals of the Study – State how environmental data will be used to meet objectives and solve problems; identify the study questions, and define alternative outcomes
- Identify Information Inputs – Identify data and information needed to answer the study questions
- Define the Boundaries of the Study – Specify target populations and characteristics of interest, define spatial and temporal limits, and define the scale of inference
- Develop the Analytic Approach – Define the parameters of interest, specify the types of inference, and develop the logic for drawing conclusions from the findings
- Specify Performance or Acceptance Criteria – Specify probability limits for false rejection and false acceptance decision errors, and/or develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use
- Develop the Plan for Obtaining Data – Select a resource-effective sampling and analysis plan that meets the performance criteria

The following sections present details on the seven-step, iterative planning approach.

5.1.1 State the Problem

The problem is defined as the areas of uncertainty identified in Section 3.8 and the additional information needed to perform the RD. In the ROD-A2, the USEPA acknowledged that these areas should be addressed during the PDI.

As required for this step in the development of DQOs, the budget to address the areas of uncertainties and collect additional information needed to perform the RD were developed and estimates were provided in the DAA. Also, as is required for this step, the project team has been developed and is identified in the SAP and in Section 7, and the anticipated schedule for performance of the activities is presented in Section 7 as well.

5.1.2 Identify the Goals of the Study

The USEPA states the following in Paragraph 2.12.2 of the ROD-A2:

> Areas of uncertainty at the Site identified in the Feasibility Study will be addressed during predesign investigations which will include but not be limited to the following activities:
>
> - Delineation of the extent of contamination in the UPCUTZ;
> - Verification of target capture zones for extraction wells to be installed in the UPCUTZ and the upper and lower sand units of the Upper Potomac Aquifer;
> - Evaluation of the interaction between the UPCUTZ and Upper Potomac Aquifer upper sand, including the area of greatest contaminant mass flux from the UPCUTZ to the Upper Potomac Aquifer;
> - Evaluation of the continuity and/or extent of the UPDC and the connection between the upper and lower sand units of the Upper Potomac Aquifer between source areas and the Llangollen well field;
> - Additional characterization to evaluate the simulated silt feature near well P-6 in the Site-specific groundwater flow model;
> - Assessment of the source of impacts (e.g., BCEE, 1,4-dioxane and/or manganese) in the vicinity of monitoring wells P-6, MW-18 and MW-34, BW-2 and MW-26N; and
> - Delineation of areas beyond the boundary of the Inert Area and the Grantham South Area impacted by subsurface migration of landfill gas in order to ensure that institutional controls are in place to prevent potential future exposure to all areas where Site-related vapor intrusion adversely affects indoor air. (USEPA, 2017c)

Based on the areas of uncertainty identified in Section 3.8 and the statements provided by the USEPA in the ROD-A2, data from the additional investigation activities will be used to address the data gaps:

1) Target capture zones and design extraction rates for the extraction wells included in the Selected Remedy
2) Migration between the hydrostratigraphic units including from the UPCUTZ to the UPA upper sand and from the UPA upper sand to the UPA lower sand
3) Source and extent of manganese and other COC impacts in groundwater downgradient of the DS&G Site and the eastern lobe of the ACL Site
4) Extent of contamination in the UPCUTZ to the east and west of the area of the DDA and well PW-1(U)

5) Potential migration of LFG beyond the facility boundaries in areas not mitigated by the existing LFG Mitigation System[27]

Refer to Tables 2 and 3 for additional information.

5.1.3 Identify Information Inputs

As discussed in Section 3.8 and 5.1.2, additional data collection is needed to address areas of uncertainty and supplement the existing data. The supplemental data in conjunction with the existing data can be used for decision making and preparation of the RD. As stated by the USEPA in the ROD-A2;

> These pre-design activities will include the advancement of borings and installation of monitoring wells using rotosonic drilling methods with vertical aquifer profiling[30[,28]] and baseline groundwater sampling to confirm target capture zones. Aquifer testing will be performed in the potential extraction well locations to confirm the modeled groundwater extraction rates and evaluate the connections between hydrostratigraphic units within the Upper Potomac Aquifer. The results of the sampling and testing will be used to update the CSM and the numerical groundwater flow model, refine the simulated capture zones and develop design extraction rates for the groundwater extraction wells. (USEPA, 2017c)

The sampling and analysis methods that will be used while addressing these data gaps are discussed in Section 6 and in the SAP (Appendix A).

5.1.4 Define the Boundaries of the Study

The study area includes areas that are currently impacted by contamination related to the DS&G Site and the eastern lobe of the ACL and areas that have the potential to be impacted by contamination from the DS&G Site and the eastern lobe of the ACL. The spatial boundaries for the remedial action are the 27-acre Site described in the Final FS Rev 1 (Golder, 2016d), and groundwater within the UPCUTZ and the UPA between the Site and the eastern lobe of the ACL Site extending to AWC's Llangollen wellfield.

5.1.5 Develop the Analytic Approach

As part of this step in the DQO process, an analytic approach is developed that will guide analysis of the study results and development of conclusions from the data. As described in Section 4.5, Golder developed and the USEPA approved ss-PRGs for the UPA groundwater in the AoA (see Table 1). The ss-PRGs, MCLs, MCLGs, and secondary maximum contaminant levels (SMCLs) (AWC's treated water supply must meet SMCLs prior to distribution) were used in development of the DQOs. The SAP provides the parameters of interest, and Section 6 relates the parameters of interest to the scope of work (see Tables 2 and 3).

5.1.6 Specify Performance or Acceptance Criteria

As part of this step in the DQO process, the performance or acceptance criteria need to be specified. Since analytical data are only an estimate of actual conditions at a Site, decisions that are made based on these measurements must be evaluated against criteria based on performance or acceptance. The SAP includes this information. Decision-making problems can be addressed by performing statistical hypothesis tests on the collected data, whereas estimation problems use collected data to estimate an unknown population parameter. It is

[27] Existing LFG Mitigation System was designed to mitigate LFG migration in areas where receptors exist. The USEPA requires that areas where future development may occur be evaluated for LFG migration.

[28] During advancement of borings, groundwater will be sampled during the Push-Ahead™ groundwater sampling system (vertical aquifer profiling) used with sonic drilling methods).

anticipated that the data collected as part of the PDI WP will be used for estimation purposes. Inherent variability and uncertainty in the collected data will lead to error/uncertainty in estimations.

5.1.7 Develop the Plan for Obtaining Data

The sample collection program (sample location and frequency) is described in Section 4.2 of the SAP. The sampling program was developed based upon the following steps:

- Identify the issue(s) to be addressed
- Identify data and information needed to evaluate the issue(s)
- Identify additional data needs
- Develop a data collection program to address those needs
- Collect data
- Identify/develop related data that will be useful in addressing the issue(s)
- Define quantitative data acceptance criteria (data quality indicators)

5.2 Data Quality Indicators

The data quality indicators include precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS). These indicators are used to evaluate data with respect to DQOs. Each indicator is defined as follows:

- Precision is the agreement or reproducibility among individual measurements of the same sample point, usually made under the same conditions
- Accuracy is the degree of agreement of a measurement with the true or accepted value
- Representativeness is the degree to which a measurement accurately and precisely represents a characteristic of a population, parameter, or variations at a sampling point, a process condition, or an environmental condition
- Comparability is an expression of the confidence with which one data set can be compared with another data set in regard to the same sample point
- Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct normal conditions
- Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest

The precision, accuracy, and representativeness of data will be functions of the sample origin, analytical procedures, and the specific sample matrices. Quality Control (QC) practices used to evaluate these data quality indicators include use of accepted analytical procedures, adherence to holding times, and analysis of QC samples such as blanks, replicates, spikes, calibration standards and reference standards. Appendix A - Tables A-9 through A-13 summarize the PARCC criteria for groundwater samples that will be collected for field and laboratory measurements. Appendix A - Table A-14 provides reporting limits for the analytical constituents for groundwater

matrices. Establishing appropriate reporting limits is important in the overall DQO process as the reporting limits are used in evaluating compliance with action levels.

Precision and accuracy are quantitative characteristics that will be established in accordance with the specific analytical method employed, published historical data, laboratory method validation studies and laboratory experience with similar samples.

Representativeness is a non-quantitative (qualitative) characteristic, which primarily addresses proper design of a sampling program in terms of number and location of samples and sample collection techniques. The rationale for the number and location of samples for this project is discussed in Section 4.2 of the SAP and the sampling procedures are described in Section 4.3 of the SAP. The representativeness of the analytical data is also a function of the procedures used to process the samples. Wherever possible, standard USEPA or USEPA-accepted analytical procedures will be followed.

Completeness is a quantitative characteristic that is defined as the fraction of valid data obtained from a measurement system (sampling and analysis) compared to that which was planned. Completeness can be less than 100 percent due to poor sample recovery, sample damage, or disqualification of results that are outside of control limits due to laboratory error or matrix-specific interference. Completeness is documented by including sufficient information in the laboratory reports to allow the data user to assess the quality of the results. For this project, every attempt will be made to attain 85 percent or better completeness (field and laboratory).

Comparability is a qualitative characteristic, which allows for comparison of analytical results with those obtained by other laboratories. This may be accomplished through the use of standard accepted methodologies; traceability of standards to National Bureau of Standards (NBS) or USEPA sources; use of appropriate levels of quality control; reporting results in consistent, standard units of measure; and participation in inter-laboratory studies designed to evaluate laboratory performance.

Appendix A - Tables A-9 through A-13 provide details regarding the planned chemical analyses and the quality criteria used to assess the data. The DQIs and DQOs, as summarized by the PARCC criteria in these tables, may not always be achievable. The laboratory will be instructed to minimize dilutions to report the lowest levels possible, but dilutions might be necessary due to matrix interferences. The USEPA Region III data validation guidelines provide direction for the determination of data usability. Qualified data can often provide useful information, although the degree of certainty associated with the results may not be as planned; therefore, professional judgment will be used to determine data usability with respect to project goals.

6.0 PDI SCOPE OF WORK

This section presents the scope of work proposed to address the areas of uncertainty (see Section 3.8) as well as ongoing groundwater monitoring activities at the Site.

6.1 SAP, HASP and ERP

The SAP provided in Appendix A consists of the Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP) prepared in accordance with “USEPA Guidance for Quality Assurance Project Plans” (QA/G-5) (USEPA/600/R-02/009, December 2002) and “USEPA Requirements for Quality Assurance Project Plans” (QA/R-5) (USEPA 240/B-01/003, March 2001). The data generation and acquisition methods to address the areas of

uncertainty, perform the PDI SOW, and continue ongoing groundwater monitoring activities are presented in Section 4 of the SAP.

The Site-specific HASP was prepared in accordance with USEPA's Standard Operating Safety Guide (PUB 9285.1-03, PB 92-963414, June 1992) and includes a Site-specific ERP. The HASP and the ERP (Attachment A of the HASP) are included in Appendix B.

6.2 Areas of Uncertainty

As presented in Section 3.8 and in Appendix N of the Final FS Rev 1, there are areas of uncertainty associated with the updated CSM presented in the Final FS Rev 1. Prior to design of the Selected Remedy, these areas require investigation. To align these areas of uncertainty with the activities that will be performed to address them, the areas of uncertainty were consolidated and are described under the following subsections: 1) target capture zones and extraction rates; 2) migration between hydrostratigraphic units; 3) manganese and other COCs in groundwater; 4) extent of contamination in the UPCUTZ; and 5) potential LFG migration.

As indicated in the Final FS Rev 1, the proposed PDI activities needed for design of the Selected Remedy require a phased approach and consist of the following sequence of activities:

- Phase 1 – Advance borings and install monitoring wells using rotosonic drilling methods with VAP, collect soil samples for grain-size analysis to assist with extraction well design, and perform baseline sampling (after well development) to confirm target capture zones
- Phase 2 – Perform aquifer testing in the potential extraction well locations to confirm the modeled extraction rate, evaluate the connection between the hydrostratigraphic units, and evaluate the nature/orientation of the "feature" used in the groundwater flow model to simulate the localized hydraulic mounding in the well P-6 area
- Phase 3 – Update the numerical groundwater flow model including the geologic model using the observations from Phases 1 and 2, refine the simulated capture zones, and develop design extraction rates for the potential remedy wells
- Phase 4 – Perform additional assessment (assumed to be similar to Phases 1 through 3), if necessary, to evaluate target capture zones, design extraction rates and/or areas of uncertainty

6.2.1 Target Capture Zones and Extraction Rates

The most significant areas of uncertainty to address prior to performance of the RD are associated with the target capture zones and the extraction rates for the six extraction wells and the UPCUTZ extraction system included as part of the Selected Remedy. As described in Section 5.1, these target capture zones and extraction rates will be confirmed through installation of monitoring wells, groundwater monitoring, aquifer testing and groundwater modeling. As listed on Table 2, the target capture zone and modeled extraction rate will be evaluated in the following locations:

- Locations DDA-18, DDA-19 and DDA-20 (see Appendix A - Figure A-3) in the area to the west and east, respectively, of the DDA and well PW-1(U) in the UPCUTZ and UPA upper sand. The locations will be used to confirm the target capture zone for the:
  - Existing extraction well PW-1(U) operated at a lower extraction rate (approximately 15 gpm) in the area to the southwest of well pair DDA-16-TZ and DDA-16-US (see DDA-18 location on Appendix A - Figure A-3).

  - Proposed UPCUTZ and well DDA-10-US/DDA-12-US extraction systems to the south of well DDA-10-US and southeast of well pair DDA-12-TZ and DDA-12-US (see DDA-19 and DDA-20 locations on Appendix A - Figure A-3).

- Locations 102, 103, and 104 (see Appendix A - Figure A-4) in the area of well P-6 in the Columbia Aquifer, the UPCUTZ, and the UPA upper and lower sand. These locations will be used to:
  - Evaluate the nature/orientation of the "feature" used in the groundwater flow model to simulate the localized hydraulic mounding in the well P-6 area.
  - Assist in confirming the modeled extraction rate and target capture zone for the potential extraction well in this area.
- Location 105 (see Appendix A - Figure A-4) in the area of wells RT-1-UP and UPA-01 in the UPA upper and lower sand. This location will be used to:
  - Assist in confirming the modeled extraction rate and target capture zone for the proposed extraction well in this area.
  - Evaluate the potential for connection between the UPA upper and lower sand.
- Locations 106 and 107 (see Appendix A - Figure A-4) in the area of wells MW-18 and MW-34 in the Columbia Aquifer, the UPCUTZ, and the UPA upper and lower sand. These locations will be used to assist in confirming the modeled extraction rate and target capture zone for the proposed extraction well in this area.
- Locations 108-1, 108-2, and 108-3 (see Appendix A - Figure A-4) in the area upgradient of well BW-2 in the UPCUTZ and the UPA upper and lower sand. These locations will be used to assist in confirming the modeled extraction rate and target capture zone for the proposed extraction well in this area.

These areas of uncertainty will be evaluated through vertical aquifer profiling, installation of monitoring wells, groundwater monitoring and aquifer testing. Tables 2 and 3 summarize these locations and activities, and Appendix A - Figures A-3 and A-4 show the proposed and contingent monitoring locations for the evaluations. It is anticipated that results from two semi-annual groundwater monitoring events for the proposed wells will be needed for the evaluation. Other areas of uncertainty associated with the CSM will be addressed through the activities performed to confirm the target capture zones and extraction rates. Table 3 illustrates the overlap in these activities.

6.2.2 Migration between Hydrostratigraphic Units

Vertical migration of groundwater contaminants occurs between the various hydrostratigraphic units at the Site; however, the locations of the areas where the vertical migration is occurring is uncertain. As the USEPA stated in the ROD-A2 regarding migration from the UPCUTZ to the UPA upper sand:

> "Despite the preference for the groundwater and COCs to migrate horizontally within the relatively coarser-grained layers of the UPCUTZ, rather than vertically through relatively finer-grained layers out of the UPCUTZ into the Upper Potomac Aquifer upper sand, it is apparent that the groundwater and COCs eventually migrate out of the UPCUTZ and into the Upper Potomac Aquifer upper sand. This downward migration may be facilitated by a downward vertical hydraulic gradient downgradient of extraction well PW-1, pinching out of the UPCUTZ, and/or interconnection of the coarser-grained layers within the UPCUTZ with the Upper Potomac Aquifer upper sand. The specific areas where mass transfer occurs from the UPCUTZ to the Upper Potomac Aquifer upper sand are not known." (USEPA, 2017c)

As part of the PDI activities, the interaction between the UPCUTZ and UPA upper sand will be evaluated in certain areas (see Tables 2 and 3), including aquifer testing and groundwater monitoring to assess the area of greatest contaminant mass flux from the UPCUTZ to the UPA.

While the presence of the UPDC was observed in the borings advanced in the well P-6 area and the UPA-series well transect (wells UPA-01, UPA-02S/D and UPA-03D) running from the DDA to AWC's Llangollen wellfield, migration of impacts from the UPA upper sand into the UPA lower sand indicates there is a connection between the UPA upper and lower sand between the area of the DS&G Site, the eastern lobe of the ACL Site and AWC's Llangollen wellfield. In addition, the groundwater modeling performed in 2014 indicates the potential for connection between the UPA upper and lower sand in the area of wells RT-1-UP and UPA-01. As part of the PDI activities, the connection between the upper and lower sand units of the UPA upper and lower sands between and downgradient of the Sites will be evaluated.

These areas of uncertainty will be evaluated through installation of monitoring wells, groundwater monitoring and aquifer testing. Tables 2 and 3 summarize these locations and activities, and Appendix A - Figures A-3 and A-4 show the proposed monitoring locations for the evaluations. It is anticipated that results from two semi-annual groundwater monitoring events for the proposed wells will be needed for the evaluation.

6.2.3 Manganese and Other COCs in Groundwater

Migration of manganese and other COCs to the area between the DS&G and ACL Sites is evidenced by increasing manganese concentrations in wells downgradient of the DS&G and ACL Sites and detections of leachate-related compounds in these wells and increasing manganese concentration have been observed in AWC's Llangollen wellfield. The extraction wells associated with the Selected Remedy are expected to mitigate this migration downgradient of the DS&G Site and the eastern lobe of ACL; however, the USEPA requested that additional investigation activities be performed to assess the impacts and their vertical distribution within the aquifer units (Columbia, UPA upper sand and UPA lower sand).

In addition, the USEPA stated "[d]etections of metals in Columbia Aquifer groundwater samples collected in 2011 from temporary monitoring wells near the Grantham South Area and the Inert Area (wells GMWGSNW and GMW-11) and the presence of metals and organic COCs in the Upper Potomac Aquifer upper sand and UPCUTZ near these landfills (at wells MW-34, MW-18, P-6, UPA-101-TZ and UPA-101-US) indicate a potential for the Inert Area and/or the Grantham South Area to contribute COC mass to the Columbia Aquifer and/or the Upper Potomac Aquifer upper sand. The uncertainty regarding the source of impacts to the Upper Potomac Aquifer in the vicinity of the Grantham South Area (elevated concentrations of VOCs and SVOCs at wells P-6/UPA-101-US and elevated manganese concentrations at MW-18) will be addressed as appropriate during remedial design." (USEPA, 2017c)

The areas of uncertainty associated with manganese and other COC concentrations in groundwater include:

- Elevated manganese concentrations detected in:
  - Temporary Columbia Aquifer well[29] GMW-11 (near well P-6)
  - Columbia Aquifer and the UPA upper and lower sand upgradient of the wells MW-18 and MW-34

[29] Wells GMW-11 and GMW-GSNW were not developed prior to sampling and were sampled the day after installation. While it is understood that these wells were purged and sampled using low-flow techniques, it is likely these samples were not representative of ambient groundwater conditions in that portion of the Columbia Aquifer.

  - UPA upper and lower sand downgradient of the wells MW-18 and MW-34
- Area upgradient of well BW-2 in the UPCUTZ and the UPA upper and lower sand associated with the following:
  - Impacts (e.g., 1,4-dioxane and manganese) to the well BW-2 area
  - Potential presence of impacts in the upper sand upgradient of the well BW-2 area

These areas of uncertainty will be evaluated through installation of monitoring wells and groundwater monitoring. Tables 2 and 3 summarize these locations and activities, and Appendix A - Figure A-4 shows the proposed and contingent monitoring locations for the evaluations. It is anticipated that results from two semi-annual groundwater monitoring events for the proposed wells will be needed for the evaluation.

6.2.4 Extent of Contamination in UPCUTZ

The extraction wells associated with the Selected Remedy are expected to mitigate migration of the groundwater impacts within the UPCUTZ; however, additional investigation activities in the UPCUTZ are required prior to design of the extraction systems.

First, the extent of UPCUTZ groundwater contamination to the west of the DDA and well PW-1(U) (area to the southwest of well pair DDA-16-TZ and DDA-16-US) and to the east of the DDA and well PW-1(U) (area to the south of well DDA-10-US and southeast of well pair DDA-12-TZ and DDA-12-US) represent areas of uncertainty that require assessment prior to design of the UPCUTZ extraction system.

Second, the source and extent of impacted groundwater observed in the UPCUTZ near monitoring well P-6 represents an area of uncertainty. In this area, it is anticipated that the upward vertical gradient from the UPA upper sand to the UPCUTZ may be causing localized contamination of the UPCUTZ[30]. This area of uncertainty requires assessment prior to design of the extraction well(s) in the existing well P-6 area.

These areas of uncertainty will be evaluated through installation of monitoring wells and groundwater monitoring. Tables 2 and 3 summarize these locations and activities, and Appendix A - Figures A-3 and A-4 show the proposed and contingent monitoring locations for the evaluations. It is anticipated that results from two semi-annual groundwater monitoring events for the proposed wells will be needed for the evaluation.

6.2.5 Assessment for Enhanced LFExS Design

Prior to design of the enhanced LFExS, a coincident set of groundwater samples from wells and vapor points screened within the DDA water table will be collected to evaluate the current nature and extent of the groundwater impacts remaining in the containment and partition areas of the DDA. A similar sampling event was performed in October 2008 prior to the design of the existing LFExS. This assessment will be performed through groundwater monitoring. Appendix A - Table A-7 summarizes these locations and Appendix A - Figure A-5 shows the proposed monitoring locations. The coincident set of groundwater samples will be collected during one monitoring event coincident with a semi-annual groundwater monitoring event.

[30] The visual and olfactory observations during drilling and the results of the VAP samples collected from the UPCUTZ in borings UPA-01, UPA-02, and UPA-03 located between extraction well PW-1(U) and AWC's Llangollen wellfield did not indicate evidence of dissolved-phase impacts in the UPCUTZ.

6.2.6 Potential LFG Migration

As discussed in Section 2, there is LFG migration beyond the facility boundaries, and the migration in the vicinity of existing receptors (Cirillo Brothers' Office Building, Vincent Dell'Aversano's residence and the DS&G Treatment Building) is being addressed by the LFG Mitigation System (SVE system with a candlestick flare) installed in 2017[31]. In the ROD-A2, the USEPA requested "[d]elineation of areas beyond the boundary of the Inert Area and the Grantham South Area impacted by subsurface migration of landfill gas in order to ensure that institutional controls are in-place to prevent potential future exposure to all areas where Site-related vapor intrusion adversely affects indoor air." (USEPA, 2017c) To evaluate LFG migration beyond the boundaries of the Inert Area and Grantham South which are outside the influence of the LFG Mitigation System, barhole probes will be advanced and screened for percent lower explosive limit (%LEL), and methane, oxygen and carbon dioxide content with a multi-gas meter as described in Section 4.3.5 of the SAP and Section 6.3.4 of the PDI WP.

This assessment will be performed during one mobilization for the area shown on Appendix A – Figure A-7.

6.3 Investigation and Evaluation Activities

As discussed above, there are areas of uncertainty that require evaluation prior to implementation of the RD. The approach and an overview of the methodologies that will be employed for this program are outlined below. Detailed descriptions of the field methods, documentation and quality assurance/quality control procedures are provided in the SAP (see Appendix A). The activities necessary to address these uncertainties include:

- Boring advancement with vertical aquifer profiling (VAP)
- Monitoring well installation and development
- Groundwater monitoring
- Aquifer testing
- Advancement and screening of barhole probes

In addition, there are ongoing activities[32] at the Site that are included in the SAP. These activities include monitoring of the Site-wide groundwater, the LFExS, and extraction well PW-1(U). The following subsections provide details about performance of these activities.

6.3.1 Advancement of Borings and Installation of Monitoring Wells

Advancement of borings and installation of monitoring wells is required to address the areas of uncertainty identified in the Final FS Rev 1 and address the PDI activities listed by the USEPA in the ROD-A2. The proposed activities to evaluate the target capture zones and determine the design extraction rates include installation of monitoring wells in the area of wells DDA-10-US/12-US, UPA-01, P-6, MW-18/34 and BW-2. As shown on Table 2, additional evaluation is needed in each of these areas to address uncertainties prior to design. The designations and locations for these monitoring wells is indicated on Tables 2 and 3, and Appendix A - Figures A-3 and A-4 show the proposed locations of these wells.

[31] Ongoing activities related to LFG monitoring and LFG mitigation system operations, maintenance and monitoring (OM&M) are included in the OM&M Plan for the LFG Mitigation System (Golder, 2018b).

[32] There are also ongoing activities related to LFG monitoring and LFG Mitigation System OM&M that are included in the HASP with the OM&M Plan for the LFG Mitigation System (Golder, 2018c).

The proposed monitoring wells will be installed by advancing borings using Rotosonic drilling techniques, which allow for a collection of continuous soil core. Once the UPCU is encountered, the casing will be advanced 2 feet into the clay layer. Then, the steel casing will be pressure tremie-grouted to the ground surface. Upon curing of the grout, the boring will be advanced through the upper and lower sands of the UPA, to the top of the Middle Potomac Confining Unit (MPCU). Recovered sonic drill materials will be screened with a PID for evaluation of impacts from organic compounds.

During advancement of the boring through the UPCUTZ and the UPA, the groundwater will be sampled using the Push-Ahead™ groundwater sampling system (for vertical aquifer profiling) used with sonic drilling methods. The groundwater sampling and boring advancement will continue through the UPA to the base of the lower sand. The groundwater samples will be collected from 10-foot intervals from the top of the UPCUTZ to the base of the UPA (top of the MPCU) and analyzed for VOCs and SVOCs by TestAmerica with expedited (24-hour to 48-hour) turnaround. VAP will only be performed in the boring advanced to the top of the MPCU, the well screen intervals for the UPCUTZ, UPA upper sand and the UPA lower sand will each be based on the VAP samples from the profile location extending to the MPCU (initial boring at each well cluster).

During boring advancement in the UPA upper sand, one soil sample from each of five locations (UPA-105[A or B]-US; UPA-107-US; DDA-05-TZ-EXTR; DDA-06-TZ-EXTR; and DDA-20-US) will be collected from the hydrostratigraphic unit proposed for extraction (UPA upper sand or UPCUTZ) to support the design of the extraction well filter packs.

The screened interval for each well will be determined for each well based on the interval within the UPCUTZ, UPA upper sand and/or UPA lower sand with the highest VOC and/or SVOC concentrations in groundwater, and in consideration of PID readings, and visual and/or olfactory evidence of impacts (see SAP Section 4.3.2.1). Prior to well construction within the advanced borehole, the USEPA will be provided with a draft annotated boring log indicating the proposed well screen interval for their review and approval of the proposed screened interval.

The monitoring wells will be completed with 2-inch diameter, 10-foot long, 0.010-inch (No. 10-slot) polyvinyl chloride (PVC) screen and appropriate lengths of 2-inch diameter, 10-foot long flush–threaded (with a non-Teflon seal) PVC riser pipe. Selection of the screen interval depth will be dependent on VOC and/or SVOC groundwater concentrations of each borehole; but it is anticipated that one, 10-foot screen will be set for each well, either in the UPCUTZ (between approximately 35 and 85 ft-bgs), upper sand of the UPA (between approximately 65 and 110 ft-bgs) or in the lower sand of the UPA (between approximately 125 and 175 ft-bgs).

Following installation, the monitoring wells will be developed and surveyed for location, ground elevation, top of PVC elevation and top of steel casing elevation. Groundwater monitoring is described below.

6.3.2 Extraction Well Installation

As described in the SAP (see Section 4.3.2.2; Appendix A - Tables A-3, A-4 and A-5, and Appendix A - Figures A-3 and A-4), the proposed extraction wells will be installed in borings advanced using Rotosonic drilling techniques. Grain-size analysis results will be used to design the well screen. It is anticipated that extraction wells will be constructed of either 6-inch or 8-inch diameter, stainless-steel screen, and appropriate lengths of 6-inch or 8-inch diameter stainless-steel riser pipe. Other specifications regarding well construction (e.g., filter pack material, slot size, screen length) will be based on sieve analysis and field observations. Prior to extraction well construction, the USEPA will be provided with the following for their review and approval: 1) an addendum to the PDI WP addressing specifics of the extraction well construction (well materials, screen length, slot size, and filter pack design, surface

completion, etc.), and 2) boring log annotated with criteria used in determining the recommended well screen interval.

6.3.3 Groundwater Monitoring

After well construction and development, the new monitoring wells will be allowed to stabilize and equilibrate with the aquifer for a minimum of two weeks prior to sampling. Depth to water measurements should be taken from all wells indicated on Appendix A - Table A-6A, within a time period (not to exceed 48 hours) that is not interrupted by changes in barometric pressure or by precipitation events. The synoptic water level measurements will be performed after collection of groundwater samples due to the inclusion of PFAS as an analyte at the Site.

Due to the extremely low method detection limits associated with PFAS analysis and the numerous potential sources of trace concentrations of PFAS, sampling programs for PFAS require the development and implementation of detailed operating procedures to reduce the potential for cross contamination and false positive sample results. These detailed procedures are included in the SAP (see Appendix A).

Groundwater samples will be collected using the low-flow purge and sampling technique[33] consistent with previous work at the Site, with a few exceptions as indicated on Appendix A - Table A-6D (see also the semi-annual monitoring reports for the Site). Prior to sampling, each monitoring well will be purged using a dedicated or decontaminated 2-inch submersible pump (Grundfos® RediFlo™, Proactive™ or equivalent) and high-density polyethylene (HDPE) tubing dedicated to each well. Once purging is complete, the discharge tubing will be disconnected from the flow-through cell and samples will be collected directly from the end of the discharge tubing. The samples will be preserved according to method-specific requirements, and promptly placed in a cooler with wet ice and maintained at approximately 4°C. Following sampling, the samples will be shipped under COC procedures to the analytical laboratory(ies).

Appendix A - Tables A-6A through A-6D includes the sampling locations, frequency and parameters, and Appendix A - Figures A-3 and A-4 show the locations. Following a baseline sampling event, the new wells will be sampled semi-annually (consistent with the current groundwater monitoring program) for VOCs, SVOCs, and metals. Appendix A - Tables A-6A and A-6B include these locations, frequency and parameters.

6.3.4 Aquifer Testing

After installation and development of the above-described monitoring wells, aquifer testing will be performed. The testing will be conducted between the DDA and the well PW-1(U) area and in two of the proposed extraction well locations (well UPA-01 area and wells MW-18/MW-34 area) downgradient of well PW-1(U) as required by the RD AOC SOW. The objectives of the UPA pumping test, UPCUTZ extraction testing and the ongoing transducer study (collectively referred to as the aquifer test) will be to evaluate the following:

- Modeled extraction rate and target capture zone for the proposed extraction wells[34] in the wells DDA-10-US/DDA-12-US area, the well UPA-01 area, and the wells MW-18/MW-34

[33] The procedure is based upon either the USEPA Region II document entitled “Groundwater Sampling Procedure, Low Stress (Low Flow) Purging and Sampling” dated March 20, 1998 or the USEPA document entitled “Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures” dated April 1996.

[34] Aquifer testing in the area of the proposed extraction well to be located at or upgradient of well BW-2 is not included in this scope due to the uncertainty in the source to well BW-2 at this time. The boring advancement and VAP sampling to be performed at locations between well BW-2 and the eastern lobe of Army Creek Landfill will provide additional information as to the source of impacts (primarily 1,4-dioxane and manganese) to the well BW-2 area. Subsequent to these activities, a scope for aquifer testing in the well BW-2 area can be provided to the USEPA for review and approval.

- Presence and orientation of the feature in the area of well P-6. Aquifer testing in this area will also evaluate the modeled extraction rate and target capture zone for the proposed extraction well in the well P-6 area
- Presence of the UPDC and the potential for connection between the UPA upper and lower sand in the areas
- Potential for mass transfer of contaminants between the UPCUTZ and the UPA upper sand
- Extraction rates for UPCUTZ groundwater downgradient of the DDA

The following subsections summarize these activities.

6.3.4.1 Transducer Study - Response to AWC Pumping

In October 2017, ten transducers[35] were deployed between the DS&G Site and AWC's Llangollen wellfield (see Appendix A – Figure A-6A) to monitor aquifer response to wellfield operational changes between the DS&G and ACL Sites and in the areas where extraction wells for the Selected Remedy will be installed. Data from these transducers are periodically downloaded and will be used to update the groundwater model as described below. Currently, the transducers are deployed in the following locations/wells:

- DDA to Well PW-1 Area – in well DDA-10-US
- Well UPA-01/RT-1-UP Area – in well UPA-01
- Well P-6 Area – in well UPA-101-US
- Downgradient of ACL's Eastern Lobe – in wells MW-40 and BW-2
- Upgradient of well AWC-G3-R – in wells MW-26N, UPA-02D, and AWC-E2
- AWC Wellfield – in well AWC-MW-6 (adjacent to production well AWC-G3R) and in former production well AWC-6 (until decommissioned in late 2017), then re-deployed in well DDA-16-US in August 2018

These transducers will remain in-place and the data will be periodically downloaded until the transducers are relocated to other wells as part of the aquifer testing for design of the Selected Remedy extraction wells. The data obtained from this transducer study will be evaluated, used in the updated groundwater flow model described in the PDI WP, and the evaluations and results will be included in the PDI Evaluation Report for submittal to and approval by the USEPA.

6.3.4.2 UPA Pumping Tests and UPCUTZ Extraction Testing

The aquifer testing scope includes pumping tests in UPA wells and extraction testing on UPCUTZ wells as presented on Appendix A - Table A-8, Appendix A – Figures A-6B through A-6H and in SAP Section 4.3.4.2. This information will be used to update the groundwater flow model. Pumping tests will be performed in series in five UPA upper sand wells (PW-1(U), DDA-10/12-US-EXTR, UPA-01-US-EXTR, MW-18/34-US-EXTR and P-6) as

[35] As PFAS analytes are potential COPCs at the DS&G and ACL Sites, the following information is included herein. Through PFAS experience at this Site and at other sites, Golder is aware that PFAS may leach from the cabling associated with transducers despite being certified as "PFAS-free". Immediately after purchase and prior to deployment of the transducer in well AWC-6, Golder decontaminated the transducer and cabling (in accordance with our PFAS decontamination SOP for non-dedicated equipment), then collected an equipment/rinsate blank for the transducer and cabling and collected a sample of the unused portion of the decontamination fluids. The equipment/rinsate blank and the unused decontamination fluids sample were sent to Eurofins for analysis of PFAS via USEPA Method 537.1 Modified. PFAS analytes were not detected in the sample of unused decontamination fluids; however, the following PFAS analytes were detected in the equipment/rinsate blank at the indicated concentrations: PFOA at 28 nanograms/liter (ng/l); perfluoroheptanoic acid (PFHpA) at 1 ng/l (J-flagged concentration); perfluorononanoic acid (PFNA) at 2 ng/l (J-flagged concentration).

shown on Appendix A - Figures A-3 and A-4, A-6B through A-6H. The recommended duration of pumping for each step is presented below and in Appendix A - Table A-8; however, the duration will be re-evaluated as the testing proceeds and proposed changes will be discussed with the USEPA. Each pumping test will be followed by 48 to 72 hours of recovery prior to initiating the next phase of the pumping test.

Pumping test data reduction and evaluation will be performed using AQTESOLV, which is an industry standard program for evaluating aquifer testing data. The pumping test data will also be used to update the groundwater flow model as described in Section 6.3.7. The data obtained from this testing scope will be evaluated, design parameters will be developed for the UPA and UPCUTZ extraction wells included in the Selected Remedy, and the evaluations and results will be included in the PDI Evaluation Report for submittal to and approval by the USEPA.

The data obtained from this pumping test scope will be evaluated, design parameters will be developed for the UPA extraction wells included in the Selected Remedy, and evaluation and results will be in the PDI Evaluation Report for submittal to and approval by the USEPA.

6.3.5 Advancement and Screening of Barhole Probes

To evaluate LFG migration beyond the boundaries of the Inert Area and Grantham South outside the influence of the LFG Mitigation System, barhole probes will be advanced and screened for %LEL, and methane, oxygen and carbon dioxide content with a multi-gas meter as described in Section 4.3.5 of the SAP. These areas are on shown on Appendix A - Figure A-7 and include the following:

- Southwest, west and northwest of the Inert Area on parcels owned by NCC or Vincent Dell'Aversano
- East of the Inert Area along the access road to the DS&G Treatment Building and the parcel owned by MBI Development LLC
- West and south of Grantham South on the parcel owned by NCC
- Southeast of Grantham South on the parcel owned by Grantham Lane Properties LLC

The proposed activities will include the following (additional details are provided in the SAP, Appendix A):

- Mark-out of proposed locations by Golder and clearance of proposed barhole probe locations in the vicinity of subsurface utilities by subcontractor using geophysical methods
- Advance barhole probes as shown on attached Appendix A - Figure A-7. Barhole probes will be driven to a minimum of 2 ft-bgs and a maximum depth of 3 ft-bgs
- Record initial and maximum measurements of landfill gases (i.e., percent LEL, O_2, and CO_2, and concentrations of CH_4, H_2S, and CO) at each barhole probe locations
- Document barhole probe locations using a mobile GPS unit (sub-foot accuracy)

Measurements of LEL at each of the barhole probes will be reviewed in the field to determine whether additional barhole probe locations are needed to evaluate extent of methane migration.

6.3.6 Data Validation, Evaluation, and Calculations

This section describes the approach for evaluation of the data collected as part of the PDI activities and ongoing groundwater monitoring. Evaluation, calculations and modeling will be performed to evaluate areas of uncertainty, refine the CSM, and develop RD parameters.

6.3.6.1 Data Validation

A large volume of data will be gathered during the PDI activities. These data will be evaluated according to the DQOs described in the SAP (see Appendix A), and their validity will be established by using the data validation procedures set forth in the QAPP portion of the SAP.

6.3.6.2 Groundwater Data Evaluations

Groundwater data will be collected from existing and newly installed Site monitoring wells and downgradient production wells, as part of the PDI WP, to address the areas of uncertainty and develop design parameters for the Selected Remedy. More specifically:

- Data will be added to the existing database and evaluated to refine the CSM.
- Contours of groundwater elevation data to review groundwater flow direction within the aquifer units, assess the mounding at well P-6, and review the vertical gradients between the aquifer units
- Trend plots and isoconcentration contour maps will be used to review migration and attenuation of the Site-related impacts in the UPCUTZ and the UPA as well as evaluate locations for potential additional extraction wells within the DDA as part of the ELFExS.
- Comparison of groundwater analytical data to ss-PRGs, MCLs, MCLGs, and SMCLs to evaluate nature and extent of impacts in the proposed investigation areas
- Calculate the mass flux from the UPCUTZ into the UPA, and from the UPA upper sand into the UPA lower sand, and evaluate mass flux through cross-section in various portions of the Site upgradient of AWC's Llangollen wellfield

6.3.6.3 LFG Data Evaluations

Field data collected during the barhole probe assessment will be tabulated, shown on appropriate maps and contoured, if necessary, for comparison to the requirement that the concentration of LFG at the facility boundary shall not exceed 25% of the LEL (Delaware's Regulations Governing Solid Waste; Delaware Administrative Code, Title 7, Section 1301, Parts 5.5.1.3 and 6.5.1.3) requiring maintenance of 25% LEL or less at landfill facility boundaries. This requirement is consistent with the performance goal for LFG Mitigation System. Areas that exceed 25% LEL beyond the facility boundary and have the potential to be occupied by receptors in the future will be identified.

6.3.7 Updated Groundwater Model

Following the boring advancement, the three-dimensional geo-statistical model in Environmental Visualization System/Mining Visualization System (EVS/MVS) will be updated to visualize the Site geology. After installation of monitoring wells and aquifer testing, the aquifer testing data and the outputs from the updated geo-statistical model will be used to update the numerical groundwater flow model for the Site (Tetra Tech, 2015). The objectives for the updated groundwater model will be to:

- Update and compare simulated capture zones with the target capture zones for extraction wells in the UPCUTZ and the UPA upper and lower sand
- Confirm extraction rates to be used in the remedial design
- Re-evaluate key aspects of the areas of uncertainty for the CSM such as observed mounding of groundwater near monitoring wells P-6 and UPA-101-US/UPA-101-TZ, and the impacts to the well BW-2 area (e.g., 1,4-dioxane and manganese)

The groundwater flow simulations will be performed using the MODFLOW-NWT code (USGS, 2011), which is a Newton-Raphson formulation for MODFLOW-2005 that improves solution of unconfined groundwater-flow problems. MODFLOW-2005 simulates three-dimensional groundwater flow through a porous medium by using a finite-difference method. MODFLOW-NWT is a standalone program built using MODFLOW-2005 that is intended for solving problems involving drying and rewetting nonlinearities of the unconfined groundwater-flow equation. Groundwater Vistas (GWV) Version 6, by Environmental Simulations, Inc. (ESI) will be the user interface software for managing model input and output for MODFLOW-NWT and MODPATH.

6.4 Project Deliverables

The following section describes the deliverables requested by the USEPA and additional deliverables to be prepared for submittal to the USEPA by the Trust.

6.4.1 PDI Evaluation Report

After completing the PDI scope of work, a concise summary of the PDI activities, findings, evaluations and modeling will be prepared along with an updated CSM and will be presented in the PDI Evaluation Report. The report will provide data collected to evaluate the areas of uncertainty presented in Section 3.8 of this PDI WP, update the CSM, present the results of the updated groundwater model, and will include the items required by the RD AOC SOW. As stated in Paragraph 3.3(b) of the RD AOC SOW, the report must include:

(1) Summary of the investigations performed;

(2) Summary of investigation results including aquifer testing;

(3) Boring and well installation logs;

(4) Summary of validated data (i.e., tables and graphics);

(5) Data validation reports and laboratory data reports;

(6) Narrative interpretation of data and results;

(7) Results of statistical and modeling analyses;

(8) Photographs documenting the work conducted; and

(9) Conclusions and recommendations for RD, including design parameters and criteria and a delineation of property subject to institutional controls to prevent potential future exposure to Site-related contaminants in indoor air. (USEPA, 2018f)

It is estimated that this report will be submitted to the USEPA for review and approval approximately 4 months after completion of all field activities and the groundwater model updates described in the PDI WP.

6.4.2 LFG Letter Report

Within 60 days of the completion of the barhole probe survey, a letter report will be submitted to the USEPA. The letter report will provide a summary of activities performed, observations in the field and results of the evaluation, a review of potential receptors that may be impacted by LFG migration if observed, anticipated next steps and a proposed schedule for additional activities as necessary.

6.4.3 Semi-Annual Monitoring Reports

The routine groundwater monitoring results and the extraction systems' performance information will continue to be summarized in semi-annual monitoring reports. More specifically, updated groundwater contours, groundwater gradients, analytical chemistry plots, LFExS mass removal estimates, and well PW-1(U) mass extraction estimates will be calculated and evaluated. Recommendations for future operational changes and/or evaluations will also be included in the reports. These reports will be prepared for monitoring periods as follows: January 1 through June 30, and July 1 through December 31. The reports will be submitted to the USEPA within 60 days of the completion of the monitoring period.

6.5 Meetings

At this time, meetings between the Trust, the Project Coordinator and Golder occur quarterly. During the time period covered by the PDI WP those meetings are anticipated to continue quarterly. Progress reports will be submitted to the USEPA monthly, and conference calls will be held between the USEPA Project Coordinator, DS&G Trust Project Coordinator, and the Supervising Contractor on a monthly basis. Meetings with the USEPA will be held on an as-needed basis to review project progress, but at a minimum, these meetings are anticipated to be held on a semi-annual basis.

7.0 PROJECT TEAM, NEXT STEPS, AND ESTIMATED TIMEFRAMES

7.1 Project Team

The key personnel involved in performance of the PDI are described below. These personnel and their roles are illustrated on the project organizational chart included in the SAP. The personnel selected for the project have been involved in the DS&G project for many years, have broad experience on a variety of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) projects, including many remedial investigations, feasibility studies, pre-design investigations, remedial designs and remedial actions.

Project Coordinator and DS&G Trust Chairperson

The Trust identified Doug Sutton, PhD, PE, LEED-AP as the Project Coordinator associated with the RD AOC SOW via letter to the USEPA dated June 18, 2018, and the USEPA approved the selection via email dated June 19, 2018. Dr. Sutton, a Principal Engineer with HydroGeologic, will coordinate execution of the RD AOC SOW and be the lead/contact between the Trust and the Agencies (USEPA and DNREC) as well as the Chairperson for the Trust.

Supervising Contractor's Lead/Contact and Overall Project Manager

The Trust identified Golder as the Supervising Contractor associated with the RD AOC SOW via letter to the USEPA dated June 18, 2018, and the USEPA approved the selection via email dated June 19, 2018. Ms. Theresa Miller, PG, LSP, a Senior Consultant with Golder, will be the lead/contact for the Supervising Contractor between the Trust, Golder and the Agencies (USEPA and DNREC) as well as the overall project manager and technical director.

Ms. Miller will be responsible for the overall schedule control and technical execution of the PDI including implementation and completion of the PDI WP, as well as integration of the various technical disciplines that will be required during this project.

Supervising Contractor's Project Director and Technical Reviewer

The Project Director is Mr. Mark Haney, a Principal and Program Leader with Golder. Mr. Haney will be responsible for the overall technical execution and quality review of the PDI.

Supervising Contractor's Field Supervisor and Task Leader

The Field Supervisor and Task Leader will be Mr. Ben Reynolds, PG, a Senior Project Geologist with Golder. Mr. Reynolds will be assisted by Ms. Megan Safranek, an Engineer with Golder. Mr. Reynolds will provide assistance to Ms. Miller for the execution of the PDI WP and management of other Golder personnel associated with the PDI based on their key technical disciplines.

DS&G Trust Administrator

The Administrator for the Trust, Ms. Susanna Mays, will assist Dr. Sutton and Ms. Miller with coordination of and communication regarding the RD AOC SOW activities between the Trust, the Agencies and other interested parties. Ms. Mays is also one of the points-of-contact within the ERP, and if needed, Ms. Mays would also be the Trust's Community Involvement Coordinator.

7.2 Next Steps and Estimated Timeframes

This section provides the anticipated next steps to address the areas of uncertainty associated with the updated CSM and remedy design, as well as the anticipated duration for those activities. As part of the PDI activities, monitoring wells will be installed to address areas of uncertainty, and function as observation wells for aquifer testing. Information from the drilling, groundwater sampling and aquifer testing activities will be used to refine the current CSM, improve the existing groundwater model, and inform the RD. Monitoring wells installed as part of the investigation will increase the density of the monitoring network, and have the potential to serve as long-term remedy performance monitoring wells.

As presented in Appendix N of the Final FS Rev 1, based on experience with previous investigations performed at the Site using the same methodology, challenges mobilizing and operating a rotosonic drilling rig at several of the potential locations, previous monitoring and aquifer testing efforts at this Site, and experience updating groundwater flow models and establishing design flow rates, it is anticipated that following receipt of the USEPA's approval for the PDI WP, the activities described above will be completed within the estimated durations below:

- Coordination and performance of the drilling, VAP and monitoring well installation program - approximately four to five month-duration assuming no weather delays and non-winter drilling conditions.
- Baseline groundwater sampling, analysis, data validation and evaluation - approximately two month-duration and would occur after well installation. Data validation and evaluation could occur simultaneously with the aquifer testing and data reduction described below.
- Aquifer testing and data reduction – approximately three to four month-duration (assuming no weather delays and non-winter conditions) and would occur after baseline groundwater sampling and analysis.

- In addition, aquifer testing in some areas (i.e., wells MW-18/MW-34) will provide some difficulties due to the volume of water that would be generated over a short period of time by the testing and the remote locations of the wells. Aquifer testing in the well RT-1-UP/UPA-01 will require that New Castle County allow temporary discharge (duration of approximately 72 hours (3 days)) from these wells to the existing POTW line on Grantham Lane[36].
- Updating the geological model and the groundwater flow model, checking calibration and running simulations – approximately two to three month-duration and would occur after completion of the aquifer testing.
- Report preparation and review, and meeting to present results - approximately four month-duration and would occur after completion of the activities listed above.

Based on these estimated durations and assuming Phase 4 activities (additional assessment) are not required, it is estimated that the duration of PDI activities would be 15 to 18 months from approval of the PDI WP to submission of the PDI Evaluation Report.

The following table provides the anticipated activities after submission of the PDI WP and the anticipated duration of the activities.

ACTIVITIES, ANTICIPATED DURATIONS AND ESTIMATED TIMEFRAMES FOR COMPLETION

Activities and Deliverables	Anticipated Duration of Activity	Estimated Timeframe for Completion after Submittal of PDI WP
Pre-Design Investigation Activities		
USEPA Review and Approval of PDI WP	2 months	8/20/2018 – 10/20/2018
Phase 1 – Well Installation	4-5 months	10/20/2018 – 3/20/2019
Phase 2 – Aquifer Testing	3-4 months	3/20/2019 – 7/20/2019
Phase 3 – Groundwater Model Updates	2-3 months	7/20/2019 – 10/20/2019
Phase 4 – Additional Investigation	Not Estimated	Not Estimated
Pre-Design Investigation Evaluation Report	4 months	10/20/2019 – 2/20/2020
LFG Migration Assessment	3 months	11/1/2018 – 2/1/2019
Semi-annual monitoring and reporting	Ongoing	Not applicable

During the PDI activities, the Trust will continue to operate, maintain and monitor the existing remedial systems at the Site (LFExS and well PW-1(U) system), and the LFG Mitigation System.

[36] As discussed in the Final FS Rev 1, connection to this discharge line is not a viable long-term option due to capacity restrictions on the line.

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Tables

Table 1
Site-Specific Preliminary Remediation Goals
Delaware Sand & Gravel Superfund Site
New Castle County, Delaware

Chemical of Concern	CAS	MCL (µg/L)	Site-Specific Carcinogenic PRG[1] (µg/L)	Site-Specific Non-Carcinogenic PRG[2,3] (µg/L)	Selected PRG[4] (µg/L)	Notes
1,2,4-Trimethylbenzene	95-63-6	NA	NA	5.7	**5.7**	COC-specific Non-Carcinogenic PRG
1,3,5-Trimethylbenzene	108-67-8	NA	NA	6.1	**6.1**	COC-specific Non-Carcinogenic PRG
1,4-Dioxane	123-91-1	NA	4.6	598	**4.6**	Carcinogenic PRG with a Target Risk of 1.0E-05
1,4-Dioxane (inhalation)	123-91-1	NA	4.6	63	**4.6**	Carcinogenic PRG with a Target Risk of 1.0E-05
Arsenic	7440-38-2	10	0.52	NA	**0.52**	Carcinogenic PRG with a Target Risk of 1.0E-05
Benzene	71-43-2	5	4.6	33	**4.6**	Carcinogenic PRG with a Target Risk of 1.0E-05
Bis(2-chloroethyl) Ether	111-44-4	NA	0.1	NA	**0.14**	Carcinogenic PRG with a Target Risk of 1.0E-05
Cobalt	7440-48-4	NA	NA	6	**6.0**	COC-specific Non-Carcinogenic PRG
Ethylbenzene	100-41-4	700	15	1310	**15**	Carcinogenic PRG with a Target Risk of 1.0E-05
Iron	7439-89-6	NA	NA	13939	**13,939**	COC-specific Non-Carcinogenic PRG
Manganese	7439-96-5	NA	NA	260	**260**	COC-specific Non-Carcinogenic PRG
N,N-Dimethylaniline	121-69-7	NA	25	NA	**25**	Carcinogenic PRG with a Target Risk of 1.0E-05
Naphthalene (Inhalation)	91-20-3	NA	1.7	0.63	**0.63**	COC-specific Non-Carcinogenic PRG
Xylenes, Total (Inhalation)	1330-20-7	10,000	NA	21	**21**	COC-specific Non-Carcinogenic PRG

Notes:

(1) Based on the United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) Residential Tap Water screening levels (May 2014) adjusted for a target cancer risk of 1.0E-05

(2) For those Chemicals of Concern (COCs) with different target organ effects between the ingestion/dermal and inhalation pathways, the lower of the Site-Specific Non-Cancer PRG was listed

(3) Site-Specific Non-cancer screening levels were selected for only those COCs that contribute to a target organ-specific Hazard Index (HI) greater than 1.0

(4) PRGs were selected using the following criterion - The lower values of the non-carcinogenic PRG (COC-specific Target Hazard Quotient (THQ)) and the carcinogenic PRG (Target Risk of 1.0E-05) or the MCL, such that the cumulative risk from COCs at the PRG does not exceed a cumulative cancer risk of 1.0E-04 or target organ specific HI of 1.0.

(5) CAS = Chemical Abstracts Service
(6) COC = Chemical of Concern
(7) HI = Hazard Index
(8) µg/L = micrograms per liter
(9) MCL = Maximum Contaminant Limit
10) NA = Not applicable
11) PRG = Preliminary Remediation Goal
12) RSLs = Regional Screening Levels
13) THQ = Target hazard quotient
14) USEPA = United States Environmental Protection Agency
(15) Table is based on Table 7 of the "Development of Site-Specific Preliminary Remediation Goals - Revision 2" prepared by Golder Associates dated October 2017. Hexavalent chromium was excluded based on April 2015 analytical data.

Prepared by: GJG
Checked by: TAM

TABLE 2
LIST OF AND RATIONALE FOR PROPOSED AND CONTINGENT MONITORING WELL LOCATIONS
DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

Profiling Location ID	Location Description	Property Ownership	Primary Purpose	Secondary Purpose	Columbia Aquifer	UPCUTZ	UPA Upper Sand	UPA Lower Sand
Between the DDA and Well PW-1(U)								
DDA-18	Southwest of well pair DDA-16-TZ/DDA-16-US (south of well pair DGC-2S/DGC-2D)	Dell'Aversano	Confirmation of target capture zones and evaluation of modeled extraction rates for proposed UPCUTZ and well PW-1(U) systems	Performance monitoring of proposed UPCUTZ and PW-1(U) systems		X	X	
DDA-19	Southeast of well pair DDA-12-TZ/DDA-12-US and south of well DDA-10-US (no UPCUTZ present at well DDA-10-US)	Dell'Aversano	Confirmation of target capture zones and evaluation of modeled extraction rates for proposed UPCUTZ and DDA-10-US/DDA-12-US extraction systems	Performance monitoring of proposed UPCUTZ and DDA-10-US/DDA-12-US extraction systems		X*	X	
DDA-20	Southeast of well DDA-10-US and northeast of wells DDA-12-US and PW-1(U)	Dell'Aversano	Confirmation of target capture zones in DDA-10/12-US area and evaluation of potential extraction rates for proposed for proposed UPCUTZ and DDA-10-US/DDA-12-US extraction systems	Performance monitoring of proposed UPCUTZ and DDA-10-US/DDA-12-US extraction systems		X	X	
Well P-6 Area								
102	North of well P-6 - between the Inert Area boundary and Grantham Lane	Dell'Aversano or New Castle County/Grantham Lane Right-of-Way	Three locations are needed for: 1) Evaluation of the nature/orientation of the "feature" used in the groundwater flow model to simulate the localized hydraulic mounding in the well P-6 area 2) Evaluation of the elevated manganese concentrations detected in temporary Columbia Aquifer well GMW-11 3) Improvement of the UPCUTZ characterization in this area 4) Assisting with confirmation of the modeled extraction rate and target capture zone for the proposed extraction well in this area	Assessment of potential presence of impacts in the Columbia Aquifer near the Inert Area, and the UPCUTZ and UPA upper and lower sand upgradient of well P-6	X	X*	X	X*
103	Northwest of well P-6 - Along Grantham Lane and south of the Inert Area	New Castle County		Assessment of potential presence of impacts in the Columbia Aquifer near the Inert Area and UPA upper sand upgradient of wells MW-18, MW-34 and P-6	X	X*	X	
104	South of well P-6 - in Area of Attainment (AoA)	Cirillo Brothers		1) Performance monitoring of proposed extraction wells in the well P-6 and RT-1-UP/UPA-01 areas 2) Assessment of potential presence of impacts in the UPCUTZ and UPA upper and lower sand downgradient of well P-6	assumed dry	X*	X	X
Well UPA-01 / RT-1-UP Area								
105A	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	Cirillo Brothers	Up to three locations are needed for: 1) Assessing the eastern extent of groundwater impacts in UPA-01 area 2) Assisting with evaluation of modeled extraction rate and target capture zone for a potential extraction well in the area of wells RT-1-UP/UPA-01 3) Evaluation of potential for connection between UPA upper and lower sand	Performance monitoring of proposed extraction well in the area of well UPA-01	assumed dry		X	X
105B	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	Cirillo Brothers			assumed dry		X	X
105C (contingent location)	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	Cirillo Brothers			assumed dry		X*	X*
Well MW-18 / MW-34 Area								
106	Northwest of wells MW-18 and MW-34 - near toe of Grantham South	New Castle County	Assessment of the manganese impacts in the Columbia Aquifer and UPA upper and lower sand upgradient of wells MW-18 and MW-34	Evaluation of potential for connection between UPA upper and lower sand between the ACL Site and the wells MW-18/MW-34 area	X	X*	X	X
107	South-southeast of wells MW-18 and MW-34 - in AoA	Cirillo Brothers	1) Assessment of the manganese impacts in the UPA upper and lower sand downgradient of wells MW-18 and MW-34 2) Assisting with evaluation of the modeled extraction rate for the proposed extraction well in this area	Performance monitoring of proposed extraction well in the area of wells MW-18 and MW-34	assumed dry	X*	X	X
Well BW-2 Area								
Vertical Aquifer Profiling (VAP) Location 1 (one of three potential locations for 108)	North of well BW-2 - between wells MW-28 and MW-29 and along downgradient side of Army Creek Landfill (ACL) Site	New Castle County	Three locations are needed for: 1) Assessment of the impacts (e.g., 1,4-dioxane and manganese) to the well BW-2 area 2) Assessment of the potential presence of impacts in the UPA upper sand upgradient of well BW-2 3) Assisting with evaluation of the modeled extraction rate for the proposed extraction well in this area	Evaluation of potential for connection between UPA upper and lower sand between the ACL Site and the BW-2 area		X*	X	X
VAP Location 2 (one of three potential locations for 108)	North of well BW-2 - downgradient of wells MW-28 and MW-29 and ACL Site	New Castle County						
VAP Location 3 (one of three potential locations for 108)	North of well BW-2 - further downgradient of wells MW-28 and MW-29 and ACL Site	New Castle County						

Notes:
1) This table is based on Final FS Rev 1 Appendix Table N-1
2) * indicates contingent well location
3) See Attachment H for acronyms and abbreviations

	Potential Well Counts				Totals
Total Proposed Wells	3	2	11	6	**22**
Total Contingent Wells	0	7	1	2	**10**
Total Potential Wells	**3**	**9**	**12**	**8**	**32**

Checked by: BAR
Reviewed by: TAM

TABLE 3
PROPOSED WELLS AND AREAS OF UNCERTAINTY MATRIX
DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

		Generalized Nature of Uncertainties							
Profiling Location ID	**Location Description**	**Target Capture Zone and Extraction Rate**	**Migration Between Hydrostratigraphic Units**	**UPCUTZ Extent of Contamination**	**Source and Extent of Manganese Impacts**	**Columbia Aquifer**	**UPCUTZ**	**UPA Upper Sand**	**UPA Lower Sand**
Between the DDA and Well PW-1(U)									
DDA-18	Southwest of well pair DDA-16-TZ/DDA-16-US (south of well pair DGC-2S/DGC-2D)	X	X	X			X	X	
DDA-19	Southeast of well pair DDA-12-TZ/DDA-12-US and south of well DDA-10-US (no UPCUTZ at well DDA-10-US)	X	X	X			X*	X	
DDA-20	Southeast of well DDA-10-US and northeast of wells DDA-12-US and PW-1(U)	X					X	X	
Well P-6 Area									
102	North of well P-6 - between the Inert Area boundary and Grantham Lane	X	X	X	X	X	X*	X	X*
103	Northwest of well P-6 - Along Grantham Lane and south of the Inert Area	X	X	X	X	X	X*	X	
104	South of well P-6 - in Area of Attainment (AoA)	X	X	X	X	assumed dry	X*	X	X
Well UPA-01 / RT-1-UP Area									
105A	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	X	X			assumed dry		X	X
105B	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	X	X			assumed dry		X	X
105C (contingent location)	Southeast of wells RT-1-UP and UPA-01 along Grantham Lane	X	X			assumed dry		X*	X*
Well MW-18 / MW-34 Area									
106	Northwest of wells MW-18 and MW-34 - near toe of Grantham South	X	X		X	X	X*	X	X
107	South-southeast of wells MW-18 and MW-34 - in AoA	X	X		X	assumed dry	X*	X	X
Well BW-2 Area									
108	North of well BW-2 - downgradient of wells MW-28 and MW-29 and ACL Site	X	X		X		X*	X	X

Notes:
1) This table is based on Final FS Rev 1 Appendix Table N-1
2) * indicates contingent well location
3) See Attachment H for acronyms and abbreviations

Checked by: BAR
Reviewed by: TAM

Figures

REFERENCE(S)

1. BASE MAP TAKEN FROM USGS 7.5 MINUTE QUADRANGLE OF WILMINGTON SOUTH, DELAWARE, DATED 2016.

0 1000 2000
1" = 2000' FEET

CLIENT
DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-10
DESIGNED	MBS
PREPARED	GLS
REVIEWED	BAR
APPROVED	TAM

TITLE
SITE LOCATION MAP

PROJECT NO.	CONTROL	REV.	FIGURE
0136052.14	0003-001	0	1

Last Edited By: gsantell Date: 2018-08-08 Time:5:24:19 PM | Printed By: AMorales Date: 2018-08-13 Time:1:02:00 PM
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

REFERENCE(S)

1. AERIAL PHOTOGRAPH COURTESY OF © 2018 MICROSOFT CORPORATION, BING

0 400 800
1" = 800' FEET

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DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-10
DESIGNED	MBS
PREPARED	GLS
REVIEWED	BAR
APPROVED	TAM

TITLE
GENERAL SITE LAYOUT

PROJECT NO.	CONTROL	REV.	FIGURE
0136052.14	0003-002	0	2

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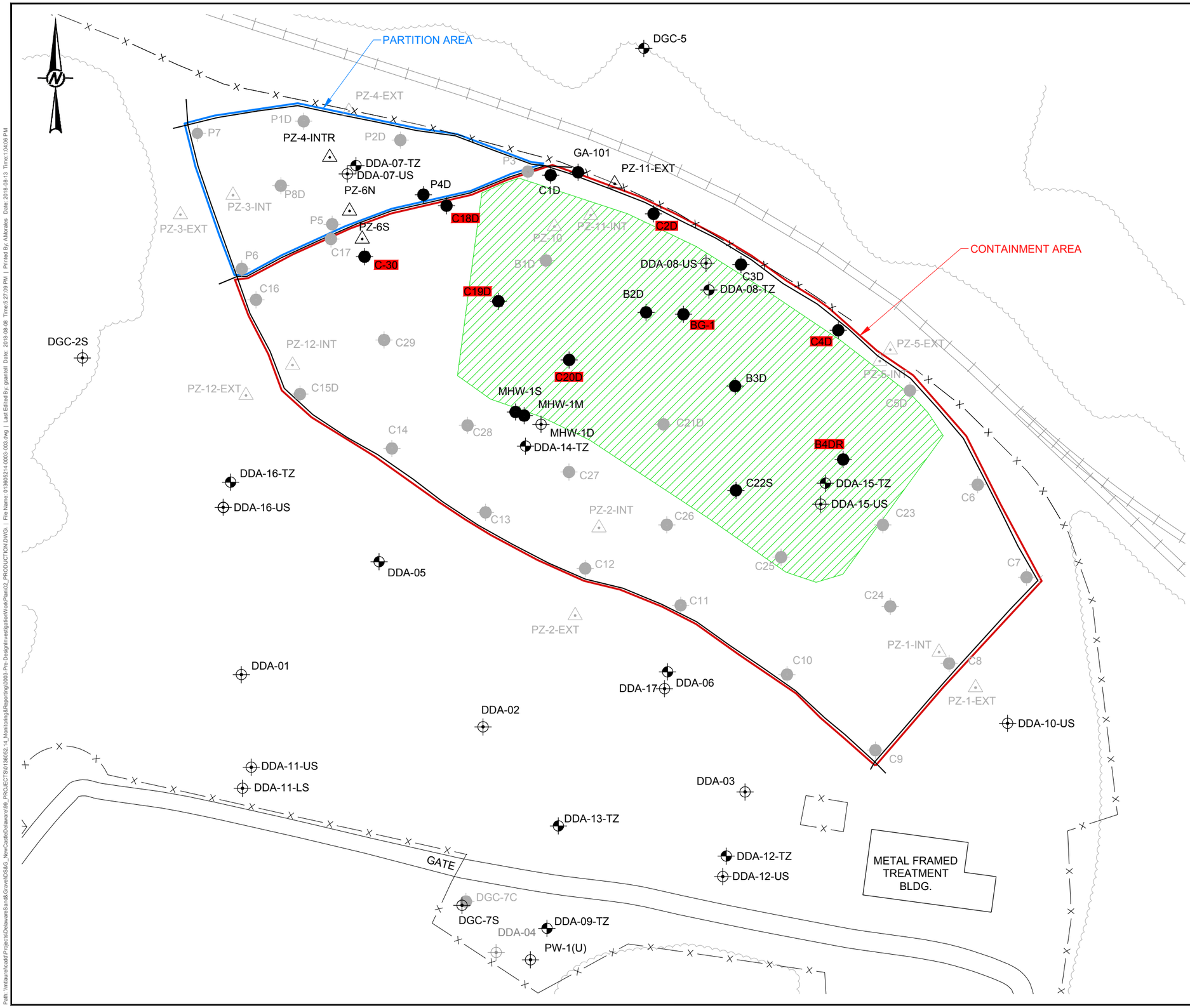

LEGEND

–X——X——X——X	FENCELINE
	CENTERLINE OF SLURRY WALL AROUND DRUM DISPOSAL AREA
	RAILROAD
C19D	DDA LOW-FLOW EXTRACTION SYSTEM (LFExS) WELL
DGC-2S	MONITORING WELL SCREENED IN UPPER POTOMAC AQUIFER
DDA-05	UPPER POTOMAC CONFINING UNIT TRANSITION ZONE MONITORING WELLS
PZ-10	DDA PIEZOMETERS
C1D	COLUMBIA MONITORING WELLS
	BIO-CELL LOCATED WITHIN CONTAINMENT AREA OF DDA ABOVE THE WATER TABLE

NOTE(S)

1. LOCATIONS OF WELLS AND BORINGS ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

REFERENCE(S)

1. BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 30 60
1" = 30' FEET

CLIENT
DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

TITLE
DRUM DISPOSAL AREA, BIO-CELL AND LFExS LOCATION MAP

CONSULTANT

GOLDER

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DESIGNED	MBS
PREPARED	GLS
REVIEWED	BAR
APPROVED	TAM

PROJECT NO.	CONTROL	REV.	FIGURE
0136052.14	0003-003	0	3

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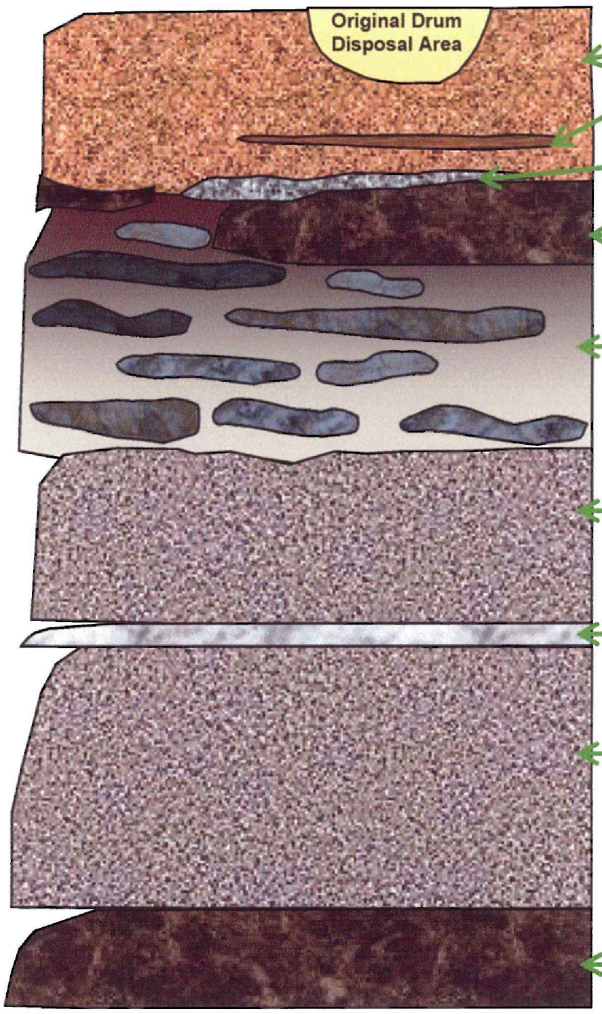
Current Conceptual Site Model Lithologic Diagram



Columbia Sand – brown, tan, orange sandy aquifer unit.

Columbia Clay (not always present) – brown, tan clay unit located within the Columbia Sand.

Basal Gravel (not always present) – gravel and cobble unit with coarse sand.

Upper Potomac Confining Unit (UPCU) (not always present) – hard, competent, dry, mottled red-orange-yellow-white clay unit. Eroded in some areas by basal gravel (paleochannel).

UPCU Transition Zone (UPCUTZ) (not known to always be present) - Interbedded silt, clay, and sand, but generally fining upward sequence observed beneath and to south of Drum Disposal Area.

Upper Potomac Aquifer (UPA) – Upper Sand – generally a fine to medium sand unit in the Site area.

Upper Potomac Dividing Clay (UPDC) – Typically, a mottled clay unit, generally present in the Site area, but can be thin or interbedded with sand.

Upper Potomac Aquifer (UPA) – Lower Sand – generally a fine to coarse sand unit greater than 10 feet thick in the Site area.

Middle Potomac Confining Unit (MPCU) - competent, grey or mottled red-orange-yellow-white clay unit.

NOT TO SCALE

CLIENT DELAWARE SAND & GRAVEL SUPERFUND SITE NEW CASTLE COUNTY, DELAWARE	PROJECT PRE-DESIGN INVESTIGATION WORK PLAN
CONSULTANT GOLDER	TITLE **CONCEPTUAL STRATIGRAPHIC COLUMN**

YYYY-MM-DD	2018-08-10
DESIGNED	MBS
PREPARED	GLS
REVIEWED	BAR
APPROVED	TAM

PROJECT NO.	CONTROL	REV.	FIGURE
0136052.14	0003-007	0	4

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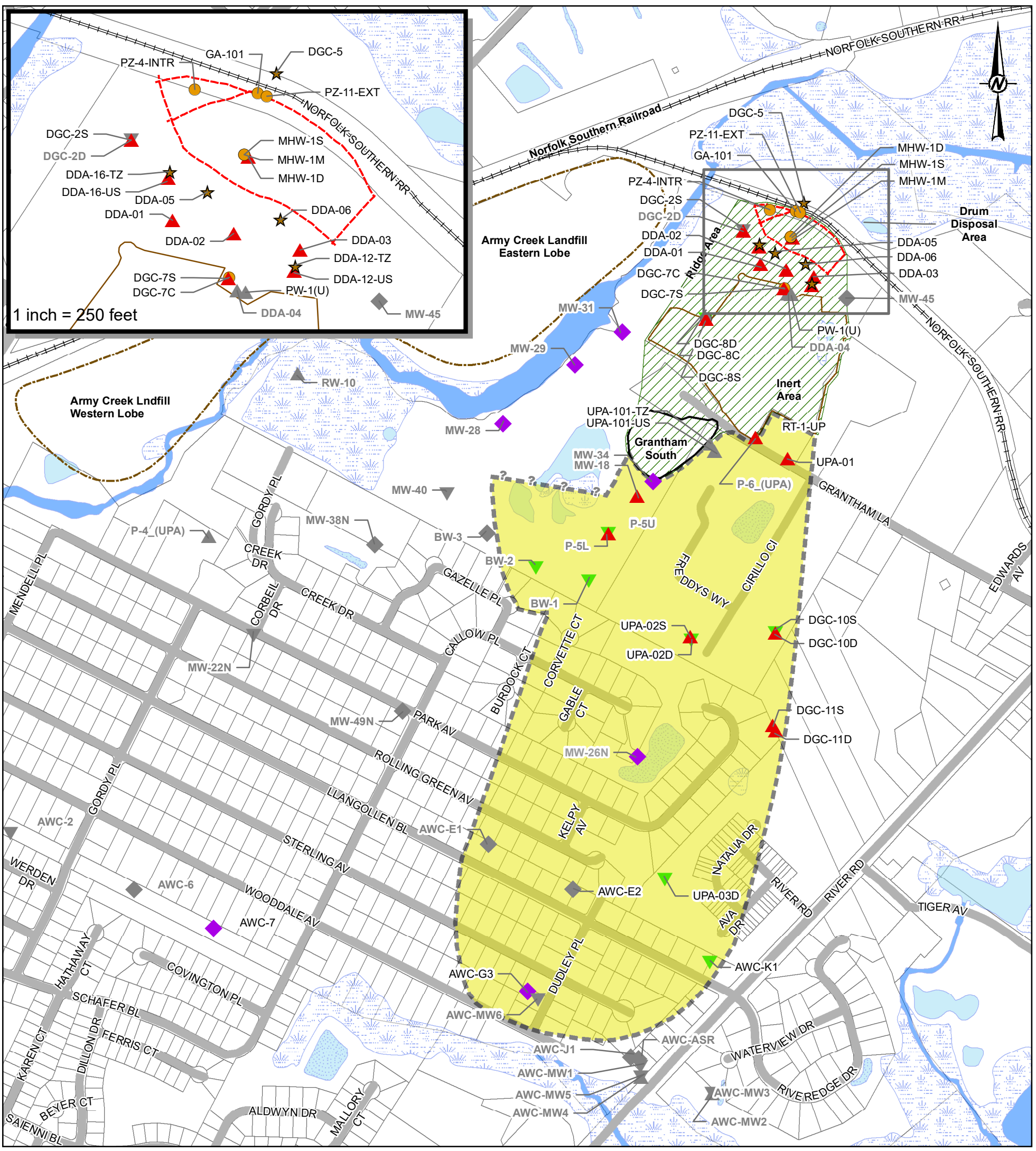
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



LEGEND

- Well screened in UPCU Transition Zone included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Upper Sand included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Upper Sand not included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Lower Sand included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Lower Sand not included in DS&G's proposed 2018 monitoring program
- Well screened across UPA Upper Sand and Lower Sand included in DS&G's proposed 2018 monitoring program
- Well screened across UPA Upper Sand and Lower Sand not included in DS&G's proposed 2018 monitoring program
- Well screened in Columbia Aquifer included in DS&G's proposed 2018 monitoring program
- Well screened in Columbia Aquifer not included in DS&G's proposed 2018 monitoring program
- Area of Attainment - The source of contaminated groundwater detected in well BW-2 remains under evaluation
- Waste Management Area

REFERENCE(S)

1. BASE DATA FROM NEW CASTLE COUNTY DELAWARE, DEPARTMENT OF LAND USE, "EPARCEL VIEW MAP" WEB SITE GIS DATA DOWNLOAD. DATA ACQUIRED 01/18/2012.

0 600 1,200
1 " = 600 feet Feet

CLIENT
DELAWARE SAND & GRAVEL
SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-10
DESIGNED	MBS
PREPARED	AM
REVIEWED	BAR
APPROVED	TAM

TITLE
WASTE MANAGEMENT AREA AND AREA OF ATTAINMENT

PROJECT NO.	CONTROL	REV.	FIGURE
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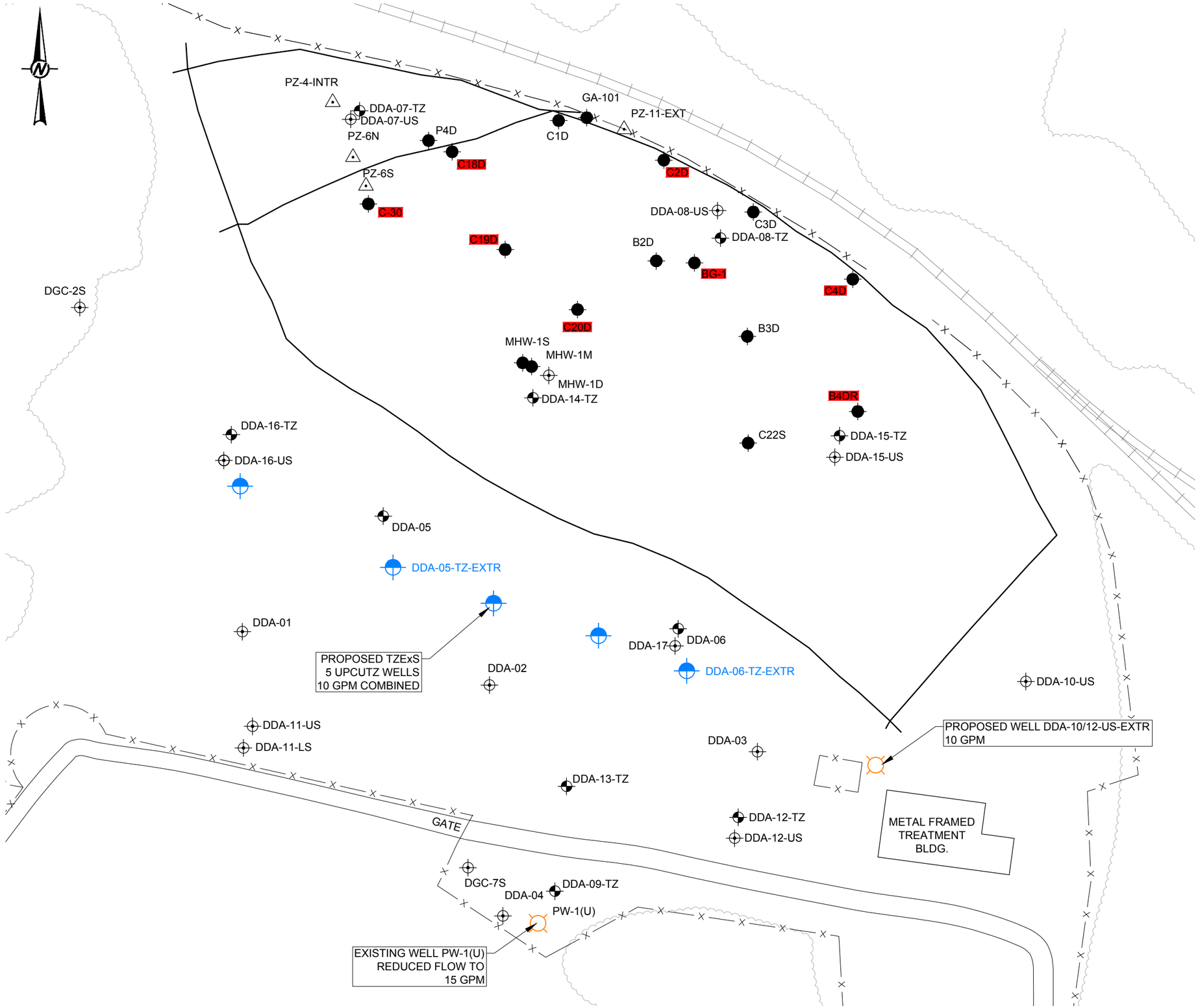
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

—— X —— X ——	FENCELINE
———	CENTERLINE OF SLURRY WALL AROUND DRUM DISPOSAL AREA
	RAILROAD
C19D	DDA LOW-FLOW EXTRACTION SYSTEM (LFExS) WELL
DGC-2S	MONITORING WELL SCREENED IN UPPER POTOMAC AQUIFER
DDA-05	UPPER POTOMAC CONFINING UNIT TRANSITION ZONE (UPCUTZ) MONITORING WELLS
	PROPOSED UPCUTZ EXTRACTION WELLS (TZEXS)
	PROPOSED UPA EXTRACTION WELLS

NOTE(S)

1. LOCATIONS OF WELLS AND BORINGS ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

REFERENCE(S)

1. BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 30 60
1" = 30' FEET

CLIENT
DELAWARE SAND & GRAVEL SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

TITLE
PROPOSED EXTRACTION WELL LOCATIONS IN THE UPCUTZ AND UPA UPPER SAND UPGRADIENT OF WELL PW-1(U)

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-10
DESIGNED	MBS
PREPARED	GLS
REVIEWED	BAR
APPROVED	TAM

PROJECT NO.	CONTROL	REV.	FIGURE
0136052.14	0003-005	0	6

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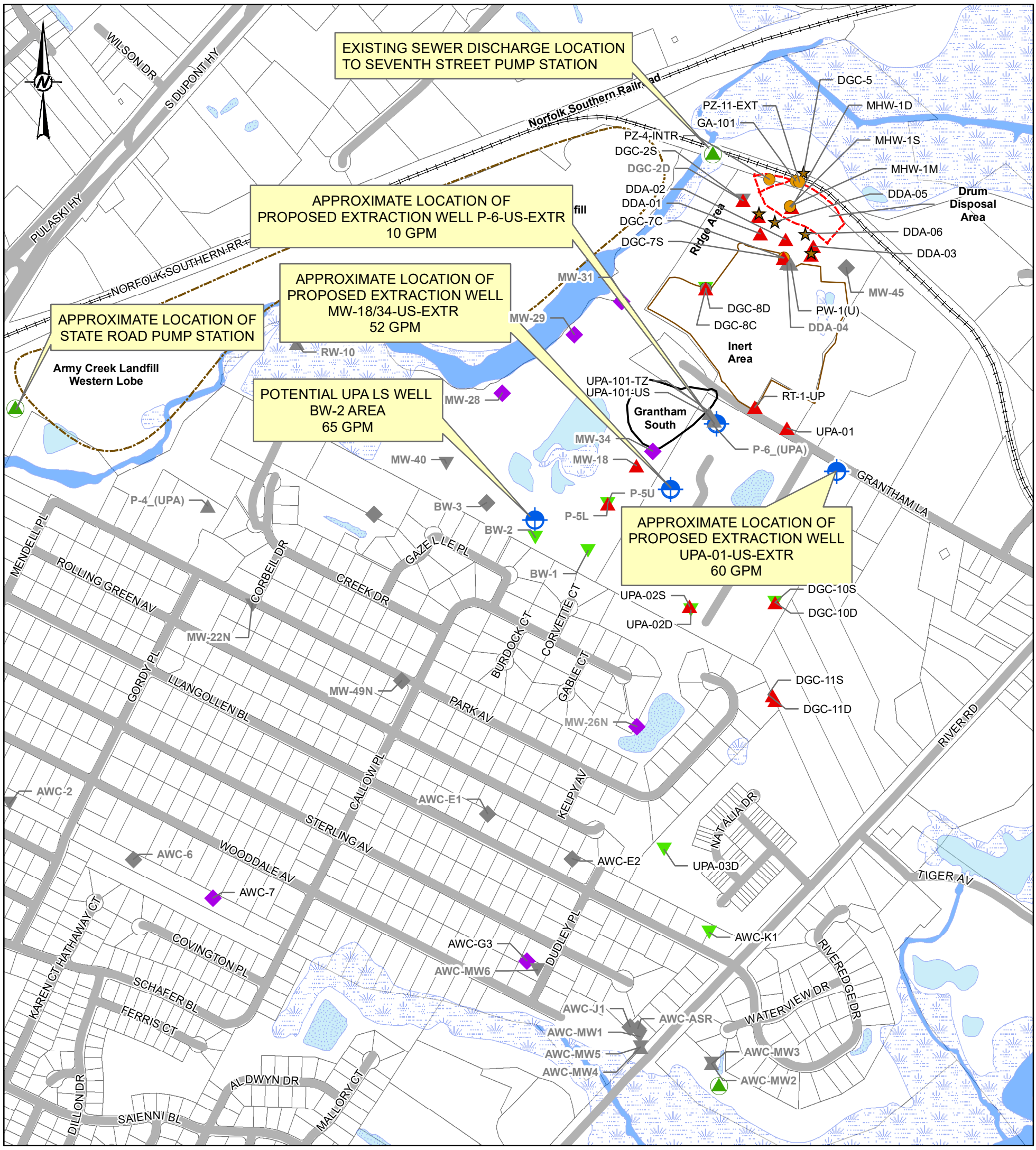


LEGEND

- Well screened in UPCU Transition Zone included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Upper Sand included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Upper Sand not included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Lower Sand included in DS&G's proposed 2018 monitoring program
- Well screened in UPA Lower Sand not included in DS&G's proposed 2018 monitoring program
- Well screened across UPA Upper Sand and Lower Sand included in DS&G's proposed 2018 monitoring program
- Well screened across UPA Upper Sand and Lower Sand not included in DS&G's proposed 2018 monitoring program
- Well screened in Columbia Aquifer included in DS&G's proposed 2018 monitoring program
- Well screened in Columbia Aquifer not included in DS&G's proposed 2018 monitoring program
- Off-Site Extraction Well
- Pump Station / Discharge Location

REFERENCE(S)

1. BASE DATA FROM NEW CASTLE COUNTY DELAWARE, DEPARTMENT OF LAND USE, "EPARCEL VIEW MAP" WEB SITE GIS DATA DOWNLOAD. DATA ACQUIRED 01/18/2012.

0 600 1,200

1 " = 600 feet Feet

CLIENT
DELAWARE SAND & GRAVEL
SUPERFUND SITE
NEW CASTLE COUNTY, DELAWARE

PROJECT
PRE-DESIGN INVESTIGATION WORK PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-25
DESIGNED	MBS
PREPARED	AM
REVIEWED	BAR
APPROVED	TAM

TITLE
PROPOSED EXTRACTION WELL LOCATIONS IN THE UPA UPPER SAND DOWNGRADIENT OF WELL PW-1(U)

PROJECT NO.	CONTROL	REV.	FIGURE
013-6052.14	0003-006	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Appendices

APPENDIX A

Sampling and Analysis Plan

APPENDIX B

Health and Safety Plan and Emergency Response Plan

Health, Safety and Environment Plan
Pre-Design Investigation and Routine Groundwater Monitoring

Delaware Sand & Gravel Superfund Site
757 Grantham Lane
New Castle, Delaware 19720

Submitted by:

Golder Associates Inc.

200 Century Parkway, Suite C Mt. Laurel, New Jersey, USA 08054
T: +1 856 793-2005

Revision 0

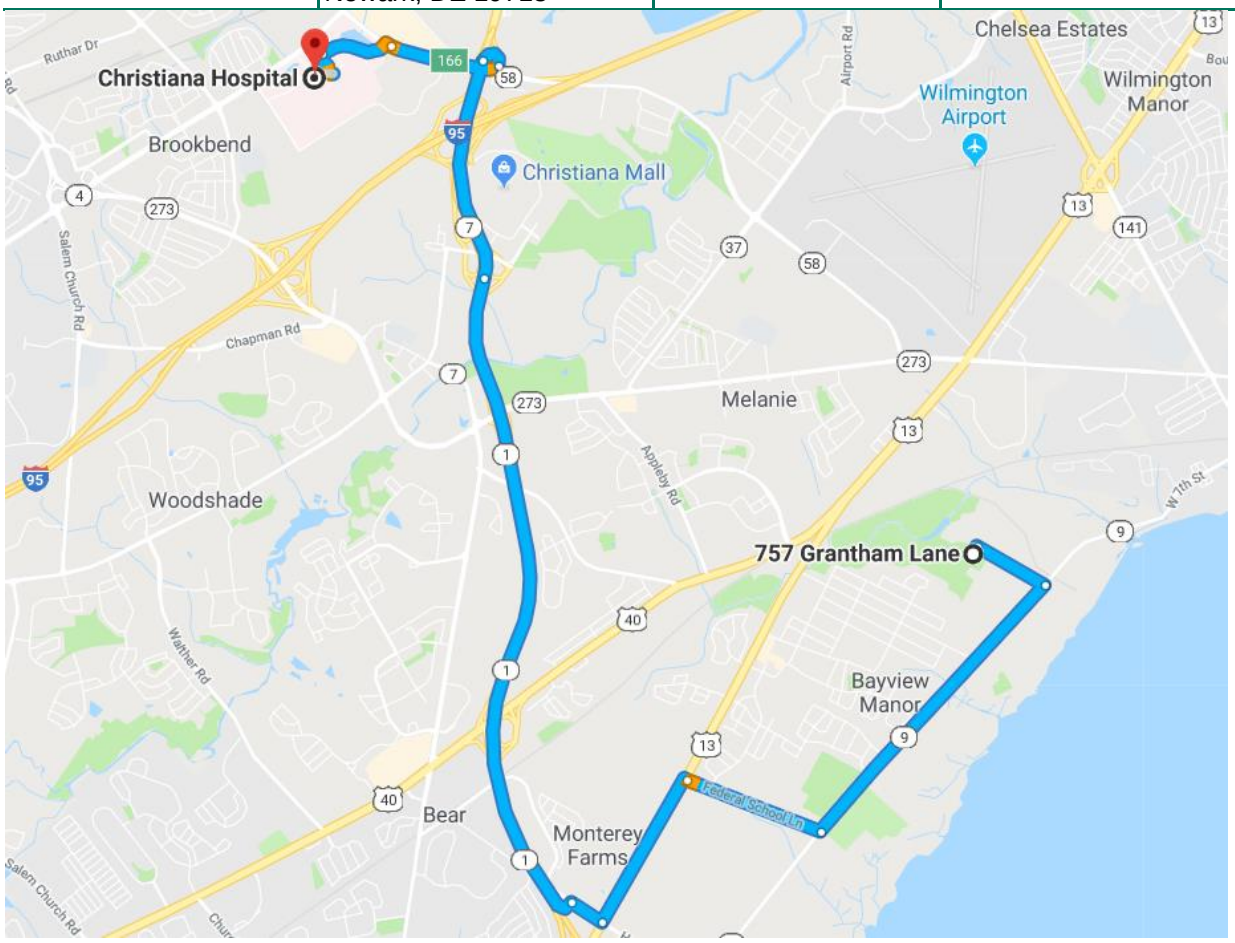
August 2018

1.0 CONTACTS LIST SUMMARY

1.1 Emergency Contacts

Contact	Number
Ambulance	911
Fire	911
Police	911
Crisis Response Hotline (Outside Canada)	+1 (403) 775-1041
Golder National Health, Safety, Security, and Environment Advisor - Renee Weaver	+1 (336) 707-3869
International SOS, Member ID: **11BYCA084630**	+1 (215) 942-8226 (Philadelphia)
Media Relations (Golder) - Tina Marano	+1 (647) 402-3596
WorkCare	+1 (888) 449-7787

Hospital name	Address	Phone	Level of Care Available
Christiana Hospital	4755 Ogletown Stanton Rd Newark, DE 19713	+1 (302) 733-1000	Trauma



See detailed directions below.

757 Grantham Ln
New Castle, DE 19720

Take DE-9 S to US-13 S

5 min (3.1 mi)

1. Head southeast on Grantham Ln toward Edwards Ave

0.4 mi

2. Turn right onto DE-9 S

1.8 mi

3. Turn right onto Federal School Ln

0.8 mi

Take DE-1 N to DE-58 W/Churchmans Rd. Take exit 166 from DE-1 N

8 min (6.2 mi)

4. Turn left onto US-13 S

0.9 mi

5. Turn right onto Bear Rd

0.2 mi

6. Turn left to merge onto DE-1 N

3.7 mi

7. Keep right to stay on DE-1 N

1.2 mi

8. Take exit 166 for DE-58/Churchmans Rd/Churchmans Crossing

0.2 mi

Continue on DE-58 W/Churchmans Rd. Drive to Hygeia Dr

5 min (1.2 mi)

9. Turn right onto DE-58 W/Churchmans Rd

0.6 mi

10. Use the left 2 lanes to turn left

0.4 mi

11. Turn left onto Hygeia Dr

0.2 mi

Christiana Hospital
4755 Ogletown Stanton Rd, Newark, DE 19713

1.2 Golder Contacts

	Name	Office Name	Office	Cell
Project Manager and Client Contact	Theresa Miller	Mount Laurel	+1 (978) 376-8434	+1 (978) 376-8434
Project Director	Mark Haney	Manchester	+1 (603) 668-0880 x67281	+1 (603) 289-3969
Field Coordinator and Manager	Benjamin Reynolds	Mount Laurel	+1 (856) 793-2005 x34484	+1 (610) 742-2848
Field Supervisor/ Field Staff	Megan Safranek	Mount Laurel	+1 (856) 793-2005 x34485	+1 (631) 553-9809
Client	Delaware Sand & Gravel Remedial Trust (DS&G Trust)			

1.3 Missed Check-in Contacts

	Name	Phone	Cell
Project Manager and Client Contact	Theresa Miller	+1 (978) 376-8434	+1 (978) 376-8434
Project Director	Mark Haney	+1 (603) 668-0880 x67281	+1 (603) 289-3969

1.4 Client and Site Contacts

	Number
Site field cell phone	to be determined

Nearest Golder office	Mt. Laurel, NJ USA
Phone	+1 (856) 793-2005
Fax	+1 (856) 793-2006
Email	tmiller@golder.com

Role	Name	Number
Contact Person on Site:	Beth Klotzbach (DS&G Trust Site Engineer)	+1 (302) 530-3832 (cell) +1 (302) 326-1181 (field office)
Client Safety Contact:	Beth Klotzbach (DS&G Trust Site Engineer)	+1 (302) 530-3832 (cell) +1 (302) 326-1181 (field office)
Company Golder Reports to:	Susanna Mays (DS&G Trust Administrator)	+1 (302) 994-7533 (office) +1 (302) 893-0800 (cell)
Company Reporting to Golder:	Cascade (Drilling)	to be determined
Golder Overall Field Supervisor:	Megan Safranek	Office: +1 (856) 793-2005 x34485 Cell: +1 (631) 553-9809
Golder alternate field supervisor:	Benjamin Reynolds	Office: +1 (856) 793-2005 x34484 Cell: +1 (610) 742-2848

You have the right to refuse any work you feel is unsafe, or that you are not trained to do. Choose to work safely and in compliance with all HSE requirements.

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Attachment 1 - Emergency Response Plan

Attachment 2 - Standard Work Practices (SWPs)

- SWP Drilling - GAI HSE 200.001
- SWP Biological Exposure Risks – GAI HSE 200.003
- SWP Heat Stress – GAI HSE 200.004
- SWP Cold Environment – GAI HSE 200.005
- SWP Inclement Weather – GAI HSE 200.007
- SWP Gas Hazards and Exposure (Benzene, CO2, CO, H2S, CH4, N, Butadiene) – GAI HSE 200.008
- SWP Overhead Hazards – GAI HSE 200.011
- SWP Respiratory Protection– GAI HSE 200.013
- SWP Slips, Trips, and Falls – GAI HSE 200.014
- SWP Groundwater Sampling – GAI HSE 200.015
- SWP Working Around Heavy Equipment – GAI HSE 200.018
- SWP Hearing Protection – GAI HSE 200.021
- SWP Housekeeping – GAI HSE 200.022
- SWP Cellular Telephone – GAI HSE 200.023
- SWP Motor Vehicles and Driving on Company Business – GAI HSE 200.024
- SWP Compressed Gas Cylinders – GAI HSE 200.026
- SWP Fitness for Duty – GAI HSE 200.027
- SWP First-Aid/CPR/AED and Bloodborne Pathogens – GAI HSE 200.036
- SWP Traffic Safety – GAI HSE 200.037
- SWP Hazard Waste and Emergency Response – GAI HSE 200.041
- SWP Silica Exposure Control – GAI HSE 200.044

Attachment 3 - HSSE Procedure 212 Ground Disturbance Preparation and Utilities Investigation

2.0 PROJECT DETAILS

Project Number	013-6052-014	**Start Date**	Anticipated in late September 2018	**End Date**	unknown
Project Title	DS&G Pre-Design Investigation and Routine Groundwater Monitoring				
Client Name	Delaware Sand & Gravel (DS&G) Remedial Trust				

Brief description of project and scope of work (include any hazardous activities, if known)

The services covered by this HaSEP include Pre-Design Investigation (PDI) and routine groundwater monitoring activities at the Delaware Sand & Gravel Superfund Site located at 757 Grantham Lane in New Castle, DE.

The PDI at the Delaware Sand & Gravel Superfund Site will involve drilling, well installations, well development, groundwater sampling and aquifer testing in support of the design for the Selected Remedy. Subcontractors will be used for underground utility clearance, drilling, well installation, and well development. It is anticipated that Cascade Drilling will perform the drilling and well installation activities. Additional subcontractors may be identified to assist with performance of the PDI activities. Routine groundwater monitoring activities have been performed at the Site for many years, and will continue to be performed during the PDI under this HaSEP.

Clearing Subsurface Utilities Prior to Drilling: Prior to any ground disturbance at the proposed drilling locations, the following activities will be performed at those locations to avoid subsurface utilities:

1) The drilling locations will be pre-marked out and Miss Utility will be contacted to mark out utilities on public properties;
2) Available Site drawings and public utility information will be reviewed to locate utilities on private and public properties;
3) Private utility locating service will be contracted to perform ground-penetrating radar (GPR) and/or electromagnetic (EM) surveys to locate utilities; and
4) Due to the known and potential presence of utilities on private property that are undetectable using GPR and EM geophysical methods, a soft-dig of at least 4 feet-below ground surface will be performed prior to drilling in the drilling locations.

After the installation and development of the new wells, additional field investigation activities will involve aquifer testing and groundwater sampling of the new wells in addition to the ongoing, routine groundwater monitoring program.

Methane in Subsurface: Ambient air and borehole monitoring will be performed during drilling, well installation, and well development activities due to the known presence of methane and other landfill gases in the subsurface in the vicinity of the landfilled areas.

Railroad Spur: A railroad spur is present along the northern perimeter of Site in the vicinity of monitoring well DGC-5 and the presence of this spur is considered a Site-specific risk. Extra precautions should be taken when crossing the rail lines including checking both directions for oncoming rail cars, listening for rail cars approaching in the distance, wearing high visibility clothing, and taking extra care to maintain stable footing to avoid slips, trips, or falls near the tracks.

Site Security: All gated entrances to the Site and doors on the Site building and sheds should be secured at the end of the day and when no one is on Site. Securing these areas includes keeping all gates and doors locked, securing equipment, and arming the security system for the on-Site building.

Publicly Accessible Areas and Interactions with Public: Many areas where work is to take place on or near the Site are publicly accessible. All personnel should be prepared for potential interaction with the public and should direct any questions to the Trust Administrator – Susanna Mays. If at any time an interaction becomes threatening, personnel should relocate to a secure area of Site or contact local authorities, if necessary.

Hunting, Target Practice and Use of ATVs by Others: In remote areas on or near the Site, risks include including hunting or target practice and the operation all-terrain vehicles (ATVs). All personnel on-Site personnel should be aware of these potential risks when working in remote areas to avoid incidents that could affect the health and safety of on-Site personnel. High visibility clothing should always be worn. If gunshots are heard evidencing that hunting or target practice is occurring near the Site or in the working area, relocate and contact the Trust Health and Safety Contact – Beth Klotzbach immediately.

Water Bodies: Surface water and wetlands are present in areas of Site. The scope of work does not include activities in or near the water bodies; however, personal protective equipment (PPE) and life-saving devices should be in place when working in or near water in case of an emergency. A safe distance from water should be maintained at all times.

3.0 GOLDER TEAM

Name	Office	Contact number (cell phone)	Office Phone	Role
Mark Haney	Manchester	+1 (603) 289-3969	+1 (603) 668-0880 x67281	Project Director
Theresa Miller	Mount Laurel	+1 (978) 376 8434	+1 (978) 376 8434	Project Manager and Client Contact
Benjamin Reynolds	Mount Laurel	+1 (610) 742-2848	+1 (856) 793-2005 x34484	Field Coordinator and Manager
Megan Safranek	Mount Laurel	+1 (631) 553-9809	+1 (856) 793-2005 x34485	Field Supervisor/Field Staff

Project Manager (PM) and Field Coordinator

- Appoint a competent Field Supervisor and alternate. If there are multiple Golder projects/disciplines working on the Site, coordinate with the overall Field Supervisor
- Oversee/develop hazard controls including work instructions
- Assign only adequately trained and competent employees to the project

Field Supervisor

- The Field Supervisor is responsible for the safety of all Golder employees, subcontractors, visitors and public on the parts of the Site under Golder's control
- Communicate all Site hazards to affected parties, in real time, as hazards, conditions and employees change
- Ensure that work is undertaken in accordance with the hazard controls included in this HaSEP

Contractor/Subcontractor

- All equipment is maintained in a safe working condition
- All equipment are to be registered/licensed and electrical equipment tagged and tested
- Potential hazards are to be controlled (e.g., cage over rotating parts)
- You will report any identified hazards to the Golder Field Supervisor

Field Staff

- Inspect your worksite and equipment before starting work
- Apply the controls outlined in this HaSEP
- Look out for the safety of yourself and others
- Report unsafe acts, conditions and incidents to the Field Supervisor

4.0 SITE LOCATION DETAILS

Project location map (paste URL here)	https://www.google.com/maps/place/757+Grantham+Ln,+New+Castle,+DE+19720/@39.6500237,-75.605797,17z/data=!3m1!4b1!4m5!3m4!1s0x89c7040ba959e05d:0xc98495a01b2dca2f!8m2!3d39.6500237!4d-75.6036083

If the project is near another Golder Office, has the local Office been notified of the work? ☒Yes ☐No

Site Name	Delaware Sand & Gravel (DS&G) Superfund Site			
Address	757 Grantham Lane, New Castle DE 19720			
Coordinates	39.650247, -75.603673			
Description	Superfund Site due to presence of impacted groundwater from capped landfill areas located within an area of light industrial and residential use. Wooded areas and areas of surface water are present to the south and east of the Site.			
Access Information	Site can be access for various points off Grantham Lane and within Llangollen Estates in New Castle, DE.			
Previous Land Uses	Former sand and gravel quarry used as a disposal area for drums, tanks, construction rubble, and scattered chemical wastes.			
Site Receptors that may be Impacted by the Proposed Work	None known			
Additional Information	Presence of methane in the subsurface from the landfills. Methane is monitored and mitigated as a separate portion of the larger project.			
HSE Induction / Orientation Provider	☒Golder	☐Client	☐Contractor	
Site Contact Numbers	**Field cell phone**	TBD	**Satellite phone**	not needed
	DS&G On-Site Contact	Beth Klotzbach	+1 (302) 530-3832 (cell) +1 (302) 326-1181 (field office)	
Nearest Golder Office	Mt. Laurel, NJ USA	**Address**	200 Century Parkway, Suite C, Mt. Laurel, New Jersey, USA 08054	
Opening Days and Hours	8am to 5pm, M-F	**Email**	tmiller@golder.com**Error! Hyperlink reference not valid.**	
Phone	+1 (856) 793-2005	**Fax**	+1 (856) 793-2006	

5.0 CHECK-IN SYSTEM

5.1 Check-in Contacts

	Primary	Secondary
Name	Ruth Twaddle	Benjamin Reynolds
Phone/Email	Office: +1 (856) 793-2005 x34000 Email: ruth_twaddle@golder.com	Office: +1 (856) 793-2005 x34484 Cell: +1 (610) 742-2848 Email: Benjamin_Reynolds@golder.com
Check-in Frequency*	On arrival to Site	On arrival or departure from Site
By Phone	☒	☒
By Email	☒	☒
By SMS (text)	☐	☒
On Site	☒ must sign in at field office	☐

5.2 Missed Check-in Procedure

Within 2 hours of missed check-in time:

1. Attempt to contact employee.
2. Contact accommodation or other project personnel to determine last contact with employee.
3. Notify Project Manager, then contact DS&G Trust Site Engineer to request assistance in locating the employee.
4. Project Manager determines timing of further action, based on project details.

Within 4 hours of scheduled call-in time:

1. Project Manager notifies Project Director and DS&G Trust Administrator.
2. Field Coordinator notifies Office Manager, and local authorities (as appropriate)
3. Initiate Crisis Response Plan (as appropriate)

☒Does missed check-in procedure for this project deviate from the standard procedure?

6.0 RISK REGISTER

6.1 Risk Definition

Health & Safety Consequence or Impact Description:

Catastrophic	5	Death, toxic release off-site with detrimental effect, very high financial loss
Major	4	Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss
Moderate	3	Medical treatment required, on-site release contained with outside assistance, high financial loss
Minor	2	First aid treatment, on-site release immediately contained, limited financial loss
Insignificant	1	No injuries, low financial loss

Environmental Consequence or Impact Description:

Catastrophic	5	Release to air, water or land with life threatening impacts on or off site. e.g.: human death(s); destruction of endangered species; habitat destruction; human water supply or food destruction; localized extinction of a species; Protracted or extensive clean up requiring external resources.
Major	4	Release to air, water or land with destructive impacts on or off site. e.g.: destruction of animal / fish life; habitat damage; making air, water or land unfit for use by living things; destruction of known or unknown indigenous people's / heritage sites ; irreversible alteration of the natural environment or its aesthetics; dust or noise affecting a region; large volumes of contaminated or hazardous waste. Requires clean up using external resources.
Significant	3	Release to air, water or land with impacts requiring long term recovery. e.g.: habitat disturbance; damage to indigenous people's/heritage sites; alteration of the natural environment or its aesthetics; generation of contaminated or hazardous waste, or large volumes of solid waste; dust or noise affecting the immediate area. Clean-up can be managed by internal resources.
Minor	2	Release to air, water or land with resulting in localised damage to worksite requiring short term recovery. e.g.: readily repairable impacts (physical or aesthetic) to the natural environment, indigenous people's/heritage items, property, or business operations; public nuisance (noise, dust, odours); generation of small quantities of waste. Clean up can be completed by internal resources.
Insignificant	1	Release to or disturbance of air, water or land resulting in no impact or localised (i.e. isolated to worksite) impacts within authorized limits. Short term impact with complete recovery. Clean up can be completed by person(s) involved.

Likelihood Description:

Almost certain	5	Incident will occur in every circumstance (e.g. every time).
Likely	4	Incident will probably occur (e.g. 1 in 10 times).
Possible	3	Incident may occur at sometime (e.g. 1 in 100 times).
Unlikely	2	Incident not expected to occur, but conceivable (e.g. 1 in 1, 000 times).
Rare	1	Incident would only occur in exceptional circumstances (e.g. 1 in 10,000 times).

Risk Analysis Matrix:

Likelihood:		**Consequence:** Catastrophic 5	Major 4	Moderate 3	Minor 2	Insignificant 1
Almost certain	5	25 (VH)	20	15	10	5
Likely	4	20	16 (H)	12	8	4
Possible	3	15	12	9 (M)	6	3
Unlikely	2	10	8	6	4 (L)	2
Rare	1	5	4	3	2	1 (VL)

0-3 (VL) Very Low Risk	No additional controls necessary. Continue to monitor risk.
4-6 (L) Low Risk	Consider additional controls to further reduce risk.
8-12 (M) Moderate Risk	Controls must be implemented to reduce risk.
15-16 (H) High Risk	Risk Unacceptable, do not proceed without controls, minimum of 'engineering controls'.
20-25 (VH) Very High Risk	Risk Unacceptable, do not proceed without controls, elimination or substitution controls required.

6.2 Risk Register

Header key:

- PA: Persons Affected
- IC: Initial Consequence
- IL: Initial Likelihood
- IR: Initial Risk
- RC: Residual Consequence
- RL: Residual Likelihood
- RR: Residual Risk
- AC: Additional controls

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Compressed Gases (SWP 26)	Explosion or Fire	Golder Employee	4	3	12	All compressed gas cylinders must be clearly marked with the name of the contents and, if empty, also labeled “empty”. Always store cylinders in a secured upright position, with regulators removed, and valve-protection covers in place. During transport, cylinder must be securely stored in the vehicle and have its valve-protection cap in place. Transport cylinders in an upright position, if possible. However, oxygen, nitrogen, and argon must be stored, used, and transported in an upright position. Compressed gas is a regulated DOT hazardous material, follow the Materials of Trade requirements when transporting in a vehicle. All fittings must be properly attached and there must be no leaks. Use appropriate PPE when moving cylinders, including steel-toed boots and leather gloves. Develop a storage plan to correctly segregate gas with different hazard classes.	3	2	6	
General	Sample Preservatives	Burns, Blindness	Golder Employee	4	4	16	When collecting environmental samples, many sample bottles provided by laboratories are preserved with a small quantity of dilute acid, such as Nitric (HNO3), Hydrochloric (HCl), or Sulfuric (H2SO4). All of these preservatives are considered hazardous substances (corrosive), primarily due to risk associated with eye and skin exposure. Review first aid, CPR, AED, & BBP SWP. Wear safety glasses and nitrile gloves when opening and filling sample containers. Be aware that adding water to a sample bottle containing a preservative can generate toxic vapors, boil, and splash. Keep your face away from the sample bottle opening.	3	2	6	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Waste Management	Waste Management	Golder Employee	4	2	8	Where appropriate, containers shall be provided for the collection and separation of waste, trash, oily and used rags, and other refuse. Containers used for garbage and other oily, flammable, or hazardous wastes, such as caustics, acids, harmful dusts, etc. shall be equipped with covers.	3	2	6	
General	Driving Vehicle (Rental/Fleet)	Driving Vehicle	Golder Employee	4	2	8	Follow Motor Vehicles and Driving on Company Business SWP24). If unfamiliar with the vehicle, allow sufficient time to familiarize oneself with the controls of vehicle. Verify the vehicle is in roadworthy condition, suited for the intended purpose, and equipped with the appropriate tires (including a spare). Ensure any signs, stickers, or labels are affixed in such a manner that they do not obstruct the driver's vision or impede the driver's use of any controls. Drivers will have a current driving license and be fit to drive. Adhere to all roadway regulations and follow speed limits. Do not drive in adverse weather or when fatigued. Equip vehicle used for on-site work with fire extinguisher and first aid kit. If any safety concerns are identified, the vehicle must not be used. For Golder fleet vehicles, report vehicle deficiencies to the Operations Manager as soon as they are noticed. The Operations Manager, or his/her delegate, will arrange for maintenance of the vehicle.	2	2	4	
General	Operating a Vehicle Around Heavy Equipment	Traffic and Road Conditions (e.g., Heavy Equipment Traffic)	Golder Employee	5	3	15	Seat belts shall be worn by all drivers and passengers in vehicles on company business. The vehicle should have a clean windshield unobstructed by rain, debris, fog, or cracks to the shield. Headlights, tail lights, brake lights, and the car's horn should be fully functional to help alert equipment operators to their presence. When reversing onsite, must have a clear rear view, reverse signal alarm, or an observer who can signal instructions to the driver while reversing. Verify the rules of the road (speed limit, type of vehicles, rules on passing, signage, method of communication with other vehicles) and follow any site-specific traffic control.	4	1	4	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Parking - Side of the Road	Parking - Side of the Road	Golder Employee	5	4	20	Where required, use barrier vehicles, pylons, or road signs both in front of and behind vehicles. Check local regulations for requirements. Pull over as far as possible from the road or park in a pull out/rest area.	3	2	6	
General	Hazardous Waste	Potential for Contaminatio n of Local Environment	Golder Employee /Local Habitat	3	4	12	Follow the EPA's RCRA hazardous waste management requirements. Know the generator status (e.g., CESQG, SQG, LQG) of the site and follow respective storage and labeling requirements. Properly characterize the waste. Only use containers that are in good condition. Containers must remain closed when not in use. Drums/containers should be stored in secondary containment, if possible. Properly label the containers. Do not commingle hazardous wastes with non-hazardous wastes. If making arrangements for disposal, only work with reputable contractors. Do not sign hazardous waste management manifests unless contractually obligated to do so. If Golder signs, must include "on behalf of company" in signature line. Those handling hazardous waste and/or completing waste manifests must be current on their RCRA training (initial or annual (pending site)). DOT Hazardous Materials training must also be current to perform hazardous waste shipping activities.	2	1	2	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	IDW	Potential for Contamination of Local Environment	Golder Employee /Local Habitat	3	3	9	Manage investigation derived waste (IDW) (e.g., drilling muds, purge water, filters, gloves, disposable sampling equipment, etc.) that may have come in contact with contamination in accordance with local requirements and any applicable site-specific requirements. Do not dispose of IDW in an area where it could enter a waterway. Return environmental media back to source, if permissible. If not, segregate "clean" soil from potentially impacted soils. Cover stock-piled soils with plastic at the end of each work day to prevent wind or water erosion or containerize media and other IDW for disposal/offsite treatment. Unless there is evidence that the IDW is a regulated hazardous waste, do not label it as hazardous waste, and manage it in a protective manner. If the characterization of the waste is unknown, a notification label should be placed on the container with the words “waste characterization pending analysis” (or the like) along with contact information. Once the waste has been characterized, the label should be changed as appropriate for a non-hazardous or hazardous waste. If hazardous IDW will be transported offsite, DOT requirements for containerizing, labeling, and transporting hazardous materials and substances may apply.	2	2	4	
General	Non-Hazardous Waste	Potential for Contamination of Local Environment	Golder Employee /Local Habitat	1	4	4	Contain and dispose of any solid wastes in accordance with local regulatory requirements. Do not commingle hazardous wastes with non-hazardous wastes. Prior to commencing work, communicate with site representatives and plan ahead on waste management issues. If onsite waste receptacles (non-Golder) will be used, obtain the necessary authorizations. If wastes are to be transported offsite in vehicle, properly secure and cover container.	1	1	1	
General	General Lifting	General Lifting	Golder Employee	3	3	9	Understand the appropriate technique for lifting materials and equipment safely. Maintain good working posture, avoid bending your back, twisting, and placing undue strain on your lower back. Hold the load close to your body to reduce the force required to lift. Lift with your legs.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Operating a Vehicle	Operating a Vehicle	Golder Employee	4	3	12	Comply with the Fitness for Duty and Fatigue SWP27. Employees will not operate a vehicle or mobile equipment if fatigued. Employees shall not drive if the work period has exceeded 14 hours. Travel to and from the work site may be considered part of the working hours. Arrange for accommodation close to the work location to limit travel time.	3	2	6	
General	Undertaking Work Without Adequate Rest	Undertaking Work Without Adequate Rest	Golder Employee	4	3	12	Identify hours of work and comply with the Fitness for Duty and Fatigue SWP27. There should be a minimum of one 30 minute break in each 8 hour work period or part thereof. If a period of 12 hours has been worked, an employee is required to ensure that a break away from work of at least 8 hours is taken prior to returning to work. Non-work activities must allow for sufficient rest.	3	2	6	
General	Working Long Hours	Working Without Adequate Rest	Golder Employee	5	3	15	Identify hours of work to comply with the Fitness for Duty and Fatigue Management SWP27. All activities should be designed to fit into the standard work day/work shift of 12 hours (including travel time). If work exceeds the maximum, a fatigue risk assessment must be conducted and permission sought by PM or OM. Employees shall not drive if the work period has exceeded 14 hours - find alternative methods of transportation.	3	2	6	
General	High Noise Environments	Noise	Golder Employee	4	4	16	Follow the Hearing Protection SWP21. Evaluate the noise level. If it is difficult to maintain a normal conversation at a distance of 3 feet, institute controls to manage the hazard. Install insulation or other noise damping techniques where possible. Establish task rotation to decrease exposure times to hazardous noise. Wear hearing protection with a sufficient protection factor to mitigate the noise hazard. This could be properly fitted ear plugs or a combination of both ear plugs and ear muffs. Consider using a dosimeter to test noise levels.	2	2	4	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Slips, Trips, and Falls	Slips, Trips, and Falls	Golder Employee	4	3	12	Follow Slips, Trips, and Falls SWP14. Use care and attention when walking. Before starting work, conduct a survey of the area looking for uneven ground, mud, water, loose material, or other conditions that could cause slips, trips, or falls. In cold weather environments, walkways shall be sanded, salted, or cleared of snow and ice as soon as practicable. Establish level pedestrian footpaths, avoiding slippery surfaces wherever possible. Relay identified hazards to others working at the site. Wear footwear appropriate to the tasks and identified hazards. Footwear should be in good condition and provide effective traction and ankle support.	2	2	4	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Subsurface Utilities	Subsurface Utilities	Golder Employee	5	3	15	Comply with the HSSE Procedure 212 Ground Disturbance Preparation and Utilities Investigation (Attachment 3). Prior to any ground disturbance at the proposed drilling locations, the following activities will be performed at those locations to avoid subsurface utilities: 1) The drilling locations will be pre-marked out and Miss Utility will be contacted to mark out utilities on public properties. Employees must contact the federally-mandated 811 notification center, 72 hours or 48 hours in advance (pending state reporting requirements), generally excluding weekends and holidays.; 2) Available Site drawings and public utility information will be reviewed to locate utilities on private and public properties; 3) Private utility locating service will be contracted to perform ground-penetrating radar (GPR) and/or electromagnetic (EM) surveys to locate utilities; and 4) Due to the known and potential presence of utilities on private property that are undetectable using GPR and EM geophysical methods, Due to the known and potential presence of utilities on private property that are undetectable using GPR and EM geophysical methods, a soft-dig of at least 4 feet-below ground surface will be performed prior to drilling in the drilling locations. Review all markings made by the locators and move work locations as needed to avoid striking identified services. Use visual clues to identify possible underground services such as service boxes, pits, manholes or patched pavement. Make note of services coming into or out of the ground like power lines and down spouts. When possible shut off utilities that are in the area while drilling.	4	2	8	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Changing Weather Conditions	Changing Weather Conditions	Golder Employee	4	3	12	Assess forecasted weather conditions before beginning work. Postpone activities if weather conditions are not favorable. Remain vigilant at all times and continually re-assess weather conditions. Consider carrying a weather radio with spare batteries. Know how to contact the local weather resources. If weather conditions deteriorate, stop work and seek shelter as necessary. Understand who is responsible for suspending work due to extreme weather conditions.	3	2	6	
General	Heat (SWP 04)	Heat stroke, heat stress, sunburn	Golder employee	4	3	12	Check daily weather reports. Wherever possible, reduce temperature and humidity through air cooling and increased air movement. Assess physical demands of the work and provide equipment that will reduce the physical demands. Work in shaded areas, or provide barrier to give shelter from the sun. Schedule work to allow workers to acclimatize. Schedule work to cooler times of the day. Increase the frequency and lengths of break periods. Provide a cool, shady place to take breaks. Assign extra workers or slow down the pace. Drink plenty of fluids. Make water and sports drinks available. Use a buddy system; check each other frequently for signs of heat stress (e.g. disorientation, lack of sweat, fatigue). Assess each worker for factors that may contribute to early onset of heat stress. Wear hats and light colored loose clothing. Cooling vests may be required. Consider the additional stress load caused by PPE such as Tyvek coveralls. If someone is suffering from heat-related illness - Move the person to a cool area, maybe the air-conditioned vehicle. - Give the person small amounts of cool (not cold) water.- DO NOT leave the person unattended.- Immediately seek qualified medical assistance if the person does not recover or their condition worsens.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Lightning	Lightning	Golder employee	5	3	15	Check daily forecast. Carry a weather radio and extra battery as well as a personal lightning detector. Postpone outdoor activities if thunderstorms are imminent. Stay away from tall objects such as towers, fences, telephone poles and power lines. Avoid touching metal if you take shelter in your car. If you must take shelter outdoors, find a low spot away from trees, fences and poles. If you feel your skin tingle and hair stand on end, squat low to the ground, on the balls of your feet. Place hands over ears and your head between your knees. Make yourself the smallest target possible, with minimum contact with the ground. DO NOT lie down.	3	1	3	
General	Sun (SWP 04)	Sunburn	Golder employee	4	3	12	Sunburn can occur even when the weather is not hot. It is possible to get sunburn in the winter time or on water. Check UV rating, wear sunscreen, look for shade, protect eyes with shaded glasses.	2	3	6	
General	Working in Cold Environments (SWP 05)	Frostbite, hypothermia	Golder employee	5	3	15	If ambient temperatures are 40 °F or below, site training should include prevention of cold injury, cold-injury symptoms, and cold-injury first-aid. If the equivalent wind chill temperature is less than minus 29 °F, outdoor work should be discontinued or effective engineering controls such as windscreens, temporary shelters, or portable heating units should be used. Work in sheltered areas, or provide barriers to give shelter from the wind. Provide a warm, sheltered place to take breaks. Never work alone in a cold environment. Check each other frequently for signs of frostbite and hypothermia (e.g. white of black spots on skin). Drink plenty of fluids, not caffeine or alcohol. Wear clothing appropriate for the weather conditions. Wear multiple layers. Foot, hand and facial protection is essential. Eye protection is required against ice particles, snow and sun. Survival kit to include hot packs, blankets and spare clothing. Workers must be trained in the use of survival equipment.	3	2	6	
General	Working in Cold Environments (SWP 05)	Maintaining necessary supplies	Golder Employee	4	3	12	Plan for, maintain and inspect supplies necessary for safe work in cold environments. These supplies may include food, water, blankets, extra clothes, hand warmers, jackets, tools, lighting and communication devices.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Working in Cold Environments (SWP 05)	Slips, trips, and falls	Golder Employee	4	3	12	Walkways and foot paths shall be sanded, salted, or cleared of snow and ice as soon as practicable. On-going maintenance of all paths must be regular.	3	2	6	
General	Working in Cold Environments (SWP 05)	Unstable snow and ice build-up	Golder Employee	4	3	12	When working in locations where snow, rain and cold alter the safety of work areas, measures will be taken to advise all employees in the area of the hazard. This notification may come in the form of signs, discussions during safety meetings, or physical barriers placed around high risk areas.	3	2	6	
Tasks	Moving Parts	Moving Parts	Employee	5	2	10	Identify the type of drill rig. If truck or track mounted rig is being used, discuss with the driller the moving and rotating equipment risks and the guarding controls.	2	2	4	
Tasks	Positioning the Rig	Stability of the drill rig	Golder Employee	3	2	6	Choose a site that allows for safe access of the drill rig. Look up for overhead lines that may limit access and operations. Ask the drill rig operator to stabilize the rig using the stabilizing arms. Slope stability and soil conditions should be considered particularly when working in close proximity to crests or at the base of steep slopes where rock falls are possible.	2	2	4	
Tasks	Working Near the Rig	Entanglement and falling objects	Golder Employee	5	2	10	Golder employees will stand clear of the drill rig when in operation. Stand uphill from drilling activities if possible as falling object may roll. No loose clothing will be worn when working near a rig. Long hair will be tied back. Consider wearing break-away safety vests.	4	2	8	
Tasks	Working Around Heavy Equipment (SWP 18)	Working around heavy equipment	Golder employee	4	3	12	Heavy equipment activity may change daily or hourly, with differing potential hazards that need to be identified and addressed. Never approach an operational piece of heavy equipment until the operator is aware of your presence, your desire to approach, and signals the OK – where possible use radio contact. Stand in a safe location. Never work or pass directly under a lifted or suspended load. Whenever a Golder employee works on a project site where heavy equipment is operated, the Working Around Heavy Equipment SWP 18 must be followed.	4	2	8	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Tasks	Groundwater - General (SWP 15)	General Procedure	Golder Employee	3	3	9	Follow the Groundwater Sampling SWP 15. When using a bailer to sample groundwater or conducting a slug test, position yourself to minimize back strain. When sampling groundwater with a bailer, take care when handling the bailer cord, as it can cause a tripping hazard. Before sampling, become familiar with the contaminants of concern and establish the appropriate action levels and response action for each potential contaminant. When opening a well, be careful of bugs that may be nesting in wells and position yourself upwind and keep your face as far from the opening as possible to avoid inhaling any volatile contaminants.	3	2	6	
Unique Issues	Allergic Reaction	Allergic Reaction	Golder Employee	4	2	8	Follow the Biological Exposure Risks SWP 3. Understand local hazardous vegetation and potential exposure issues. Be knowledgeable in their identification and signs and symptoms of exposure. Prevent exposure through recognition and avoidance, as well as wearing long pants, long-sleeved shirt and gloves. Reduce exposure by frequently washing hands and avoiding facial contact with hands and plant matter. Decontaminate or dispose of any clothing or tools that might have contacted poisonous plants since oils and resin can remain toxic for years. If employee has a known allergy, carry appropriate medication.	3	1	3	
Unique Issues	Bees, wasps	Bees, wasps	Golder employee	3	3	9	Follow Biological Exposure Risk SWP 3. Check the area for nests. Do not disturb nests. Wear light-colored clothing and cover as much of the body as possible. Avoid perfumed soaps, shampoos, and deodorants. Don't wear cologne or perfume. Avoid flowering plants when possible. Keep work areas clean. Social wasps thrive in places where humans discard food. Remain calm and still if a single stinging insect is flying around. (Swatting at an insect may cause it to sting.) If you are attacked by several stinging insects at once, run to get away from them. (Bees release a chemical when they sting, which may attract other bees.) Employees with a history of severe allergic reactions to insect bites or stings should consider carrying an epinephrine auto injector (EpiPen).	3	1	3	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Unique Issues	Mosquitoes	Mosquitoes	Golder employee	3	2	6	Follow Biological Exposure Risk SWP 3. Wear full length clothing. Light colored clothing makes it easier to see mosquitoes. Avoid working at dawn and dust when mosquitoes are most active. An insect repellent containing diethyl-meta-polyamide (DEET, > 20% for longer protection) or something similar (e.g., picaridin, or oil of lemon eucalyptus) should be applied to clothing and skin before going into the field. Permethrin may be used, but on clothing only. The repellent should be applied and re-applied according to the manufacturer's instructions. Determine if area is impacted by West Nile virus, Encephalitis viruses, Dengue fever or Malaria. If so, know the symptoms of infection and seek medical treatment, as needed.	3	2	6	
Unique Issues	Spiders	Spiders	Golder employee	2	3	6	Follow Biological Exposure Risk SWP 3. Do not place bare hands in hollow logs or under piles of wood or trash. Be cautious inside manholes and other confined spaces. Wear leather gloves or similar when handling these items. If boots or clothing removed, check them prior to putting them back on for the presence of spiders. Keep your tetanus boosters up-to-date (every 10 years). Spider bites can become infected with tetanus spores. Bites by most spiders result in local swelling only. If bitten: 1. Remain calm. 2. Clean the area with soap and water. 3. Apply ice to relieve swelling and pain. 4. Elevate bite area, if possible. 5. Seek medical assistance. If possible, collect the spider or remains of spider to facilitate identification.	2	2	4	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Unique Issues	Ticks	Ticks	Golder employee	3	2	6	Follow Biological Exposure Risk SWP 3. Wear full length clothing (tucking pants into socks prevents access for ticks). Light colored clothing makes it easier to see ticks and remove them before they can attach to the skin. Walk in the center of trails. An insect repellent containing diethyl-meta-toluamide (DEET) (20 – 30%) or other effective repellent should be applied to clothing and skin before going into infested areas. The repellent should be applied and re-applied according to the manufacturer's instructions. All clothing should be removed after visiting tick infested areas and the entire body checked for ticks. Paying particular attention to the scalp, areas behind the ears and the back of the head or neck. Review and understand the signs and symptoms of a tick bite.	3	1	3	
General	Overhead Hazards - Review Conditions	Overhead Hazards - Review Conditions	Golder Employee	4	3	12	Follow Overhead Hazards SWP11. When working with heavy equipment, such as drill rigs, dump trucks, and front-end loaders, the area above the zone of operation must remain clear of overhead hazards and obstructions. Review overhead hazards with equipment operators before commencing tasks. Consider the route of travel for this equipment and be aware of/review overhead hazards. Check local regulations and possibly contact local utilities for minimum clearance distances from overhead power lines.	3	1	3	
Tasks	High pressure fluids	High pressure fluids	Golder employee	4	2	8	Request driller undertakes pre-start check on hydraulic and air systems. Stand well clear of the machinery when in operation and be familiar with emergency stop devices fitted to rig. Do not stand behind barrel when the driller is extruding the core barrel as high pressure fluids can release unexpectedly. Request the driller uses 'whip checks', pins or similar devices on all water hoses as the pressure can result in them 'snaking'.	2	2	4	
Tasks	Inspections	Moving or Defective parts	Golder Employee	5	2	10	Drill rig operators shall perform daily pre-start inspections of all equipment. Golder employees will not operate drill rigs. Understand where to locate and how to operate all emergency stop devices on the rig.	2	2	4	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Tasks	Other activities in the work area	Other activities in the work area	Golder Employee	4	2	8	Assess what other activities are occurring. At the daily tailgate meetings discuss how these activities may impact drilling operations. Consider delineating the area to prevent unexpected activities.	2	2	4	
Tasks	Hazardous Dust (SWP 44)	Exposure	Golder Employee	3	5	15	Silica sand and Bentonite are hazardous substances primarily because of dust inhalation. Use in a well-ventilated area and stand upwind to reduce the risk. Also cement products can produce similar silica dust hazards. Evaluate the need to wear a dust mask or other respiratory protection depending on site conditions. Wear nitrile gloves when handling these materials to avoid skin contact. Do not eat, drink, use tobacco products, or apply cosmetics in areas where there is dust containing crystalline silica.	2	2	4	
Tasks	PVC Pipe Installation	Sharp surfaces	Golder Employee	3	3	9	When cutting PVC pipe, the material must be placed on a stable surface. Do not lean the pipe against your body when cutting it. Use scissors or a retractable knife to cut filter socks.	2	2	4	
Tasks	Chemical Exposure - Response	Chemical Exposure - Response	Golder Employee	3	3	9	Understand the hazards of chemicals in the work area. Be able to recognize signs of exposure. Review emergency response procedures for the project site and know location of the nearest medical facility. Know where first aid and emergency response equipment is located (shower/eye wash stations). Review first aid, CPR, AED, & BBP SWP. At a minimum one Golder employee at every work site must be first aid and CPR certificated.	3	2	6	
Tasks	Groundwater - Pumping (HSE_204)	Electricity	Golder Employee	4	3	12	Groundwater sample pumps or compressors are generally powered by electricity from a generator or battery. When using a source of electricity use the following controls: 1) Follow hot work procedures if near a flammable source, 2) ground the generator, 3) use ground fault circuit interrupters and inspect all equipment before use. Set up equipment to avoid splashing water onto controller, batteries or pump connectors. Follow Golder's Electrical Safety Program HSE 204. When using batteries understand procedures for safety connecting the cables. Store batteries in a way that would contain any acid leakage.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Tasks	Sample Location Access	Vehicle movements	Golder Employee	2	2	4	Move the vehicle to be close to the location of the sampling location, inspect the area for access, soft ground, obstacles that may damage the vehicle. If possible, drive in and drive out of the location, rather than reversing. If you need to reverse, use a spotter to guide you.	2	1	2	
Tasks	Sampling - Contaminated Media	Sampling - Contaminated Media	Golder Employee	3	4	12	Review available data about chemical of concerns (SDS) and potential concentrations to be encountered. Understand the exposure routes, published exposure limits, and monitoring requirements. Select necessary PPE for the potential chemical hazards. If chemical contaminants are unknown consult with a Golder Health and Safety professional for PPE recommendations and to develop an appropriate sampling plan with necessary safety precautions. Avoid direct contact between contaminated media and skin surface and eyes. When handling containers of sample preservatives, appropriate gloves and eye protection are required. When sampling groundwater with a bailer, keep bailed water away from yourself and avoid splashing onto equipment.	2	2	4	
Unique Issues	Rodents	Rodents	Golder Employee	3	2	6	Follow Biological Exposure Risk SWP 3. Maintain clean, well-sealed workplaces and storage buildings so rodents are less apt to nest within. Avoid areas with rodent activity, particularly enclosed spaces in rural areas. Avoid activities that create dust in buildings or shelters where rodents may be present. Hantavirus infections are possible after exposure to infected rodents and their droppings. Droppings should be sprayed down with bleach water and cleaned up while wearing a dust mask and gloves. Know the symptoms of Hantavirus and if experience the symptoms, seek medical attention. Hands shall be washed prior to eating of handling food. All fecal samples collected for identification purposes must be placed in an airtight, watertight bag/container and double-bagged. Hands must be washed afterwards. Sampling equipment should be disposed after sampling.	2	2	4	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Unique Issues	Snakes - Potential Encounters	Snakes - Potential Encounters	Golder Employee	3	3	9	Do not handle snakes (even those that appear to be dead). Wear boots, leather gloves (when appropriate), long pants, and long-sleeved shirts to reduce the potential for envenomation. Tread heavily - vibrations can alert snakes to your presence and give them time to move away. Never place hands or feet where you cannot see them and always look closely when near hollow logs, piles of wood or trash, boulders, and pipes. When possible, ask the client to clear long grass. Where this is not practical, plan your route to avoid excessively overgrown areas. Consider wearing snake gaiters in dense vegetation.	3	2	6	
Work Environment	Explosion, Fire, Spill, Leak, Exposure	Explosion, Fire, Spill, Leak, Exposure		5	4	20	Measure for LEL with a combustible gas meter. At levels <10% LEL continue with the work. At levels between 10% and 25% LEL continue onsite monitoring with extreme caution as higher levels may be encountered. At levels >25% LEL there is an explosion hazard. Withdraw from area immediately. Evacuate at least 30 feet upwind of the source of methane. Contact the Project Manager. If methane is found at any detectable concentration, do not allow ignition sources (smoking, sparks, cell phones, hot work such as cutting or welding) within 25 feet of structures, vaults, manholes, blower-flare facility or other low lying areas where methane may collect. Use only intrinsically safe equipment within 15 feet of the sampling point. When possible, work from a position upwind of activities.	5	1	5	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Work Environment	Exclusion Zones	Contaminants - General	Golder Employee	3	2	6	Follow the Hazardous Waste and Emergency Response SWP 41. Where exposure to chemicals may occur, use monitoring devices to quantify the exposure (i.e. a photoionization detector to monitor for Vapor exposure). Avoid unnecessary contact with chemicals and contaminated materials. Personal protective equipment including nitrite gloves shall be worn when handling soils or groundwater. Where other gloves are required, nitrile gloves shall be worn under these. Hygiene facilities with soap and detergent must be available for regular hand washing. Contaminated soils, water and/or contaminated clothing and PPE (e.g., into drums for treatment and disposal) must be disposed of in an environmentally safe manner. A minimum of one first aid trained and CPR person shall be on site at all times work is being undertaken. Emergency access and egress must be maintained at all times.	3	2	6	
Work Environment	Ground penetrating work	Contaminants - Ground penetrating work	Golder employee	3	4	12	Create an exclusion zone to prevent non-essential staff and members of the public from entering the work area. Avoid excessive plant / vehicle movements as this can disperse and spread potential contamination. Where water restrictions permit, dampen the soil during earthworks to reduce dust and odor generation. Where possible, stand and work upwind from earthworks.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Work Environment	Hazardous/Flammable Atmosphere (SWP 08)	Flammable / combustible gases and liquids	Golder employee	4	3	12	All hazardous areas, defined as areas where flammable atmospheres are likely to be present must be designated and identified on a site plan. Review this plan on entry to the site. Electrical and battery-powered equipment and equipment capable of producing a local source of ignition (e.g. flame, static electricity, friction, heat, spark, exhaust) are not permitted unless approved by the permit and certified as intrinsically safe (documented evidence required). Some examples of such equipment are power tools, portable radios, mobile phones, pagers, calculators and water quality meters. As some gases are heavier than air, entry into all excavations deeper than 4 feet is strictly prohibited because it may be classified as a potential confined space. Monitoring of flammable gases in ambient air (the breathing zone) will be undertaken where ground penetrating work is being performed or where any work is undertaken in enclosed areas. If <10% LEL: continue with investigation. 10% and 25% LEL: Continue onsite monitoring with extreme caution as higher levels may be encountered. >25% LEL: Explosion hazard. Withdraw from area immediately. All personnel to evacuate upwind, to a safe distance. Contact Project Manager. Flame retardant clothing shall be worn in potentially flammable environments.	4	2	8	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
Work Environment	H2S	H2S	Golder employee	5	3	15	Follow the gas hazards SWP 08. H2S gas is an irritant and chemical asphyxiant. Avoid pits, manholes, and depressions in ground elevation. Where possible work from a position upwind of excavation activities. For entry into an area where there is a low risk of encountering H2S, gas monitoring is to be conducted using a meter with an H2S sensor. If the instrument reading is 1 ppm, proceed with work cautiously and continue air monitoring. If the instrument reading is 5 ppm or higher, cease work, consider controls to reduce the levels or upgrade to respiratory protection. The use of cartridge type (air purifying) half-face respirator is not appropriate where H2S is present. Upgrade to full face cartridge type (air purifying) or any powered or supplied air respirator, or self-contained breathing apparatus with a full face piece. Exposure to greater than 100 ppm is Immediately Dangerous to Life and Health. H2S is also highly flammable. The LEL of H2S is 4%. The action level is 10% of the LEL.	4	1	4	
Work Environment	Oxygen Deficiency	Asphyxiation	Golder employee	5	3	15	Monitoring of oxygen (O2) in the ambient air (breathing zone recommended) if the work is in an enclosed area. Conduct air monitoring for CO and VOC's. Avoid areas where potential gas accumulation is likely, such as, pits, manholes, depressions in ground elevation, etc. Deviation from normal O2level (21-22%) may be due to presence of other substances. Continue investigation with caution. At O2levels >23.5% or <19.5%, cease work and evacuate area. Contact PM. Upgrade PPE to Level B if investigation is authorized to continue. NOTE: Combustible gas readings are not valid in atmospheres with <19.5% O2.	4	1	4	

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Fire - Emergency Response	Fire	Golder Employee	5	3	15	An emergency response plan (ERP) for the project site and scope of work is included in Attachment 1. If client or property owner has an established ERP, understand all aspects including your escape route from buildings or sites and muster locations. Keep access routes to all emergency exits clear. If an emergency occurs in a remote area of site, refer to Section 1.5 of the Emergency Response Plan (Attachment 1) for guidance on how to direct emergency response personnel to the area.	5	1	5	
General	Working Near Water-Environmental	Water Pollution/Habitat Disturbance	Golder Employee /Local Habitat	3	3	9	Maintain a safe distance from the water and if working near water, have the proper water rescue equipment (life vest, rope, life preservers, etc.) available in case of an emergency. If entering the water for work, evaluate area prior to commencing the work and determine the best location to enter the water that will have minimal impact. Avoid any known protected wetland areas (unless conducting authorized task within wetland). Select equipment lay down areas in appropriate upland areas. Do not store chemicals close to surface water (including drainage channels). Containerize any waste materials (e.g., consumables) for proper disposal. Secure all materials on the boat so they do not fall overboard. If working on an ocean vessel, any hazardous materials must be properly identified, classified, named, packaged, marked, labeled, and manifested. If these requirements are not met, the vessel captain has the full authority to refuse transportation of hazardous materials. Avoid undertaking ground disturbing activities within the locally designated buffer zone of watercourses, including dry creek beds, without prior authorization. Consider sediment and erosion control measures.	2	1	2	
General	Security - General	Security	Golder Employee	5	2	10	Discuss any local security issues with client and local authorities, if appropriate. Determine if the client can provide adequate security and evacuation resources. If client cannot provide security or evacuation resources, develop a plan using external resources.	3	2	6	

HEALTH AND SAFETY ENVIRONMENT PLAN (HASEP)

Risk Group	Initial Risk	Hazard	PA	IC	IL	IR	Controls	RC	RL	RR	AC
General	Threatening Situations	Threatening Situations	Golder Employee	4	3	12	Consider the area adjacent to and surrounding the work. No person shall work alone where there is likely contact with potentially threatening people. Make contact with local authorities and agree on a plan to deal with physical threats or violence. Increase the frequency of check-in calls in situations where additional controls have been implemented due to the risk of threatening situations. If work is being conducted after hours in an area stated above, security services shall be engaged. Emergency phone numbers shall be readily available at all times. Direct all questions from members of the public regarding the work to the client.	3	2	6	
Work Environment	Visibility working near rail infrastructure	Colored clothing and lights	Golder employee	4	2	8	No red or green objects (including lights, clothing, barrier mesh, hardhats) shall be used on or near live tracks as these may be mistaken for rail signals. High visibility clothing should be worn. If temporary lighting is required to be positioned in the vicinity of the tracks, white lights shall be to the approval of the rail operator.	2	1	2	
Work Environment	Walking on or near rail lines	Irregular, uneven surfaces	Golder employee	2	3	6	Maintain awareness when walking, in particular when walking on ballast and side slopes. Never walk along the track between the rails. Always walk to one side of the tracks. The exception is bridges unless the rail authority has built pedestrian access next to the track. High visibility clothing should be worn. When crossing the rail lines, check both directions to ensure no rail cars are approaching.	2	3	6	

7.0 PERSONAL PROTECTIVE EQUIPMENT

Item	Required	Provided by Golder	Provided by Client	Specific Requirement
Respiratory Protection				
Full-face respirator	☒	☒	☐	As needed during drilling
Gloves				
Disposable	☒	☒	☐	Required during drilling and sampling
Head Protection				
Hard Hat	☒	☒	☐	Required during drilling
Hearing Protection				
Disposable foam ear plugs	☒	☒	☐	As needed during drilling
High Visibility Clothing				
Yellow	☒	☒	☐	
Safety Footwear				
Safety boots	☒	☒	☐	
Eye Protection				
Splash resistant safety goggles	☒	☒	☐	Required during groundwater sampling

8.0 TRAINING

Course Name	Employee Name or Role
OSHA HAZWOPER	All Golder personnel on-Site
CPR/First Aid	All Golder personnel on-Site

9.0 INCIDENT AND EMERGENCY MANAGEMENT

In the case of an incident or emergency occurring on the Site, initiate the appropriate procedures as outlined in the Emergency Response Plan (ERP; Attachment 1). If the emergency occurs in a remote area on Site, please refer to Section 1.4 - Response in Remote Areas in Attachment 1 (ERP).

Emergency Response Contact Information

Field Supervisor (Megan Safranek) is the designated Site Emergency Coordinator and has final authority for first response to on-Site emergency situations. Ben Reynolds is the designated Back-up Site Emergency Coordinator.

Upon arrival of the appropriate emergency response personnel, the Site Emergency Coordinator shall defer all authority, but shall remain on the scene if necessary to provide any and all possible assistance. At the earliest opportunity, the Site Safety Officer or the Site Emergency Coordinator shall contact the Project Manager or Health and Safety Officer. See Section 3 - Emergency Response Calling Tree in Attachment 1 (ERP).

Contact	Office	Cell
Project Manager – Theresa Miller	+1 (978) 376-8434	+1 (978) 376-8434
Field Coordinator – Benjamin Reynolds	+1 (856) 793-2005 x34484	+1 (610) 742-2848
Health & Safety Officer – Kevin Dunsmore	+1 (856) 793-2005 x34328	+1 (856) 373-6576
Client Health & Safety Contact – Beth Klotzbach	+1 (302) 326-1181	+1 (302) 530-3832
Field Supervisor – Megan Safranek	+1 (856) 793-2005 x34485	+1 (631) 553-9809
Ambulance	911	
Fire	911	
Police	911	
Crisis Response Hotline (Outside Canada)	+1 (403) 775-1041	
Golder National Health, Safety, Security, and Environment Advisor - Renee Weaver	+1 (336) 707-3869	
International SOS, Member ID: **11BYCA084630**	+1 (215) 942-8226 (Philadelphia)	
Media Relations (Golder) - Tina Marano	+1 (647) 402-3596	
WorkCare	+1 (888) 449-7787	

10.0 HaSEP REVIEW AND REVISION CONTROL

It is the responsibility of the Project Manager to ensure that this HaSEP is prepared and the contents communicated at the pre-start / toolbox meeting to all project staff, Golder or subcontractor, with a copy held on Site. The HaSEP has been reviewed or prepared by the Project Manager.

If the project site is remote from the home office, this HaSEP is to be reviewed and approved by the local Golder office whether in another country, province or city.

Role	Name (printed)	Date	Signature
Prepared by	Megan Safranek	6/22/2018	
Reviewed by	Theresa Miller	6/26/2018	
Approved by	Kevin Dunsmore	6/26/2018	
Other	Ben Reynolds	6/25/2018	

Golder Sign-off

Signing below indicates you have read and agree to comply with the information contained in this document.

Date	Name	Company	Signature

ATTACHMENT 1

EMERGENCY RESPONSE PLAN

Attachment 1: Emergency Response Plan
Pre-Design Investigation and Routine Groundwater Monitoring

Delaware Sand & Gravel Superfund Site
757 Grantham Lane
New Castle, Delaware 19720

Submitted by:

Golder Associates Inc.

200 Century Parkway, Suite C Mt. Laurel, New Jersey, USA 08054
T: +1 856 793-2005

Revision 0

August 2018

FOREWORD

This Emergency Response Plan (ERP) was prepared to describe procedures to be used in the event of an accident or emergency at the Site associated with the Pre-Design Investigation (PDI) and routine groundwater monitoring activities. Although provided as examples in the RD SOW Paragraph 5.6(b), incidents involving landfill slope, water impoundment and/or treatment plant failure would not be concerns associated with the SOW, and incidents involving power outages at the facility would not result in an incident as it relates to the SOW. As such, these items are not addressed in this ERP. If there are changed conditions during the execution of this PDI Work Plan, then this ERP (and the Health, Safety and Environment Plan) will be updated as necessary.

Bulk chemicals and/or waste materials are not currently used or stored on-Site, and use and/or storage of bulk chemicals is not anticipated during performance of the PDI and/or Remedial Design (RD) activities or other on-going Site activities. de minimis quantities of chemicals associated with preservatives used in groundwater sampling and decontamination of sampling equipment will be used during performance of PDI activities and routine groundwater sampling. A Spill Prevention, Control, and Countermeasures (SPCC) is not applicable for these activities.

At this time, there are no plans for a meeting with the local community; however, the DS&G Trust Administrator will contact and provide a copy of the ERP to the local emergency services departments (Fire and Ambulance) after approval of the PDI Work Plan by the USEPA and prior to initiation of PDI field activities.

1.0 RESPONSE PROCEDURES – HEALTH AND WELFARE

Required Emergency Equipment On-Site

The following equipment should be on Site at all times for use in the event of an emergency:

1. Fully-charged ABC Class fire extinguisher
2. First Aid Kit
3. Eyewash solution

In the case of an incident or emergency occurring on Site involving human health and safety, initiate the appropriate procedures as indicated below.

1.1 On-site Injury, Illness, or Chemical Exposure

Emergency Requiring First Aid:

If able, the injured person should proceed to the nearest available source of first aid. Remove outer garments and if necessary, wash the injured area with soap and water. If the injury involves foreign material in the eyes, immediately flush the eyes with emergency eye wash solution and/or rinse with copious amounts of potable water. Obtain or administer first aid as required.

In the event of an injury requiring more than minor first aid immediately call WorkCare at (888) 449-7787, immediately dial 9-1-1 or if possible, take the victim to Christiana Hospital located at 4755 Ogletown Stanton Road, Newark, DE 19713 phone 302-733-1000. See hospital directions below.

Appropriate measures should be taken to protect the privacy of workers in connection with putting on and taking off of protective clothing. First aid providers shall wear latex gloves when providing any first aid. Severe injuries involving large quantities of blood require that first aid providers don Tyvek coveralls and safety glasses in addition to gloves.

Emergency Involving Chemical Exposure:

Site workers must notify the Site Health and Safety Officer immediately in the event chemical exposure or any of the signs or symptoms of overexposure to hazardous substances. If the injury involves a potential overexposure to hazardous gases or vapors, (headache, dizziness, nausea, disorientation), get the victim to fresh air. If the injury involves eye or skin exposure, flush the eyes or skin with emergency eyewash solution and/or rinse with copious amounts of potable water.

After following the appropriate procedures, take the victim Christiana Hospital located at 4755 Ogletown Stanton Road, Newark, DE 19713 phone 302-733-1000, for a complete physical examination as soon as possible.

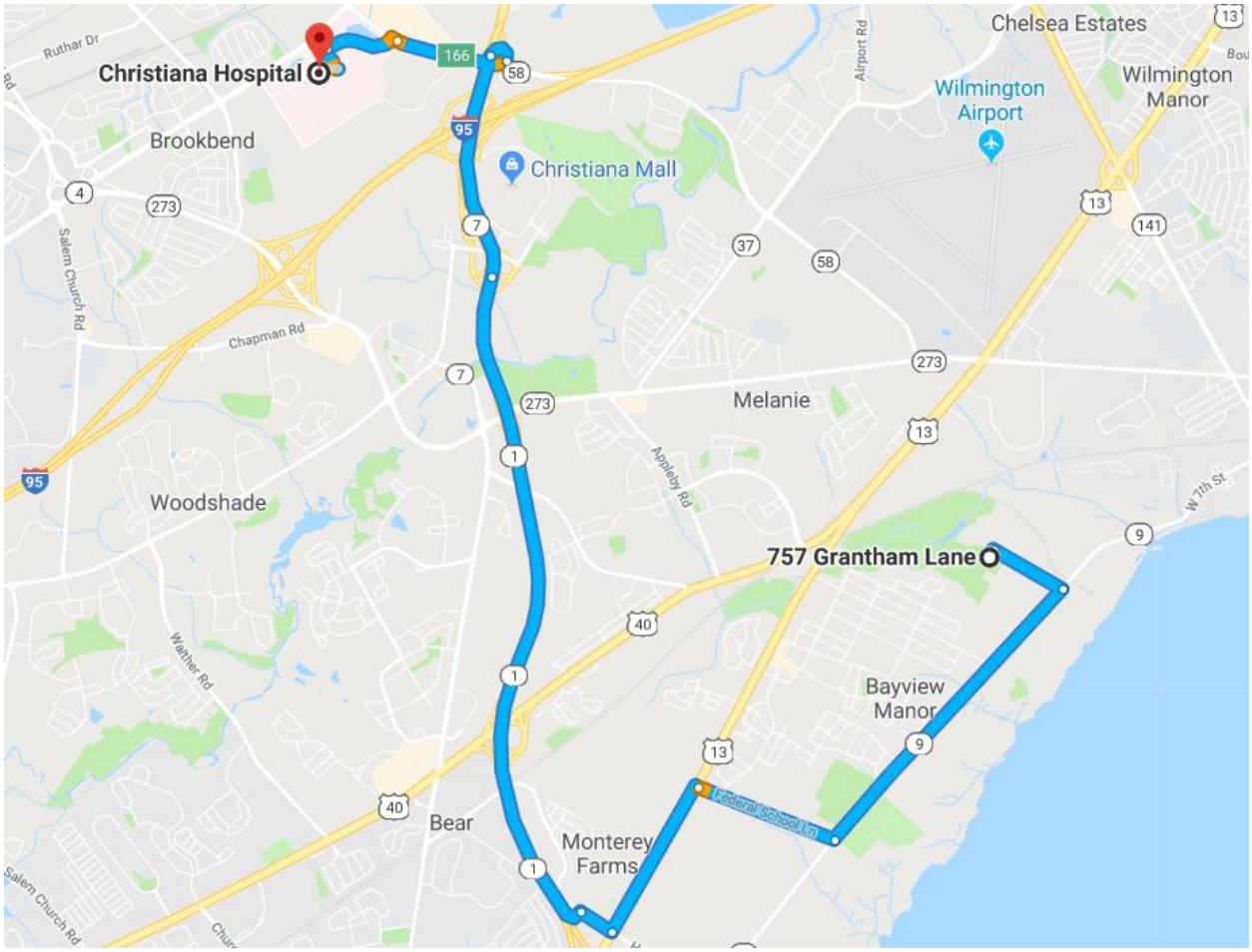
Emergency Involving Unconscious or Immobilized Victim:

If the victim is unconscious or unable to move, or if there is any evidence of spinal injury, do not move the injured person unless absolutely necessary to save his or her life, until the nature of the injury has been determined. Administer rescue breathing using a CPR barrier if the victim is not breathing, control severe bleeding and immediately seek medical assistance as discussed below.

Life-Threatening or Traumatic Injury:

In the event of life-threatening or traumatic injury, implement appropriate first-aid and immediately call for emergency medical assistance at 911.

1.2 Directions to Hospital



See detailed directions below.

757 Grantham Ln

New Castle, DE 19720

Take DE-9 S to US-13 S

5 min (3.1 mi)

1. Head southeast on Grantham Ln toward Edwards Ave

0.4 mi

2. Turn right onto DE-9 S

1.8 mi

3. Turn right onto Federal School Ln

0.8 mi

Take DE-1 N to DE-58 W/Churchmans Rd. Take exit 166 from DE-1 N

8 min (6.2 mi)

4. Turn left onto US-13 S

0.9 mi

5. Turn right onto Bear Rd

0.2 mi

6. Turn left to merge onto DE-1 N

3.7 mi

7. Keep right to stay on DE-1 N

1.2 mi

8. Take exit 166 for DE-58/Churchmans Rd/Churchmans Crossing

0.2 mi

Continue on DE-58 W/Churchmans Rd. Drive to Hygeia Dr

5 min (1.2 mi)

9. Turn right onto DE-58 W/Churchmans Rd

0.6 mi

10. Use the left 2 lanes to turn left

0.4 mi

11. Turn left onto Hygeia Dr

0.2 mi

Christiana Hospital

4755 Ogletown Stanton Rd, Newark, DE 19713

1.3 Fire, Explosion, Release or Other Incident Necessitating Evacuation

In the event of a fire, explosion, release or threat of chemical or waste material release, take the following actions dependent if the incident is readily controlled or not.

Readily-Controlled Incident
If the situation can be readily controlled with available resources without jeopardizing the health and safety of you, other Site personnel, the public, or the environment take immediate action to do so using the information pertinent to the situation provided in this ERP and/or the HASP.

Not Readily-Controlled:
If the situation cannot be readily controlled with available resources and the health and safety of you, other Site personnel, the public, or the environment are at risk; then do the following:

1. Notify emergency personnel by calling 911.
   (Site Address is 757 Grantham Lane, New Castle, DE)

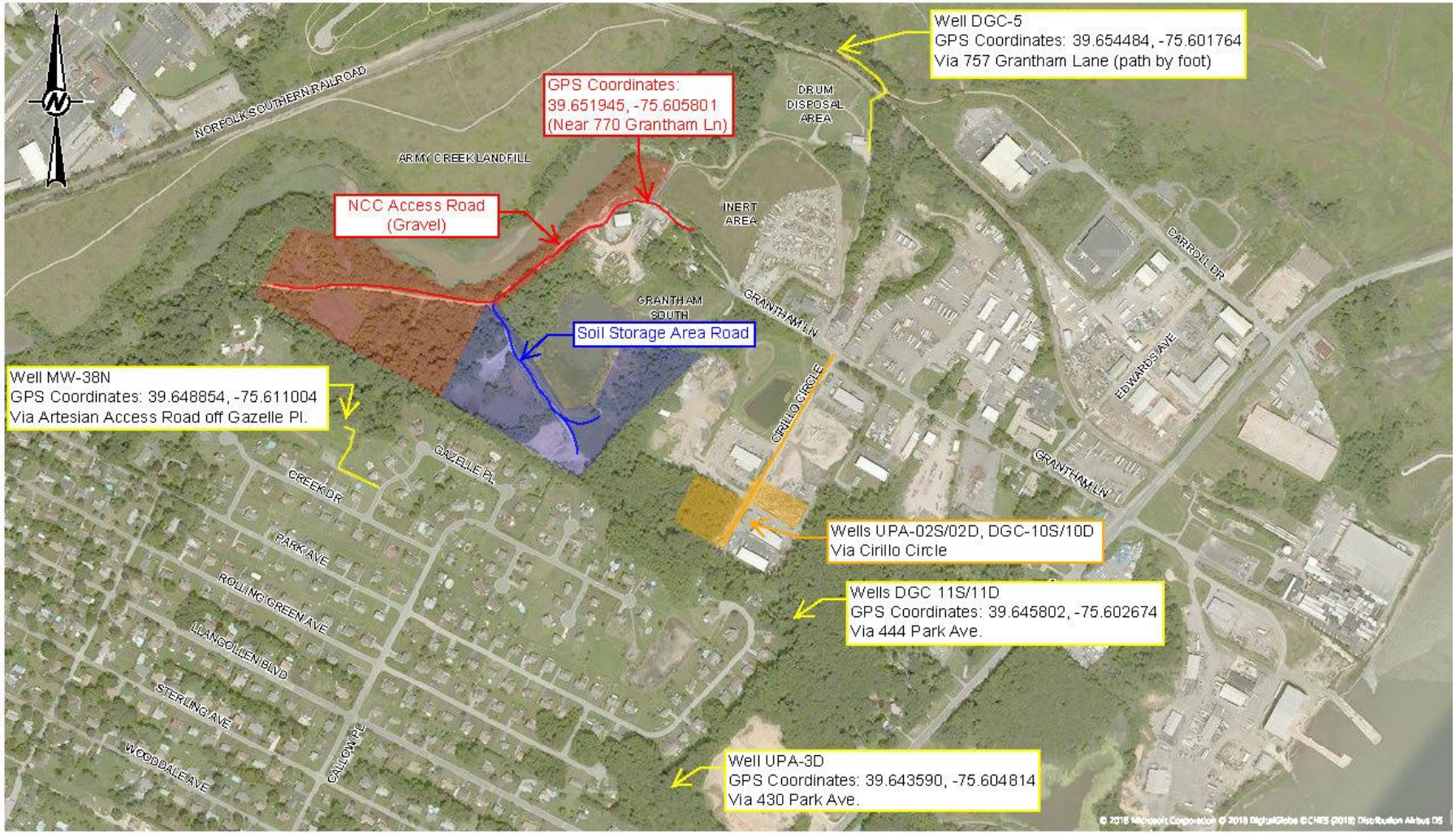
2. If possible without jeopardizing safety, isolate the fire or release to prevent spreading.

3. Evacuate the area and meet in a designated meeting point a safe distance from the fire, explosion, and/or release. **The recommended muster point is the mailbox labeled "757 Grantham Lane" located along Grantham Lane near the access road to the Site**.

4. Perform a head count to ensure all personnel are safe and accounted for, notify the Project Manager. Project Manager will notify the DS&G Trust Administrator.

1.4 Response in Remote Areas

In the case of an emergency that occurs in a remote area of Site, please refer to the figure below to direct emergency response personnel. Please note all GPS coordinates are approximate and updated coordinates should be communicated to emergency response personnel if possible.



2.0 RESPONSE PROCEDURES – PUBLIC WELFARE AND ENVIRONMENT

Waste material in the form of investigation-derived waste (IDW) will be generated during the PDI activities. The IDW will be stored on-Site in labeled and sealed drums for testing. After waste characterization of the drummed IDW, the materials will be transported off-Site for disposal at a licensed disposal facility.

If an emergency or an immediate threat to public welfare and/or the environment results from a release or the potential release of waste material on, at or from the Site, the following procedures shall be followed:

1. Immediately take appropriate actions to prevent, abate, or minimize the release or threat of release including calling 911 for response from local emergency services.

2. Contact the Project Manager and give a detailed account of the incident as soon as possible and within two hours of the onset of the incident.

3. Project Manager relays information to the Delaware Sand & Gravel (DS&G Administrator) who will notify the authorized USEPA officer orally within less than 48 hours of the onset of the incident.

4. Take action based on consultation with the authorized USEPA officer and in accordance with this Emergency Response Plan (ERP), the Health, Safety, and Environment Plan (HaSEP) and provisions of other pertinent documents approved by the USEPA for the Site.

Section 5 provides notification and reporting requirements to be followed after the emergency situation has been addressed.

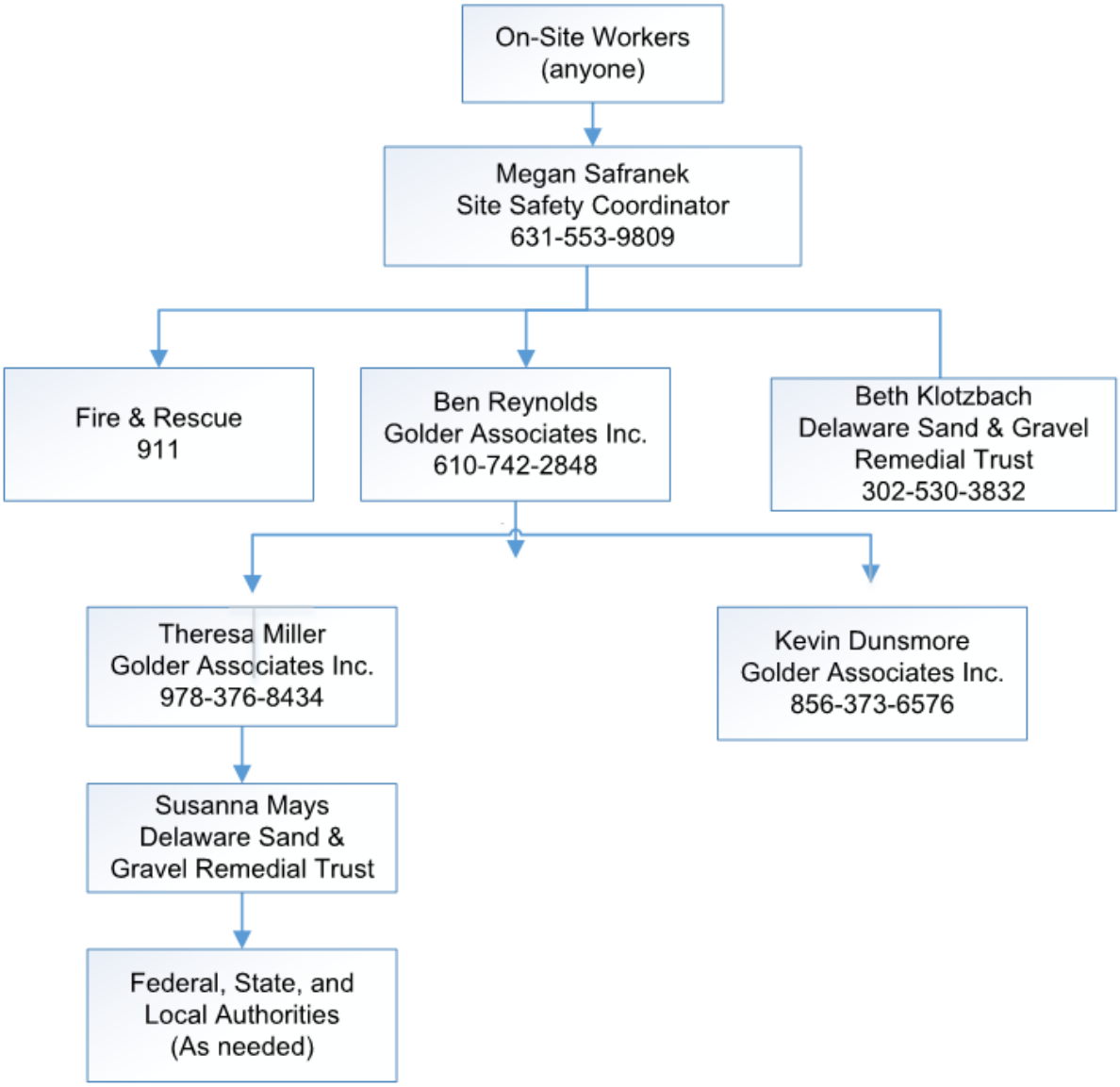
3.0 CONTACT INFORMATION

Field Supervisor (Megan Safranek) is the designated Site Emergency Coordinator and has final authority for first response to on-Site emergency situations. Ben Reynolds is the designated Back-up Site Emergency Coordinator.

Upon arrival of the appropriate emergency response personnel, the Site Emergency Coordinator shall defer all authority, but shall remain on the scene if necessary to provide any and all possible assistance. At the earliest opportunity, the Site Safety Officer or the Site Emergency Coordinator shall contact the Project Manager or Health and Safety Officer (See Section 2 - Emergency Response Calling Tree).

Contact	**Office**	**Cell**
Project Manager and Client Contact – Theresa Miller	+1 (978) 376-8434	+1 (978) 376-8434
Field Coordinator – Benjamin Reynolds	+1 (856) 793-2005 x34484	+1 (610) 742-2848
Health & Safety Officer – Kevin Dunsmore	+1 (856) 793-2005 x34328	+1 (856) 373-6576
Client Health & Safety Contact – Beth Klotzbach	+1 (302) 326-1181	+1 (302) 530-3832
Field Supervisor – Megan Safranek	+1 (856) 793-2005 x34485	+1 (631) 553-9809
Ambulance	911	
Fire	911	
Police	911	
Crisis Response Hotline (Outside Canada)	+1 (403) 775-1041	
Golder National Health, Safety, Security, and Environment Advisor - Renee Weaver	+1 (336) 707-3869	
International SOS, Member ID: **11BYCA084630**	+1 (215) 942-8226 (Philadelphia)	
Media Relations (Golder) - Tina Marano	+1 (647) 402-3596	
WorkCare	+1 (888) 449-7787	

Emergency Response Calling Tree



*Please note the Golder Site Safety Coordinator may change depending who is on Site and should be identified each day in the Health & Safety Tailgate

4.0 SITE LOCATION DETAILS

Site Name	Delaware Sand & Gravel (DS&G) Superfund Site			
Address	757 Grantham Lane, New Castle DE 19720			
Coordinates	39.650247, -75.603673			
Description	Superfund Site due to presence of impacted groundwater from capped landfill areas located within an area of light industrial and residential use. Wooded areas and areas of surface water are present to the south and east of the Site.			
Access Information	Site can be access for various points off Grantham Lane and within Llangollen Estates in New Castle, DE.			
Previous Land Uses	Former sand and gravel quarry used as a disposal area for drums, tanks, construction rubble, and scattered chemical wastes.			
Site Receptors that may be Impacted by the Proposed Work	None known			
Additional Information	Presence of methane in the subsurface from the landfills. Methane is monitored and mitigated as a separate portion of the larger project.			
HSE Induction / Orientation Provider	☒Golder	☐Client	☐Contractor	
Site Contact Numbers	**Field cell phone**	TBD	**Satellite phone**	not needed
	DS&G On-Site Contact	Beth Klotzbach	+1 (302) 530-3832 (cell) +1 (302) 326-1181 (field office)	
Nearest Golder Office	Mt. Laurel, NJ USA	**Address**	200 Century Parkway, Suite C, Mt. Laurel, New Jersey, USA 08054	
Opening Days and Hours	8am to 5pm, M-F	**Email**	tmiller@golder.com**Error! Hyperlink reference not valid.**	
Phone	+1 (856) 793-2005	**Fax**	+1 (856) 793-2006	

5.0 ADDITIONAL NOTIFICATIONS AND REPORTING

5.1 Notifications

While not anticipated for this Site, if the release or potential release is a hazardous substance that requires reporting under Section 103 of CERCLA, 42 U.S.C. 11004, 42 U.S.C 9603, or Section 304 of the Emergency Planning and Community Right-to-Know Act (EPCRA), the Project Manager will relay this information to the (DS&G Administrator) who will immediately notify the authorized USEPA officer orally. The "authorized USEPA officer" for purposes of immediate oral notifications and consultations under ¶ 3.7(a) and ¶ 3.7(b) is the USEPA Project Coordinator, the USEPA Alternate Project Coordinator (if the USEPA Project Coordinator is unavailable), or the USEPA Region 3 Hotline at (215) 814-3255 (if neither USEPA Project Coordinator is available).

5.2 Reporting

In accordance with RD SOW Paragraph 3.7, for any event which occurs during performance of the SOW that causes or threatens to cause a release of waste material, on, at or from the Site, and that either constitutes an emergency or that may present an immediate threat, the follow reporting will be performed:

> (1) Within 5 days after the onset of the event, a written report will be submitted to the USEPA describing the actions or events that occurred and the measures taken, and to be taken, in response, and
>
> (2) Within 14 days after the conclusion of the event, a written report will be submitted to the USEPA describing all actions taken in response to the event.

These reporting requirements are in addition to the reporting required by CERCLA § 103 or EPCRA § 304, if the event involves the release or potential release of a hazardous substance that requires reporting under those regulations.

6.0 ERP REVIEW AND REVISION CONTROL

Role	Name (printed)	Date	Signature
Prepared by	Megan Safranek	6/25/2018	
Reviewed by	Theresa Miller	6/26/2018	
Approved by	Kevin Dunsmore	6/26/2018	
Other	Ben Reynolds	6/25/2018	

Golder Sign-off

Signing below indicates you have read and agree to comply with the information contained in this document.

Date	Name	Company	Signature

ATTACHMENT 2

STANDARD WORK PRACTICES

Approved by	Steve Kogon	Issue Date	August 31, 2012
Revision by	Renee Weaver	Revision Date	December 19, 2016

1.0 SCOPE

This Standard Work Procedure (SWP) applies to Golder Associates Inc. (Golder) staff who work on drilling projects. These procedures are not intended to conflict with or supersede regulatory requirements.

2.0 DRILLING

Drilling techniques involve heavy equipment and include, but not limited to auger, rotary, and sonic which have high-speed rotating and/or moving components which require mitigation/controls to avoid injury when working. Prior to the commencement of drilling activities, the following tasks must be performed:

- Prepare a Health and Safety Environmental Plan (HaSEP) that includes a worksite hazard assessment/risk register or equivalent.
- Obtain site-specific HaSEP from the drilling subcontractor.
- Review the driller's prestart inspection including all pertinent safety equipment.
- Locate underground and overhead utilities and obstacles. Many states require the responsible party to pre-locate the boring locations.
- Identify your safe spot(s) around the equipment.
- Conduct a Workplace Inspection
  - if drilling on a mining site regulated by MSHA (see SWP Mining Safety – GAI HSE 200.049 for requirements and workplace inspection template).

As a supplement to the HaSEP, a Job Safety Analysis (JSA) or Job Hazard Analysis (JHA) should be conducted on-site at the start of the work day and prior to moving equipment to each new drilling location. The JSA is used to assess specific HSE hazards and controls at the work locations for individual tasks and are created or revised on the project site by the employees performing the work.

Conduct a tailgate/prestart meeting to discuss the HaSEP, JSA, hazard assessment, site hazards and mitigation.

Do not act as the driller's helper. Do not handle heavy rods, equipment or materials that our driller was hired to manage. Remember that the drilling contractor is responsible for providing the necessary drilling equipment and personnel to complete their scope of services safely. The driller should provide soil samples (i.e., cut acetate liners, provide open split-spoons, etc.) to Golder employees in a safe manner. Requiring the driller to perform their work should reduce the potential for drilling hazards to Golder personnel by keeping Golder field staff a safe distance from the drilling activities.

3.0 KEY HAZARDS

- Working around heavy and mobile equipment
- Encountering subsurface utilities
- Encountering overhead utilities, other overhead hazards, and surface obstructions
- Mobilizing equipment
- Clothing, fingers or other body parts caught in pinch points and high speed / high torque rotating equipment
- Exposure to contaminants
- Falling objects
- High pressure air and fluids
- Noise generated by the equipment
- Environmental Impact

4.0 PRECAUTIONS

Hazard	Minimum Standard
Working around heavy and mobile equipment	■ Identify a safe location to observe the drilling work and/or conduct environmental/geotechnical sampling. ■ Do not enter the zone of influence of mobile equipment until you have positive ok from the operator. Verify the equipment is stopped before you approach. ■ If using hand signals, make sure everyone knows what they are. ■ Follow Golder's SWP for working around heavy equipment, GAI HSE 200.018. ■ Follow Golder's Fatal Risk Controls for Working around Heavy and Mobile Equipment. • Be visible and identify your safe spot • Do not enter the zone of influence of mobile equipment until you have positive OK.

Underground services	■ Check for the presence of underground utilities prior to commencing ground-penetrating work (It's the law) and verify they are appropriately marked. Even with locates marked, look for evidence such as markings, buried utility lines, wire, conduits, tanks, service boxes, plugs, exposed pipe, trenches, patching of pavements, pits, and manholes. ■ Use state, local, or 811 utility location services to obtain clearance at each drilling location. Plan at least 48 hours in advance prior to scheduled work (72 hours required in some states). If subcontractor is responsible for these clearances, verify it was completed and acceptable. ■ Contact owners/operators of properties on which the work will be performed outside of limits of public utility locations services to review owner/operator local knowledge of utility lines. ■ Consider additional methods to locate utilities such as soft digging, day lighting, private service locators, or geophysical methods to supplement the 811 services. ■ Golder's field team leader, the site health and safety officer (if applicable), and subcontractor supervisor shall confirm with each other that utilities have been located at each boring location prior to drilling. ■ See Utility Locates SWP – GAI HSE 200.017.
Overhead and surface obstructions	■ LOOK UP for overhead hazards. ■ Overhead utility lines of any kind are a major concern and must be avoided or de-energized. Unless suitable verification can be made that lines are de-energized, assume they are energized. ■ Do not work in close proximity to overhead power and communication cables. Even without direct contact, electricity can arc from the power lines to another object. Follow minimum distances to power lines based on voltage. Drill rigs shall not be operated within 10 feet of energized lines up to 50 kV. Greater clearances are required for overhead lines operating at voltages exceeding 50 kV. Local regulations may be more stringent. ■ Post signs, flags, or use other visual methods to draw attention to an overhead hazard or surface obstacles (e.g., guy wires). ■ See Golder's SWP Overhead Hazards – GAI HSE 200.011.

Moving and rotating equipment	■ Drill rig operator shall perform daily pre-start safety check of drill rig and tools. This includes checking beneath the equipment for any signs of dripping oil or hydraulic fluid. Additional inspections may be needed pending the rig's specific use, field conditions, and manufacturer's recommendations. Equipment defects affecting safety shall be corrected before the equipment is used. ■ In the event of power failure, drill controls shall be placed in the neutral position until power is restored. ■ While in operation, drills shall be attended at all times. Persons shall not drill from positions which hinder their access to the control levers, have insecure footing or insecure staging, or atop equipment not suitable for drilling. ■ Identify the location and use of emergency stop devices. Have the operator test the emergency stop on a daily basis. ■ No loose clothing to be worn, shoe laces tied, and all long hair to be tied back. If safety vests are worn, they must be fastened at the front. ■ Fixed guard required around rotating drill string. The drill guard has to be of suitable construction and attached to the rig. Follow the AUTO principle (unable to reach Around, Under, Through, or Over the guard). ■ Persons shall stay clear of augers or drill stems that are in motion. ■ Be aware of pinch points. ■ If using continuous flight auger, remain out of the 'line of fire' when drillers are changing drills stems.

Vehicle movements	■ Prior to moving heavy equipment or vehicles, check access/egress routes to identify ground conditions (e.g., stability, slopes) possible obstructions (e.g. posts, utilities, equipment), and sensitive receptors (e.g., water bodies, storm drains). ■ . ■ If heavy equipment is to be mobilized in an area of potential obstructions, clearly mark these obstructions. Use spotters, who must be able to see each obstruction from a safe location during equipment movement. In some instances, multiple spotters may be needed. ■ Any spotters shall be in sight of, or in communication with, the operator at all times. ■ When a drill is being moved from one drilling area to another, drill steel, tools, and other equipment shall be secured and the mast placed in a safe position. ■ Prior to demobilizing, inspect vehicles and remove any site dirt and debris that could be tracked onto roadways and adjacent properties. ■ During demobilization check the ground surface area which was beneath the drilling equipment for any staining or other evidence of oil or hydraulic fluid leakage that occurred during drilling and repair before entering roadways or new work locations. ■ If possible, drive in and drive out of the location, rather than reversing. If you need to reverse, use a spotter to guide you. ■ Keep a safe distance from moving vehicles.

Exposure to contaminants	■ Evaluate the potential for exposure to chemical contaminants in soil and groundwater and develop a plan to control those exposures.
	■ Monitor for suspected gas hazards (e.g., CH4, CO, H2S). Consult your HSC or a CIH before selecting the monitoring devices and to set appropriate action levels and responses if action levels are reached.
	• Explosive gases, such as methane (CH4), can be generated through the biological breakdown of organic matter present in fill or native soil deposits and can accumulate below buildings, structures, and paved surfaces. For sites where explosive gases may be released as a result of drilling activities, monitor for gases and set action levels (≥10% LEL).
	• H2S occurs naturally in crude petroleum and natural gas, and is also produced by the breakdown of organic matter and human/animal waste. H2S is heavier than air (i.e. collecting in low-lying and enclosed areas such as basements, manholes, sewer lines, underground vaults, etc.). Regardless of the origin, H2S is dangerous due to its toxicity and explosive nature. Inhalation is the principal concern. However, airborne H2S is flammable and can migrate downwind close to the ground. Use monitors for any work activities on worksites with the potential to have H2S present.
	• If undertaking work in an enclosed area such as a building, tunnel, or pit, the following controls to limit CO exposure shall be implemented:
	  • Verify the area is well ventilated and/or the exhaust is vented outdoors.
	  • Monitor carbon monoxide and oxygen levels in ambient air (e.g., the breathing zone).
	• See SWP Gas Hazards and Exposure – GAI HSE 200.008.
	■ Silicosis is caused by exposure to respirable crystalline silica dust. Crystalline silica is a basic component of soil, sand, granite, and most other types of rock and it is used as an abrasive blasting agent.
	• When crushing and drilling rock and concrete use wet methods, monitor exposure and wear respiratory protection, as needed.
	• When using silica sand in the well installation process, use silica sand containing less than 1% crystalline silica, use pre-washed sand (reduced dust), slow pour through pipe, and reduce visible dust generated.

	• See SWP Silica Exposure Control – GAI HSE 200.044. ■ Wear appropriate PPE for the types of contaminants expected on site. Consider potential exposure routes associated with the contaminant (e.g., inhalation, ingestion, skin contact). ■ Identify an escape route, should things go wrong. Be aware of wind direction and consider escaping upwind if an inhalation threat is present. ■ See SWP Respiratory Protection – GAI HSE 200.013.
	■
	■
Falling or projected objects	■ Stand clear of drill rig during rod making and breaking processes and during drilling (at least 20 ft from the back of the rig and 10 ft from the sides or front of the rig or the height of the mast, whichever is greater). ■ Consider guarding as a control for falling/projected objects. ■ Avoid standing downhill from the drilling activities (if possible) as falling drill strings may roll. ■ Do not walk under a suspended load and remain a safe distance. Follow Golder's Fatal Risk Controls for Working around Suspended Loads .
Drilling near water	■ Contain drill cuttings and sediments to prevent run-off of soil or sediment into waterways. ■ Follow SWP Working on or Over the Water – GAI HSE_200.025.
Noise	■ Ear protection must be worn by employees working in close proximity to equipment that generates noise (85 dBA or greater). ● A general rule of thumb for detecting excessive noise levels is if you have to raise your voice when talking to someone three feet away. ■ Follow SWP Hearing Protection – GAI HSE 200.021.

High pressure air or fluids	■ All hoses carrying high pressure air or fluids should have safety chains or cables (whip checks) at connectors. ■ Cease drilling if leaking hoses or connections are evident and make the appropriate repairs before commencing activities. ■ Have spill kits and clean-up equipment on hand. Verify spill kit contents are appropriate for the work being conducted. ■ Do not stand behind barrel when the driller is extruding the core barrel as high pressure fluids can release unexpectedly.
Portable power auger	■ Use equipment with kill switch and safety clutch. ■ Obtain training prior to using equipment. ■ Assign staff physically capable of performing the work. ■ Grab samples only after the clutch disengages.
Stability of drill rig	■ Slope stability shall be considered when working in close proximity to crests or at the base of steep slopes where rock falls are possible and if near excavations either open cut or sheeted as equipment loads or vibrations could impose stress on excavation support/stability. ■ Verify the drill rig operator uses stabilizing arms or stays to provide a stable surface.
Fire	■ Have a fire extinguisher(s) available and know how to use it. Check the charge condition before the start of project activities, and monthly thereafter. MSHA sites require that the fire extinguishers have an annual inspection tag. ■ Do not park a vehicle in tall dry grass as the exhaust components could start a fire.

Slip, trips and falls	■ Periodically throughout the day and at the end of each work day clean-up the worksite to prevent trip hazards and maintain a neat environment. ■ Maintain good housekeeping standards and avoid leaving items on the ground where they could present a trip hazard. ■ Keep walkways clear and in good condition. ■ Set up adequate staging areas for all equipment needed. ■ Never leave a borehole open for an extended period. Backfill and compact the near surface soils following borehole abandonment and/or placement of instrumentation to prevent slumping. Also, put a plate over the active borehole opening if public could access outside of work hours (e.g., urban environment is street/sidewalk). ■ If performing night work, lighting on the site or rig shall be properly installed and sufficient in quantity to provide adequate illumination. ■ If working in icy or snowy conditions, use additional traction devices (i.e., Yaktraks) to reduce the potential for slips. ■ Follow SWP Slips, Trips, and Falls – GAI HSE 200.014.
Manual handling	■ Observe proper lifting techniques (e.g., core boxes). ■ Assign staff physically capable of performing the work. ■ Consider footing before lifting. ■ Obtain help with lifting heavy objects. ■ As needed, use gloves that provide good grip.
Lightning	■ Be aware of the potential for lightning in the work area. ■ Postpone drilling activities if thunderstorms are imminent. ■ Make use of a lightning detector or other monitoring practices in areas and during seasons where lightning is common. Stop work if monitoring detects electrical storm activity in area. ■ Use the 30-30 rule to determine the threat of lightning in your area. When you can count 30 seconds or less between lightning and thunder, head for safe shelter. Remain sheltered for 30 minutes after the last sound of thunder.

Other activities around the drill site	■ Do not allow unauthorized personnel into the work zone. Delineate the area by placing cones, warning signs, barricades or other means to identify the work zone. ■ Implement noise/light/dust reduction or control procedures to prevent impacts to neighboring workers, residences or properties, as needed.
Investigation derived waste	■ Investigation-derived waste, including but not limited to drill cuttings, purge water, and decon water, must be managed, stored, and disposed of appropriately based on waste characteristics and regulatory requirements. Only trained personnel can manage and classify hazardous substances covered under RCRA and DOT regulations. ■ Soil stockpiles should be covered with tarps that are securely fastened, to prevent dust and run-off and stored on an impervious surface, if potential for contamination. ■ Do not allow runoff from stockpiles to enter surface water or storm water management features without appropriate sediment controls. ■ Handle drums with proper equipment (e.g., forklift, drum dollies, etc.). ■ Label and securely store waste containers on site pending disposal in accordance with state and federal regulations. ■ Review project scope of work and contract to verify responsibilities for management of investigation waste and include protections against exposure associated with such management.
Cross-Contamination	■ Seal and grout the monitoring well to prevent cross contamination of the aquifer. ■ Properly decontaminate all drilling equipment between drilling locations and before it leaves site.
Damage to protected/preserved environmental areas	■ Assess the worksite and identify structures, trees, vegetation, wetlands, watercourses or wildlife habitat that needs to be protected/preserved. ■ Develop a plan to isolate sensitive receptors from drilling and site assessment activities (e.g., fencing, warning tape, or other means of isolation).

Long grass, wet and swampy conditions	■ Caution is to be taken when entering these areas. Animals, reptiles, and other unseen hazards may be present, and not seen due to groundcover. ■ Contact the client and request suitable access to the sampling location be provided (e.g., grass slashing). ■ Walk pathways of intended travel mob/demob and between sample locations, to check for changes that may have occurred after initial scoping. ■ Select travel path that minimizes damage to habitat.

5.0 MINIMUM PERSONAL PROTECTIVE EQUIPMENT REQUIRED

- Hard Hat
- Steel Toe Safety Boots
- High Visibility Vest
- Hearing Protection
- Safety Glasses
- Dust Mask or Respirator, if required
- Gloves

6.0 TRAINING

- OSHA 10 hour Construction Safety course
- First Aid and CPR courses
- Underground Utilities Locate
- Crystalline Silica Exposure

7.0 RELATED GOLDER DOCUMENTS

- SWP Working Around Heavy Equipment – GAI HSE 200.018
- SWP Utility Locates – GAI HSE 200.017
- SWP Overhead Hazards – GAI HSE 200.011
- SWP Respiratory Protection – GAI HSE 200.013
- SWP Silica Exposure Control – GAI HSE 200.044
- SWP Gas Hazards and Exposure – GAI HSE 200.008
- SWP Hearing Protection – GAI HSE 200.021
- SWP Slips, Trips, and Falls – GAI HSE 200.014
- SWP Fall Protection – GAI HSE 200.033

SWP Biological Exposure Risks

GOLDER ASSOCIATES INC.

Biological Exposure Risks

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Amanda Cote	Revision Date	July 1, 2013

Golder Associates

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1.0 SCOPE

This Standard Work Practice (SWP) applies to all Golder Associates Inc. (Golder) staff that work in the field in locations where there may be biological exposure risks to hazardous flora and fauna.

2.0 BIOLOGICAL EXPOSURE RISKS – HAZARDOUS FLORA AND FAUNA INFORMATION

Many of the biological risks potentially faced by project personnel are regionally or conditionally specific. Project personnel should research possible biological hazards during the planning stages. This SWP is not meant to be inclusive of all biological hazards potentially encountered at project sites rather it provides guidance for some of the more common hazards, mitigation methods, and medical responses. If a field team member comes in contact with, is bitten or stung by any hazardous plant or animal, always follow the proper first aid procedures and contact the Site Safety Officer immediately. *See Golder's First Aid and CPR SWP and site-specific measures presented in the risk register.*

Precautionary measures should be taken to reduce possible contact with hazardous flora and fauna which may include, but not be limited to: application of bug spray, caution and care in handling collected organisms including wearing gloves, avoiding or leaving an area identified as containing a suspected hazardous plant or animal (e.g. venomous snake).

In general, almost any terrestrial animal can be hazardous at times. Animals may attack if you are in their territory, too close to their nest, between them and their offspring, etc. Also, if you are handling/attempting to handle wildlife, there may be a risk of bites or scratches leading to infection, excessive bleeding, or worse. Please always use caution when working with/around wildlife. Although they are often wary and will stay away from you, there are specific times where this is not the case.

3.0 HAZARDOUS TERRESTRIAL ANIMALS

3.1 Venomous Spiders

Several genera of venomous spiders occur in North America, *Latrodectus* (widow spiders), *Loxosceles* (recluse spiders), *Tengenaria* (hobo spiders), and *Cheiracanthium* (yellow sac spiders). While the venomous spiders listed above are not known to be aggressive, spider bites can occur when the spiders are disturbed or feel threatened. Be careful of reaching under objects where a spider could be hiding or when putting on clothing, gloves or shoes that have been sitting or stored for a long time. Spiders can be commonly found both outdoors in debris piles and indoors in garages and attics. On project sites you should also be cautious working inside manholes and other confined spaces.

3.1.1 Spider Bite – First Aid

Common symptoms of a spider bite include:

- Intense pain
- Rigid abdominal muscles and/or muscle cramping
- Malaise
- Localize sweating
- Nausea and possible vomiting
- Hypertension

Blisters frequently appear at the bite site, which can result in dead tissue because of an interruption of blood supply to the area. If bitten, and you experience any of the symptoms listed above, remain calm, and seek medical attention (contact your physician, hospital and/or poison control center). Clean the bitten area with soap and water. Apply an ice pack directly to the bite area to relieve swelling and pain. If possible to do so without further endangerment, collect the spider (even a mangled specimen has diagnostic value) for positive identification by a spider expert.

3.2 Insects

Stinging or biting insects that are commonly encountered include honeybees, bumblebees, wasps, caterpillars, flies, hornets, mosquitoes, fire ants and scorpions. More people die in the United States per year from allergic reactions from insect stings and bites than from snake bites.

3.2.1 Prevention of Insect Stings or Bites

The Center for Disease Control (CDC) recommends the following steps to prevent insect stings or bites:

- Wear light-colored, smooth-finished clothing or bug suits
- Avoid perfumed soaps and deodorants
- Avoid scented toiletries

- Wear clean clothing and bathe daily to reduce sweat odors that may incite bees
- Avoid flowering plants
- Remove garbage from work areas
- Remain calm and do not swat at insects flying nearby
- If attacked by multiple stinging insects, run from the area and seek shelter
- If a stinging insect enters your vehicle, calmly stop the vehicle and open all windows

Using an insect repellent can help reduce your risk of being bitten by insects. Commercially available insect repellents contain several different active ingredients including DEET, citronella, and oil of lemon eucalyptus. The National Pesticide Information Center (npic@ace.orst.edu) has an on-line resource for identifying insect repellents suitable for various applications: http://pi.ace.orst.edu/repellents/.

Some chemicals contained in insect repellents can impact water quality samples and should not be worn when sampling groundwater or surface water. The United States Geological Survey (USGS) in its field manual for the collection of water quality data recommends using a repellent containing oil of lemon eucalyptus or picaridin instead of a DEET-containing repellent.

3.2.2 Response to an Insect Sting

Allergic reactions to the venom produced by insects are the primary hazard. Anyone who has a history of severe allergic reactions to bee stings should carry an anaphylactic kit with an Epinephrine syringe (epi-pen), with them at all times when working in the field. It is recommended that you inform people working near you about the epi-pen and if possible provide instructions for using it. If an epi-pen is unavailable, remove the victim from the area (to avoid further exposure to the insects), monitor for signs of anaphylactic shock, and seek medical attention. Anaphylactic shock is characterized by a sharp drop in blood pressure and severe breathing difficulties. The reaction can be fatal if emergency treatment is not given immediately, including administering an epi-pen.

People with no history can experience severe allergic reactions. For minor allergic reactions, you may want to carry an over-the-counter oral anti-histamine or ointment to combat itching and swelling.

Stings and bites should be monitored closely for signs of allergic reaction for at least 60 minutes. Stingers should be removed by carefully brushing them away: Never squeeze the stinger. Stings should be washed with soap and water and ice should be applied to reduce swelling. Do not scratch irritated areas as this can increase the risk of infection and swelling.

3.3 Mosquitoes

In the US, besides itching and irritation, the primary concern associated with mosquito bites is the potential for contracting an illness such as West Nile Virus (WNV). The best tool for reducing mosquito bites when working outdoors is to apply a proven, commercially-available insect repellent in accordance

with the manufacturer's instructions. Clothing that minimizes exposed skin will also reduce bites, particularly when working outdoors at dusk or dawn when mosquito activity is greatest. Tightly-woven, light-colored clothing is best. Also consider wearing specially designed bug suits which can be found at most outdoor gear/camping stores. Minimizing stagnant water at jobsites and ensuring doors and screens are closed securely will also reduce mosquito bites. Although WNV infections are rare, the symptoms can be severe. If symptoms such as fever, headache, muscle stiffness, weakness, or swollen lymph glands develop after mosquito exposures, seek medical attention immediately.

3.4 Fire Ants

If attacked by fire ants, quickly move away from the source while brushing off ants with a gloved hand or cloth. To avoid attacks, do not disturb or stand near ant mounds or nests. Be careful when lifting boards or other items under which ants might be found. Tucking pant legs into boots or socks can reduce stings. Pharmacists can help select treatments for minor stings and irritation. Seek medical attention immediately if there is shortness of breath or severe swelling.

3.5 Scorpions

Most scorpion stings cause moderate symptoms in most people; however, some species (bark scorpions in particular) can cause severe symptoms and even death. As with all venomous injections, there is also a risk of allergic reaction and anaphylaxis. According to the CDC, symptoms typically subside within two days and include:

- Pain and burning at the sting site (although very little swelling)
- Restlessness
- Convulsions

3.6 Ticks

Most ticks do not carry diseases and most tick bites are not dangerous; however, ticks can be carriers of a variety of dangerous diseases including Lyme disease and Rocky Mountain spotted fever. Ticks are commonly encountered in warm, humid areas with dense vegetation. While you should take preventative measures year-round, ticks are most active in the warmer months (April –September).

To avoid tick bites, wear long-sleeved shirts and long pants. In tick-infested areas, consider using a commercially-available insect repellent on your skin and a repellent containing permethrin on clothing and gear. Also consider wearing a bug suit. If possible, walk in the center of trails.

Check your body and scalp closely for ticks after returning from work in tick-infested areas. Conduct a body check upon return from potentially tick-infested areas and multiple times a day while outdoors by

searching your entire body for ticks. Use a hand-held or full-length mirror to view all parts of your body, if available.

3.6.1 Safely Remove Ticks

Early tick removal may reduce the risk of infection of some tick-borne diseases. Follow the steps below to safely remove ticks from animals and humans:

1. Use fine-tipped tweezers and protect bare hands with a tissue or gloves to avoid contact with tick fluids.
2. Grab the tick close to the skin. Do not twist or jerk the tick, as this may cause the mouthparts to break off and remain in the skin.
3. Gently pull straight up until all parts of the tick are removed.
4. After removing the tick, wash your hands with soap and water (or waterless alcohol-based hand rubs when soap is not available). **Clean the tick bite** with an antiseptic such as iodine scrub, rubbing alcohol, or water containing detergents.
5. Watch for signs of illness such as rash or fever, and see a health care provider if these develop.

Do not apply fingernail polish, rubbing alcohol, or a hot match head to the tick to facilitate tick removal; these do not affect tick detachment. These methods also may induce the tick to salivate or regurgitate into the wound, thus transmitting more of an infectious agent. Clean the tick bite with soap and water. Mark your calendar with the date of the tick bite. Monitor the tick bite for approximately 30 days after discovery of the tick for infection or other tick-borne illnesses (severe headaches, fever or rash).

3.7 Chiggers (red bugs)

Chiggers are tiny mites that live in areas with grass or brush. Chiggers, also known as red bugs or harvest mites, usually cannot be seen without a magnifying glass. In the United States, they are found mostly in the southeast, the south, and the Midwest. They are most numerous in early summer when grass, weeds and other vegetation are heaviest.

Chiggers attach to skin pores and feed on skin cells for a few days, most often in the warm creases of the body. In the United States chiggers do not cause any diseases. The mites will fall off the body within a few days.

Chigger bites can result in:

- Intense itching at the bite site beginning a few hours after the bite. Itching may be at its worst on the second day and may last for days or weeks.
- A raised bump that gets bigger over 24 to 48 hours and may be present for up to 14 days.
- Less commonly, fever and a rash.

Home treatment can help relieve itching. Many home remedies for chigger bites are based upon the incorrect belief that chiggers burrow into and remain in the skin. Nail polish, alcohol, and bleach have been applied to the bites to attempt to "suffocate" or kill the chiggers. But because the chiggers are not present in the skin, these methods are not effective.

3.8 Reptiles

Reptiles generally receive negative media coverage and attention that are disproportionate to the actual risks they pose. Most reptile encounters are entirely innocuous. Still, some reptiles (particularly venomous snakes) do pose actual risks that must be considered when working outdoors. Since safe, accurate identification of venomous versus harmless snakes can be tricky at best, the primary goal in snakebite prevention is avoidance. Snakes can strike from a great distance so it is best to give them a wide berth. When a snake or lizard is encountered, simply assume it could be dangerous and calmly leave the area.

3.8.1 Venomous Snakes

Venomous snakes can be a significant threat to health and safety when adequate snakebite prevention is not practiced. In rare cases of snakebite envenomation, the paramount concern is getting the victim to a hospital as quickly as possible.

Snakes are typically most active when temperatures are warm: 70°F-85°F (21°C-29°C.) In spring and fall they are more likely to be active during the day, and in summer they are more active at night. Snakes are very secretive animals that seek shelter under/near rocks, logs, vegetation, and debris or in underground refuges. Of course, snakes occasionally move in the open and they may be encountered basking on warm surfaces – day or night. Examples of ideal snake habitat include areas with tall grass, rocky terrain, wood piles, and flat-lying debris such as plywood. Areas with high rodent populations (e.g. outbuildings and farms) are apt to have snakes nearby ready to feed on the rodents. Extra awareness must be employed when working in ideal snake habitat – particularly when temperatures are warm.

3.8.1.1 Snakebite Prevention and Planning

Snakes and the potential for their encounters evoke fear in many people that may lead to distracted or even panicked behavior that can be more dangerous than the snakes themselves. When staffing backcountry projects, managers should assess personnel carefully and select candidates who are relatively comfortable outdoors, reducing the potential for unsafe behavior in snake country. Managers should respect individual differences regarding fear of snakes and be prepared to offer the level of PPE that field personnel require to feel safe at a given jobsite. Planning for work in remote areas should include communication and evacuation procedures in the unlikely event of snakebite.

Most snakebites occur on the lower legs or hands because people step on/near a venomous snake or because they foolishly attempt to handle one. Snakebite prevention is simple – never place any portion of

your body near a snake. Awareness of hand and foot placement at all times in snake habitat yields nearly zero chance of snakebite.

- Leave snakes alone. Do NOT handle snakes (even those that appear to be dead) or attempt to identify them. Do NOT harass or attempt to kill them.
- Never place hands or feet where you cannot see them and always look closely before positioning them near concealments like logs, boulders, pipes, and rubbish.
- Wear leather boots, long trousers, long-sleeved shirts, and leather gloves (when appropriate) to reduce the potential of envenomation.
- Wear snake gaiters, snake leggings or chaps when hiking in tall grass or dense vegetation where it is difficult to visually ascertain safe footing.
- Use a flashlight when working in low light, even on pavement.
- Tread heavily – vibrations can alert snakes of oncoming traffic and give them time to move away.
- Keep jobsites and storage areas tidy to reduce habitat and eliminate rodents, a food source for snakes. Snakes do not stay in areas with no habitat or food.
- Never work alone in remote areas (SWP Remote Work: Working Alone - GAI HSE 200.012)
- At remote jobsites with poor cell phone service, carry a radio, SPOT device, satellite phone or other means of communication for use in emergencies.

3.8.1.2 Signs and Symptoms of Venomous Snakebite

In most cases it is obvious when someone has been envenomated due to sudden pain and swelling. In the event of an envenomation, it is important to remain calm and to seek treatment as rationally as possible. Within minutes of being bitten, the following reactions are possible at the bite site:

- Broken skin - often bleeding or oozing
- Burning pain - often sharp like a bee sting
- Swelling
- Bruising and discoloration
- Numbness

Within two hours of being bitten, the following are possible:

- Advanced swelling, bruising, blistering and pain around the bite
- Nausea and vomiting
- Sweaty, clammy skin
- A metallic taste on tongue
- Dizziness
- Lethargy
- Breathing difficulties
- Loss of consciousness

3.8.1.3 Snakebite Treatment – How to Respond

Snakebite treatment recommendations have simplified considerably in recent years. The primary focus is to get the victim safely and quickly to a hospital where antivenom can be administered if necessary. Modern antivenom is a very effective treatment for snakebite, but public stocks are typically kept only in hospitals – NOT in ambulances, doctors' offices, or urgent care facilities. Therefore, the most effective way to ensure expedient care might vary depending on distance to nearest vehicle, distance to hospital, and severity of bite. In any case, the most important step is to call 911. The American Red Cross recommends the following steps for bites from US snakes:

- Check the scene to make sure it is safe and that there are no snakes close to the victim.
- Remain calm. Reassure the victim.
- CALL 911.
- Wash the wound with soap and water to remove any excess venom from the surface (so long as this does not delay medical attention).
- Keep the injured area lower than the heart.
- Remove clothing or jewelry (shoes, rings, bracelets) that might constrict if swelling occurs.
- Seek medical attention as quickly as possible.

Note that it is no longer necessary in the US to know what kind of snake bit the victim because modern antivenom is effective against every type of North American pit viper – all rattlesnakes, copperheads, and cottonmouths. Do not waste time and risk further injury trying to identify, kill or capture a snake. Coral snake bites (which are incredibly uncommon – fewer than 10 per year in the US) require alternate antivenom and treatment, but management is essentially the same: CALL 911 and get hospital care as quickly as possible.

3.8.1.4 Snakebite - WARNING - WHAT NOT TO DO

Many outdated and potentially harmful methods of snakebite treatment persist in public lore. Current recommendations from the American Red Cross include:

- **NEVER** cut the wound.
- **NEVER** apply suction to the wound.
- **NEVER** apply a constrictive bandage or tourniquet.
- **NEVER** apply ice.
- **NEVER** use electric shock.
- **NEVER** consume alcohol or stimulants and do not use pain relievers until prescribed by a doctor.
- **NEVER** panic or exert energy other than what is required to get medical attention.

3.8.2 Non-venomous Snakes

Native non-venomous snakes pose a minimal safety concern. Nonvenomous snakebites are rare except when the snakes are intentionally handled. In rare cases when they do bite, the damage is no greater than minor skin abrasions. Nonvenomous snakes do not breed with venomous snakes as is often rumored and their bites are not highly infectious. Treatment involves simply washing the wound with soap and water as with any other minor wound.

Nonvenomous snakes employ a wide variety of tactics – like gaping, hissing, striking, tail rattling, and bright coloration – to deter would-be antagonists. Again, if you are not 100% sure of a snake's identification, treat it as a potentially harmful animal and calmly leave the area.

3.8.3 Gila Monsters

The Gila Monster is one of only two species of venomous lizards. It can bite quickly and hold on tenaciously. While a Gila monster bite is extremely painful to humans, none has resulted in a reported human death. To warn off potential predators, Gila Monsters will open their mouth and hiss.

Gila monsters are primarily found in Arizona, the southeastern corner of California, the southern tip of Nevada, and the southwestern corners of Utah and New Mexico, and northwestern Mexico. Gila Monsters are inactive most of the time, hiding in burrows or under rocks. They are rarely seen above ground. Most of their above-ground activity occurs in the spring months during mating season.

3.8.4 Alligators

Alligators are common in waterways throughout much of the southeastern US. Although they very rarely attack humans, encounters are on the rise as we continue to encroach on formerly wild areas and alligator populations grow. The best strategy for managing alligator encounters avoidance or prevention. When left alone, alligators will stay away from humans and pose little threat. The springtime is when alligator breeding season begins in Florida. During breeding season, male alligators become very territorial and will defend their area against intruders. Following the breeding, in June-July, females will lay their eggs in nests created in the preceding months. These nests are mounds of mud, leaves and other vegetation and can be ~1 meter tall and ~2 meters wide. Look out for these nests near the shoreline of swamps, rivers, and estuaries, as female alligators remain near the nest, in nearby water or other shelter, throughout the incubation period, which averages 65 days, and will defend her nest if danger threatens. If someone is attacked by an alligator, apply first aid, including pressure to any open wounds, and seek immediate medical attention.

Health and safety plans for projects taking place in or along waterways in alligator habitat must include detailed plans for working safely near alligators. Following a few simple rules will virtually eliminate the chances of an adverse encounter with alligators:

- **NEVER** swim or wade in areas where alligators are present or potentially present.
- **NEVER** feed alligators.
- **NEVER** approach an alligator on land or in water.
- **NEVER** tease or throw objects at alligators.

3.9 Mammals

Most mammals actively avoid confrontation with humans; however, there are exceptions and Golder personnel should be aware of their possibility when working outdoors. If you are bitten or scratched by a wild mammal seek medical advice immediately due to a fear of rabies.

3.9.1 Deer-Vehicle Collisions

With approximately 250,000 collisions, 200 human deaths and 1 billion dollars in property damage each year in the US alone, deer-vehicle collisions are among the most likely biological hazards we may face. When driving in areas with high deer populations, please drive slowly and use extra caution – especially at dusk and dawn when deer are most active and visibility is limited. When one or more deer are observed on/near the road, assume that others are nearby and that they might leap in front of your vehicle. Remember that deer populations may even be high in urban and suburban areas, making it important to always be alert when behind the wheel.

3.9.2 Dogs

There are approximately five million dog bites each year in the US alone, making dog attacks far more likely than attacks from wild animals. Since dogs may be encountered in virtually any outdoor setting, it is important to take precautions to avoid aggressive encounters. If dogs are known in the area and may present a hazard, consider a defensive spray. Use the same precautions when working in areas with coyotes and wolves.

- Look for warning signs (body language, bared teeth, raised fur) and never taunt any animal.
- NEVER run.
- Remain calm, hold your ground, assume a non-threatening position, use authoritative commands, and back away slowly.
- If an attack seems imminent, use any item within reach, such as a block.
- If attacked or if an attack is witnessed, use any means necessary to end it, including hitting the dog with a solid object on the back of the neck.
- Bites should be washed, treated with antibiotic ointment, bandaged and watched for signs of infection. Severe bites and infections require medical care.

3.9.3 Bears and Cougars

When working in the wilderness where encounters with large predators like bears and cougars are possible, it is important to have a thorough plan in place for avoiding problems and managing encounters.

In bear country, it is important to know which species of bears are in the area (black bears, grizzly bears, or both) and prepare accordingly. If bears or cougars are known in the areas and present a hazard, consider carrying bear or pepper spray. If bear or pepper spray is deemed necessary, be sure read the instructions and keep the bear spray in reach for easy access. If you are working in an area where you are unsure of the hazards posed by large predators, contact the local Golder office for regional information.

3.9.4 Rabid Animals

Rabies is a viral disease that can infect any mammal and is almost always fatal. Rabies incidents have increased in recent years across much of the US. The most common carriers are raccoons, skunks, foxes, and bats. Consider getting a rabies vaccination if working in areas with a known rabies hazard.

- Avoid direct contact with wildlife (dead or alive), especially with animals that are displaying unusual behavior like absence of fear.
- If bitten by a domestic animal, ask the owner for proof of rabies vaccination.
- If bitten or scratched by a wild mammal, get medical advice immediately.

3.9.5 Rodents and Hantaviruses

Hantavirus infections are possible throughout North America after exposure to infected rodents or their droppings. Infections are most common in rural, enclosed spaces where contaminated particles become airborne and are subsequently inhaled. Seldom-used buildings where rodents are active (e.g. storage rooms) are particularly at risk for harboring Hantaviruses.

Symptoms of Hantavirus infection include:

- Fever
- Deep muscle ache
- Severe shortness of breath

If you experience these flu-like symptoms – particularly after being around rodents or their nests – seek immediate medical attention.

Hantavirus prevention includes maintaining clean, well-sealed workplaces, storage buildings, and homes so rodents are less apt to nest within. Avoid areas with rodent activity, particularly enclosed spaces in rural areas. Avoid activities that create dust in buildings or shelters where rodents may be present. Droppings should be sprayed down with bleach water and cleaned up while wearing a dust mask and gloves.

4.0 HAZARDOUS AQUATIC LIFE

From water-borne bacteria to jellyfish to alligators, the variety of potentially hazardous aquatic life is so numerous that discussion of each hazard is beyond the scope of this document. When projects require working in and around aquatic environments, planning must include contingencies for avoiding and addressing hazards specific to the conditions likely to be encountered. If you are working in an area where you are unsure of the hazards posed by aquatic life, contact the local Golder office for regional information.

4.1 Fin spines

Many fish have sharp spines in their fins that can cause puncture wounds if not handled properly. Although most do not have toxins/venom in their spines, the wound may still get infected if not properly cleansed and bandaged. Sharp teeth may cause moderate to severe lacerations if not handled properly. The following sections provide examples of fishes and/or organisms that may require special handling or avoidance.

4.1.1 Scorpion fishes, Leatherjackets, Toadfishes

Some, if not all species of fish in these groups have poisonous spines in their dorsal, pectoral, and/or anal fins. The spines are very sharp and the toxin in them can cause varying degrees of reaction. By far, the scorpion fishes have the most potent toxin in their spines and some species can be much larger than others. In the case of being stung by any of these fish, apply first aid for a puncture wound, and watch for signs of reaction to the toxins. Seek medical attention if necessary. The pain of the toxin can be alleviated before reaching medical facilities by applying a heat compress to the wound or soaking it in clean, hot water.

4.1.2 Sea Urchins

Sea urchins have sharp spines that project out and protect their main body, or test, from all angles. While some species have poisonous or toxic spines, the primary hazard is from puncture wounds where the spine breaks off in the wound and the resulting infection. The spines, like the rest of the urchin's body, are primarily made of calcium that can be brittle and hard to remove. If someone gets stuck with urchin spines, flush the area well with water and hydrogen peroxide (if available). If the wound is large or there are large pieces of spine embedded in the wound, apply first aid as you would for a normal puncture wound and monitor for signs of allergic reaction to possible toxins. Applying a heat pack in the immediate area of the wound may relieve some of the pain associated with the toxin if it is present. It may be necessary to go to the hospital to get the pieces of spine removed.

4.1.3 Jellyfish

Most species of Jellyfish have stinging cells, called nematocysts, which trigger or “fire” upon touch. If jellyfish are encountered in the net, the use of gloves in handling them can prevent the person from being stung, as the nematocysts are usually very small and will not penetrate the glove. However, be cautious after handling jellyfish even with a glove, as some of the nematocysts can rub off and remain on the glove and still fire long after the jellyfish has been removed. If someone gets stung by a jellyfish, it is best to rinse the area with vinegar (do not use fresh water, as that can cause more nematocysts to fire). Different species of jellies have various levels of toxin in their sting. There is a potential for allergic reaction, so monitor the victim and seek medical attention if necessary.

5.0 TOXIC PLANTS

A wide variety of poisonous plants may be encountered when working outdoors. As a rule of thumb, you should never ingest wild plants unless you are 100% certain they are not poisonous and that you will not have an allergic reaction. Accidental ingestion of toxic plant oils can be reduced by frequently washing hands and avoiding facial contact with hands and plant matter.

The most common hazards associated with toxic plants are allergic reactions after touching plants such as poison ivy, oak, and sumac. Most people are prone to some degree of allergic reaction when exposed to the oil of toxic plants. Reactions vary from minor rashes and itching up to severe complications and even death. The following precautions will reduce the potential for contact with toxic plants and their oils:

- Learn to identify poisonous plants (see attachments) and avoid them at all cost
- Wear long-sleeved shirts and long pants
- Wear gloves - preferably disposable, chemical-resistant varieties since cotton gloves will eventually absorb toxic oils
- Apply commercially-available creams (e.g. Ivy Block) that reduce absorption of toxic oils
- Avoid contact with water where toxic plants are abundant since oils can transfer to skin via water
- Decontaminate or dispose of any clothing or tools that might have contacted poisonous plants since oils and resin can remain toxic for years
- NEVER burn poisonous plants as the smoke can cause extreme external and internal reactions

6.0 ADDITIONAL INFORMATION

Tick Information

- Ticks are slow-moving, external parasites that have 8 legs, bulbous bodies, and tiny heads. They live exclusively off the blood from their hosts.
- Although widely distributed across most of the world, ticks are especially common in warm, humid areas with dense vegetation like meadows, forests, brush, and among leaf litter.
- While most tick bites are harmless, ticks can harbor a variety of pathogens that can cause tick-borne illnesses, infections and allergies in humans.
- Ticks typically wait on the outer branches of vegetation and attach to hosts that brush by. They can be difficult to detect on humans because they are small and move slowly over clothing in search of skin to attach to.

Treatment for Ticks

- Use a small pair of tweezers and wear gloves so you don't spread bacteria from the tick to your hands.
- Grasp tick firmly with the tweezers as close to the skin as possible. Gently pull until the tick comes free. Do NOT twist or turn. Do NOT attempt to burn or squeeze the tick while it is attached and NEVER apply gasoline or other solutions to kill the tick while it is still attached.
- Once removed, rinse it down a sink or flush it down a toilet. Consider keeping it in a tightly closed jar or taped to a piece of paper. You may need to show the tick to the doctor if you become ill.
- The area of the bite should leave a small crater or indentation where the head and mouthparts were embedded. If significant portions of the head or mouthparts remain, they may need to be removed by a doctor.
- Cleanse the bite area with soap and water or a mild disinfectant. Observe the area for several days for any reaction to the bite, such as a rash or signs of infection. Apply antibiotic cream to the area.
- Remember to wash your hands thoroughly after handling any tick or instruments that touched a tick. Clean and disinfect any instruments that were used.
- Most tick bites are probably harmless and may cause no problems. The earlier a tick is removed, the less the likelihood that the tick transmitted any disease.

Venomous Snake Information

- Venomous snakes are found in a variety of habitats across most of North America.
- Distinguishing between venomous and harmless species can be difficult and therefore, it is better to avoid snakes altogether and not risk a potentially dangerous encounter.
- Nearly all venomous snakebites in North America are from pit vipers - copperheads, cottonmouths, and rattlesnakes.
- Pit vipers are normally heavy-bodied with triangular-shaped heads. They crawl slowly - although they can strike approximately half their body lengths with remarkable speed. They have a wide variety of colors and patterns that typically camouflage with their surroundings.
- Coral snakes are the only venomous snakes from North America that are not pit vipers. Because coral snakes are small, secretive, and inoffensive; sightings are uncommon and bites are extremely rare. Coral snakes have bold red, yellow, and black bands that can be distinguished from harmless king snakes by remembering the rhyme, “Red touches yellow, kill a fellow. Red touches black, friend of Jack.”
- Most snakebites occur below the knee (due to stepping on/near a snake) or to the hands (due to handling a snake.) Snakebites can be avoided simply by staying away from snakes and being aware of hand and foot placement at all times. When walking in terrain with limited visibility (e.g. tall grass), commercially-available snake gaiters can eliminate the risk of snakebite below the knee.
- Do not believe everything you hear or read about snakes! Snakes are a major subject of misinformation including myths that grossly exaggerate their dangers.
- In the unlikely event of a venomous snakebite, the primary focus should be to get medical attention as quickly as possible.

Western Diamondback Rattlesnake

Snake Gaiters

Cottonmouth (Water Moccasin)

Southern Copperhead

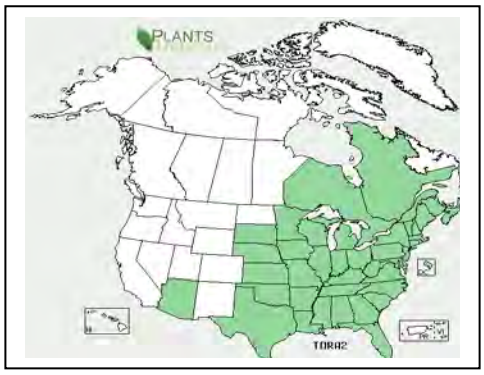
Sonoran Coral Snake

Poison Ivy (*Toxicodendron radicans (eastern)& Toxicodendron rydbergii (western)*) Identification

- Three forms of poison ivy, 1) Erect woody shrub, 2) Running Shrub 3) Woody Vine.
- Three leaflets, two to four inches long, dull or glossy green with pointed tips.
- The middle leaflet is generally larger than the two laterals.
- The margins of the leaflets are variable, appearing irregularly toothed, lobed, or smooth.
- The leaves are positioned *alternately* on the stems.
- Woody vines grow on trees or objects for support and have aerial roots along the stem.

Treatment for Poison Ivy

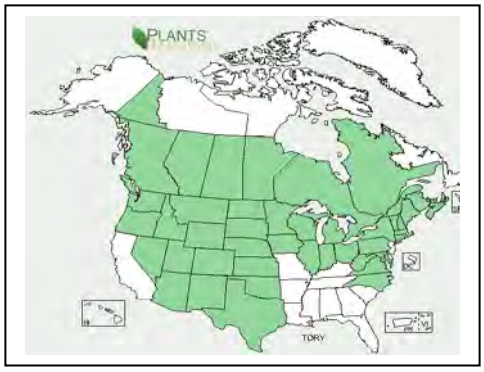
- Have a 'poison ivy action kit' ready, with rubbing alcohol.
- A large bottle of water, some soap and gloves.
- Cleanse exposed areas with rubbing alcohol.
- Next, wash the exposed areas with water only (no soap yet, since soap can move the urushiol, which is the oil from the poison ivy that triggers the rash, around your body and actually make the reaction worse).
- Now, take a shower with soap and warm water.
- Lastly, put gloves on and wipe everything you had with you, including shoes, tools, and your clothes, with rubbing alcohol and water.
- Apply Ivy-Block to exposed areas to prevent Poison Ivy.



Eastern Poison Ivy

Do NOT burn these poisonous plants! The smoke will irritate your skin badly, and if it enters your nasal passages, throat and lungs it will likely cause serious problems and could result in death.

Map Sources:
http://plants.usda.gov/java/profile?symbol=TORA2
http://plants.usda.gov/java/profile?symbol=TORY



Western Poison Ivy

Poison Oak Identification

- Grows in the Eastern United States (from New Jersey to Texas) as a low shrub.
- Grows in the Western United States (along the Pacific coast) as 6-foot-tall clumps or vines up to 30 feet long.
- Oak-like leaves, usually in clusters of three.
- Can have clusters of yellow berries.

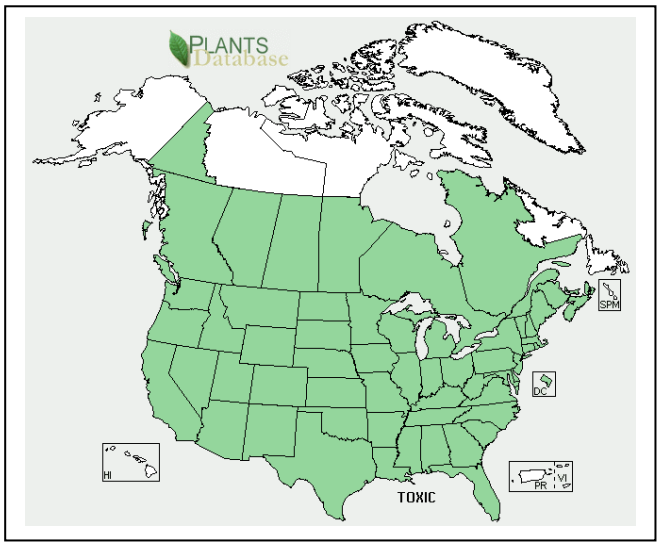
Treatment for Poison Oak

- Initial treatment consists of washing the area with water immediately after contact with the plants. To relieve symptoms, use wet compresses and take cool baths.
- Nonprescription antihistamines and calamine lotion also may help relieve symptoms.
- Moderate or severe cases of the rash may require treatment by a health professional, who may prescribe corticosteroid pills, creams, or ointments.

Do NOT burn these poisonous plants! The smoke will irritate your skin badly, and if it enters your nasal passages, throat and lungs it will likely cause serious problems and could result in death.

Geographic Distribution of Poison Oak in North America

Source: http://plants.usda.gov/java/profile?symbol=TOXIC



Poison Sumac Identification

- Grows exclusively in very wet or flooded soils.
- Ranges in eastern United States and Canada.
- Pinnate leaves, 25-50 cm long.
- 7 - 13 leaflets to each leaf, leaflets are 4-10 cm long.
- Red Leaf veins.
- Small white or grey berry, produced in panicles 10-20 cm long.
- Panicles distinguish it from other sumacs which have red berries.

Treatment for Poison Sumac

- Immediately wash everything that might have touched the plant.
- Soothe itching with cool, wet compresses.
- Add ground oatmeal (approximately 5 cups) or baking soda to a cool bath and soak for 15 to 30 minutes you can even add baking soda or epsom salts to your bath, or make a paste of either of these and apply it to the rash.
- Opt for lotions containing calamine, alcohol and zinc acetate; these will dry the blisters and help speed healing and leave rash open to air. That will help it heal.
- Take an oral antihistamine if you are extremely uncomfortable or if the rash is covering a large area of your body.

Do NOT burn these poisonous plants! The smoke will irritate your skin badly, and if it enters your nasal passages, throat and lungs it will likely cause serious problems and could result in death.

Geographic Distribution of Poison Sumac North America

Source:
http://plants.usda.gov/java/profile?symbol=TOVE

Wild Parsnip Identification

- Pinnately compound leaves, with a main stem and 5 to 15 leaflets.
- Yellow flowers, in flat-topped umbrella-like clusters at the top of the plant.
- Wild parsnip rosettes are among the first plants to become green in spring, and its flowers turn a prominent yellow in midsummer. After flowering and going to seed, plants die and turn brown in fall, but first year rosettes remain green until frost.
- Grows throughout the United States along: Roadsides, abandoned fields, unmowed pastures, edges of woods, prairie restorations.

Treatment for Wild Parsnip

- Take Ibuprophen for help with swelling and pain. The burned area can be covered with a cool, wet cloth. If blisters are present, do not pop them and if the blisters rupture, leave the skin "bandage" in place. To avoid infection, keep the area clean and apply an antibiotic cream.
- Adding Domeboro powder to cool cloth compresses can help dry any of the seeping blisters.
- Doctors will recommend a topical or systemic cortisone-steroid for extreme discomfort. See a doctor for serious cases.
- Washing with Fels-Naptha soap <u>will not</u> help.

Geographic Distribution of Wild Parsnip in North America

Source:
http://plants.usda.gov/java/profile?symbol=TOVE

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Brian Tuccillo	Revision Date	August 2013
Revision by	Angela Kinderis	Revision Date	July 2015

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees who work in the field and in locations where there is potential for heat-stress conditions to develop.

2.0 HEAT STRESS

Heat stress is a condition that can develop when the body is unable to adequately cool itself through responses such as sweating and blood circulation. Employees may experience heat stress due to a combination of environmental factors such as temperature; humidity; radiant heat (i.e., from the sun or another heat source); air velocity; and the concurrent use of personal protective equipment (PPE).

All Project Managers will be trained in the elements of this SWP prior to supervising employees where heat-stress conditions may be present. Project Managers should consider the need to monitor heat stress during the project planning stage based on the site location, type of work, and time of year. Whenever ambient temperatures are forecast to exceed 95ºF, the Site Safety Officer (SSO) and/or field employees will follow high-heat procedures (Section 5.0).

3.0 HEAT-RELATED ILLNESSES

Heat rashes, sunburns, and heat cramps can be painful and uncomfortable, but they are generally not life threatening. Field personnel should be aware that heat rashes or cramps can progress into more serious, potentially life-threatening conditions such as heat exhaustion and heat stroke. Project Managers will be trained in the signs, symptoms, and response measures necessary in the event that emergency conditions develop with any employee under their supervision. Information about these heat-related illnesses is presented below:

Heat Rash Caused by continuous exposure to heat and humid air, and aggravated by chafing clothes. Symptoms: Red cluster of pimples or small blisters often occurring on the neck, upper chest, in the groin, under the breasts, and in elbow creases. First Aid: Keep affected areas dry. Apply dusting powders to increase comfort.

Sunburns Caused by too much exposure of the skin from the sun (i.e., ultraviolet [UV] radiation). Symptoms: Red or painful skin that can blister or peal. Wear protective clothing such as long pants and shirts, or hats and sunglasses. First Aid: Wear water-resistant sunscreen lotion of greater than SPF 30. Work in the shade or under cover.

Fainting Caused when standing in one place in heat, which may cause the blood to pool in the lower areas of the body (due to enlarged blood vessels), leaving the brain without adequate replenishment. Symptoms: Light headedness, dizziness, weak pulse, or cool moist skin. First Aid: Sit down and place your head between your legs or lie down. Once the dizziness subsides, get up and walk around to prevent any further pooling of the blood. Note: Fainting can indicate a serious medical condition. It may be necessary to call 911. Fainting or loss of consciousness, if work related, is an OSHA recordable injury. Contact the Golder Project Manager as soon as time permits.

Heat Cramps Caused by profuse perspiration with inadequate fluid intake and chemical replacement. Signs: Muscle spasms and pain in the extremities and abdomen. If heat cramps are suspected – stop work, move to a cool place, and drink clear juice or a sports drink. Seek medical attention if the employee has a history of heart problems or cramps do not subside within 1 hour.

Heat Exhaustion Caused by increased stress on various organs to meet increased demands to cool the body. Symptoms: Heavy sweating, extreme fatigue or weakness, dizziness, confusion, shallow breathing, nausea, pale, and clammy moist skin. First Aid: If symptoms occur, the employee should leave the work area and proceed to the nearest cool, shaded or air-conditioned location, and drink plenty of water or other cool, non-alcoholic beverages; if possible, take a cool shower or bath and rest until the symptoms pass. Contact the Golder Project Manager immediately.

Heat Stroke The most severe type of heat-related illness. Heat stroke is a medical emergency that may rapidly result in death or permanent disability. It occurs when the body is unable to control its body temperature; the body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. When this occurs, the body temperature can rise to 106°F in 10 to 15 minutes. Symptoms: Red, hot, dry skin or profuse sweating, hallucinations, chills, throbbing headache, high body temperature, confusion/dizziness, and slurred speech. First Aid: Call 911 and seek medical help immediately. If heat stroke is suspected, implement Emergency Response Plan. Move the employee to a cool shaded area, remove excess clothing and cool the person by spraying, sponging, or showering the employee with cool or lukewarm water. Fan their body. Drink water (sip do not gulp, if conscious). Do not give an unconscious person anything to eat or drink. Never place ice on the person. Contact the Golder Project Manager as soon as time permits.

4.0 HEAT-RELATED ILLNESS PREVENTION PLAN

4.1 Monitoring the Heat Index

Employees who are exposed to extreme heat or work in hot environments may be at risk for a heat-related illness. If hot conditions are expected, site-specific training should include heat stress recognition, control, and first aid for heat stress-induced illnesses.

The National Weather Service, which is part of the National Oceanic and Atmospheric Administration (NOAA), published the following Heat Index to evaluate the likelihood of heat-related illness when

temperature and humidity are factored together. Note: values were devised for shady conditions with a light wind. Exposure to full sunshine can increase the Heat Index by up to 15°F. Using the Heat Index, employees can evaluate how hot it really feels when humidity is factored into the actual air temperature. Local weather conditions must be monitored daily or more frequently if conditions warrant.

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: NOAA

4.2 Identifying Risk Factors

Several personal factors can affect how an employee responds to high-heat conditions. It is important to recognize these characteristics when scheduling work and when monitoring field employees for signs of over-exposure. Project Managers must take the following fitness for duty factors into consideration prior to assigning any employee work in an area where heat-related illness may be a factor. Characteristics that can adversely affect a body's reaction to temperature include:

- Fitness level
- Existing medical conditions such as heart disease, diabetes, or high blood pressure
- Pregnancy
- Age (65+)
- Medications (e.g., antihistamines)
- Previous heat-related illness events
- Low fluid consumption (including from the previous day)

Additional increased risk factors that must be considered when preparing to work in hot environments include:

- Exposure to direct sunlight
- Limited or no air flow
- Level of physical exertion required
- Heavy or non-breathable PPE
- Length of the shift

4.3 Heat-Related Illness Prevention

The following steps will help prevent heat-related injuries and illnesses:

- As part of project planning, this SWP will be made readily available to affected Golder employees through the HaSEP document required for the work. This document will be included as part of the mandatory appendices, and all project employees will acknowledge their understanding of the elements contained therein by signing the HaSEP.
- Project Managers, the SSO, and employees will be trained to the content of this SWP to prevent heat-related illnesses prior to managing/supervising and/or conducting work in a hot environment. Training will also include emergency response procedures to follow when an employee exhibits symptoms consistent with possible heat-related illness. See Section 8.0 of this SWP for training requirements.
- Whenever possible, schedule work for cooler times of the day. Attempt to reschedule your work hours or restrict certain work activities so that you are not working in the hottest time of the day, which is typically between 10 a.m. and 2 p.m.
- Project Managers will take steps to help employees become acclimatized (gradually build up exposure to heat, usually 4 to 14 days), especially those employees who are new to working in the heat or have been away from work for a week or more. Gradually increase workloads and allow more frequent breaks during the first 2 weeks of work.
- Employees must be allowed and encouraged to take preventive cool-down breaks in the shade when they feel the need to do so to protect them from overheating. Access to shade shall be permitted at all times. An individual employee who takes a preventive cool-down break (A) shall be monitored and asked if he or she is experiencing symptoms of heat-related illness; (B) shall be encouraged to remain in the shade; and (C) shall not be ordered back to work until any signs or symptoms of heat-related illness have abated, but in no event less than 5 minutes in addition to the time needed to access the shade. If an employee exhibits signs or reports symptoms of heat-related illness while taking a preventive cool-down break or during a preventive cool-down rest period, the Project Manager shall provide appropriate first aid or emergency response.
- The location of adequate medical services must be identified in the project HaSEP.
- All employees must have access to sufficient quantities of fresh, suitably cool, potable water and/or alternative fluids containing electrolytes intended to replace the salt and minerals lost due to sweating. These fluids must be free of charge to the employees. These fluids shall be located as close as practicable to the areas where employees are working.

- Employees should begin drinking extra fluids before starting any work activities. As a general rule of thumb if you are thirsty, your body is already dehydrated.
- If sweating heavily, employees should drink 1 to 2 cups of water (i.e., 16 fluid ounces or 0.24 liters) every 15 to 20 minutes or at each rest break for a total of 17 to 34 cups (i.e., 135 to 270 ounces or 4 to 8 liters) per day.
- Shade shall be present when the temperature exceeds 80°F. Employees shall have access to a cool, shaded, preferably air-conditioned area for rest breaks and meal breaks when the outdoor work area temperature exceeds 80°F. The amount of shade shall be at least enough to accommodate the number of employees on a rest break, so they may sit in a normal posture fully in the shade without having to be in physical contact with each other and shall be located as close as practicable to the areas where employees are working.
- Employees should not consume beverages that contain alcohol, caffeine, or large amounts of sugar to rehydrate. These substances do not help the body to rehydrate and alcohol can cause additional adverse effects. Employees should refrain from drinking alcohol at night and from drinking coffee during working hours.
- Employees should be familiar with the signs of the different heat-related illnesses and should monitor for signs of heat stress for themselves and for those around them (i.e., use the buddy system). Closely monitor employees who have increased risk factors for heat-related illnesses.

5.0 HIGH-HEAT PROCEDURES

All Project Managers shall implement high-heat procedures when the temperature equals or exceeds 95°F. These procedures shall include the following to the extent practicable:

- Ensuring that effective communication by voice, observation, or electronic means is maintained so that employees at the work site can contact their supervisor when necessary. An electronic device, such as a cell phone or text messaging device, may be used for this purpose only if reception in the area is reliable.
- Designating one or more employees on each worksite as authorized to call for emergency medical services, and allowing other employees to call for emergency services when no designated employee is available.
- Holding pre-shift meetings before the commencement of work to review the high-heat procedures, encourage employees to drink plenty of water, and remind employees of their right to take a cool-down rest when necessary.
- Observing employees for alertness and signs or symptoms of heat-related illness. The Project Manager shall ensure effective employee observation/monitoring by implementing one or more of the following:
  - Supervisor or designee observation of 20 or fewer employees, or
  - Mandatory buddy system, or
  - Regular communication with sole employee such as by radio or cellular phone, or
  - Other effective means of observation.
- Reminding employees throughout the work shift to drink plenty of water.

5.1 Emergency Response Procedures

The Project Director, Project Manager, supervisor, or designee shall implement effective emergency response procedures, including:

- Responding to signs and symptoms of possible heat-related illness, including but not limited to first aid measures and how emergency medical services will be provided.
  - If a supervisor or designee observes, or any employee reports, any signs or symptoms of heat-related illness in any employee, the supervisor or designee shall take immediate action commensurate with the severity of the illness.
  - If the signs or symptoms are indicators of severe heat-related illness (such as, but not limited to, decreased level of consciousness, staggering, vomiting, disorientation, irrational behavior, or convulsions), emergency response procedures must be implemented.
  - An employee exhibiting signs or symptoms of heat-related illness shall be monitored and shall not be left alone or sent home without being offered on-site first aid and/or being provided with emergency medical services.
- Contacting emergency medical services and, if necessary, transporting employees to a place where they can be reached by an emergency medical provider.
- In the event of an emergency, ensuring clear and precise directions to the work site can and will be provided as needed to emergency responders.

6.0 ACCLIMATIZATION

All employees shall be closely observed by a supervisor or designee during a heat wave. For purposes of this section only, “heat wave” means any day in which the predicted high temperature for the day will be at least 80°F and at least 10°F higher than the average high daily temperature in the preceding 5 days.

- An employee who has been newly assigned to a high heat area shall be closely observed by a supervisor or designee for the first 14 days of the employee's assignment.

7.0 PERSONAL PROTECTIVE EQUIPMENT FOR SUN PROTECTION

- Select PPE that will take into account both the need to block out UV radiation and the need to reduce the effects of heat.
- It is recommended that Golder employees wear tight-woven clothing that has a minimum ultraviolet protection factor (UPF) of at least 30 (i.e., allows 1/30th of the UV radiation falling on the surface of the clothing to pass through it). Clothing should be lightweight, light colored, loose-fitting, and have a collar to assist with keeping cool.
- Hats should be made of close-weave material and have a wide brim or be legionnaire-style. In circumstances where the wearing of a broad-brimmed hat causes difficulties due to their size, sunscreen and other protective measures should be used instead.
- Sunscreen does not offer complete protection and should always be used in conjunction with other protection such as protective clothing. Broad-spectrum and water-resistant sunscreen with an SPF of 30+ should be used.

- Employees using sunscreen should check the “use by date” of the sunscreen to verify if its effectiveness has expired per the manufacturer’s recommendations.
- Sunscreen will be placed in an easily accessible location, and employees instructed in correct application and use. Sunscreen should be generously applied to all areas of exposed skin at least 20 minutes before going outside and should be reapplied at least every 2 hours, as directed by the manufacturer’s instructions, or as changing conditions warrant.

8.0 TRAINING

8.1 Employee Training

Effective training in the following topics shall be provided to each supervisory and non-supervisory employee before the employee begins work that should reasonably be anticipated to result in exposure to the risk of heat-related illness:

- The environmental and personal risk factors for heat-related illness, as well as the added burden of heat load on the body caused by exertion, clothing, and PPE.
- Golder’s procedures for complying with the requirements of this standard, including Golder’s responsibility to provide water, shade, cool-down rests, and access to first aid as well as the employees’ right to exercise their rights under this standard without retaliation.
- The importance of frequent consumption of water, up to 4 cups per hour, when the work environment is hot and employees are likely to be sweating more than usual in the performance of their duties.
- The concept, importance, and methods of acclimatization.
- The different types of heat-related illness, the common signs and symptoms of heat-related illness, appropriate first aid and/or emergency responses to the different types of heat-related illness, and that heat-related illness may progress quickly from mild symptoms and signs to a serious and life-threatening illness.
- The importance to employees of immediately reporting to the Project Manager, directly or through the employee's supervisor, symptoms or signs of heat-related illness in themselves or in co-workers.
- Golder’s procedures for responding to signs or symptoms of possible heat-related illness, including how emergency medical services will be provided should they become necessary.
- Golder’s documentation in the HaSEP for contacting emergency medical services, and if necessary, for transporting employees to a point where they can be reached by an emergency medical service provider.
- Golder’s documentation in the HaSEP of directions to the work site that can be provided to emergency responders.

8.2 Supervisor Training

Training on the following topics shall be provided to the supervisor prior to supervising employees performing work that should reasonably be anticipated to result in exposure to the risk of heat-related illness:

- The information required for employees above.
- The procedures the supervisor is to follow to implement the applicable provisions in this section.
- The procedures the supervisor is to follow when an employee exhibits signs or reports symptoms consistent with possible heat-related illness, including emergency response procedures.
- How to monitor weather reports and how to respond to hot weather advisories.

9.0 REFERENCES

- Cal/OSHA T8 CCR 3395
- Center for Disease Control (CDC) Preventing Heat-related Illness or Death of Outdoor Workers
- NIOSH: Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986)
- OSHA: Using the Heat Index: A Guide for Employers

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Brian Tuccillo	Revision Date	October, 10 2013

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) staff that work in the field in locations where there is potential for cold stress conditions to develop.

2.0 COLD ENVIRONMENT – COLD STRESS

Employees who are exposed to extreme cold or work in cold environments may be at risk of cold stress. Extreme cold weather is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter, outdoor workers, and those who work in an area that is poorly insulated or without heat. What constitutes cold stress and its effects can vary across different areas of the country. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered factors for "cold stress." Whenever temperatures drop decidedly below normal and as wind speed increases, heat can more rapidly leave your body. These weather-related conditions may lead to serious health problems.

In a cold environment, body heat must be conserved to maintain the core temperature at normal levels and to maintain an adequate blood flow to the brain and extremities. Feelings of cold and discomfort should not be ignored, since these may be early warning signals. The effects of cold are such that problems can occur before the employee is aware of them, and furthermore, over-exposure to cold may affect judgment.

3.0 MANAGING THE CAUSES OF COLD STRESS

Work environments that may expose employees to cold stress conditions must be carefully evaluated as part of development of the site-specific health safety and environment plan (HASEP). Project sites with potential for the development of cold stress include:

- Work in winter months in areas with rain or snow weather conditions and/or
- Work in high altitude locations and/or
- Work in or over water

The following controls may be appropriate to protect employees from cold stress:

- Schedule maintenance and repair work in cold areas for warmer months.
- Schedule cold work for the warmer part of the day.

- Reduce the physical demands of employees.
- Use relief employees or assign extra employees for long duration, demanding jobs.
- Provide warm liquids to employees.
- Provide warm areas for use during break periods.
- Monitor employees who are at risk of cold stress.

Prior to work in an environment where cold stress is an identified hazard (and annually thereafter) provide cold stress training that includes information about:

- Employee risk
- Prevention
- Symptoms
- The importance of monitoring yourself and coworkers for symptoms
- Treatment
- Personal protective equipment

4.0 TYPES OF COLD STRESS

4.1 Frostbite

Frostbite is a condition in which the skin and underlying tissues freeze. Usually affects fingers, hands, toes, feet, ears, cheeks and face – especially the nose. The following specific steps should be taken [adapted from the Centers for Disease Control and Prevention National Institute for Occupational Safety and Health (NIOSH) workplace safety and health topics].

4.1.1 Symptoms

Symptoms of frostbite include:

- Reduced blood flow to hands and feet (fingers or toes can freeze)
- Numbness
- Tingling or stinging
- Aching
- Bluish or pail, waxy skin

4.1.2 First Aid

Employees suffering from frostbite should:

- Get into a warm location as soon as possible.
- Unless absolutely necessary, do not walk on frostbitten feet or toes-this increases the damage.

- Immerse the affected area in warm-not hot-water (the temperature should be comfortable to the touch for unaffected parts of the body).
- Warm the affected area using body heat; for example, the heat of an armpit can be used to warm frostbitten fingers. Rewarming should not be attempted if there is a chance of refreezing; the damage is significantly worse on refreeze and thaw.
- Do not rub or massage the frostbitten area; doing so may cause more damage.
- Do not use a heating pad, heat lamp, or the heat of a stove, fireplace, or radiator for warming. Affected areas are numb and can be easily burned.

4.1.3 Temperatures 40 °F or Below

If ambient temperatures are 40 °F or below, site training should include prevention of cold injury, cold-injury symptoms, and cold-injury first-aid.

- If ambient temperatures are 40 °F or below, and there is a potential for employees to become significantly wet (splashed or soaked), the Site Safety Officer or Field Team Leader should perform at least one of the following controls:
  - Obtain a supply of dry, warm clothing that can be made available immediately.
  - Check to see if the employees are wearing the clothing appropriate for water contact (e.g., immersion-survival suits, neoprene chest waders, wet suit,).
  - Secure an area that will allow employees to take heated break(s) that can be made available immediately.
- A heated break area should be provided if ambient temperatures are below 32 °F.
- At a minimum, breaks should be taken in a warm area every 120 minutes if ambient temperatures are below 32 °F.
- Employees should be allowed to take unscheduled breaks, if needed, in a warm area.

4.2 Hypothermia

When exposed to cold temperatures, the human body begins to lose heat faster than it can be produced. Prolonged exposure to cold will eventually use up the body's stored energy. The result is hypothermia, or abnormally low body temperature. A body temperature that is too low affects the brain, making the victim unable to think clearly or move well. This makes hypothermia particularly dangerous because a person may not know it is happening and will not be able to do anything about it.

When a person has hypothermia, simply applying dry clothes or blankets alone will not help raise a person’s core body temperature. In these situations, an external heat source is necessary. Do not raise a person’s core body temperature rapidly.

4.2.1 Symptoms

Signs and symptoms of hypothermia include:

- Early Symptoms
  - Shivering
  - Fatigue
  - Loss of coordination
  - Confusion and disorientation
- Late Symptoms
  - No shivering
  - Blue skin
  - Dilated pupils
  - Slowed pulse and breathing
  - Loss of consciousness

4.2.2 First Aid

Take the following steps to treat an employee with hypothermia:

- Alert the supervisor and request medical assistance.
- Move the victim into a warm room or shelter.
- Remove their wet clothing.
- Warm the center of their body first-chest, neck, head, and groin-using an electric blanket, if available; or use skin-to-skin contact under loose, dry layers of blankets, clothing, towels, or sheets.
- Warm beverages may help increase the body temperature, but do not give alcoholic beverages. Do not give beverages to an unconscious person.
- After the body temperature has increased, keep the victim dry and wrapped in a warm blanket, including the head and neck.
- If victim has no pulse, begin cardiopulmonary resuscitation (CPR).

4.2.3 What should be done (land):

- Move the person to a warm, dry area. Don't leave the person alone. Remove any wet clothing and replace with warm, dry clothing or wrap the person in blankets.
- Have the person drink warm, sweet drinks (sugar water or sports-type drinks) if they are alert. Avoid drinks with caffeine (coffee, tea or hot chocolate) or alcohol.
- Have the person move their arms and legs to create muscle heat. If they are unable to do this, place warm bottles or hot packs in the arm pits, groin, neck and head areas. Do not warm a person too quickly (shower, warm baths, massaging limbs, etc.), the rapid warming will dilate blood vessels causing a rapid drop in blood pressure, which may induce cardiac arrest.

4.2.4 What should be done (water):

- DO NOT remove any clothing. Button, buckle, zip and tighten any collars, cuffs, shoes, and hoods because the layer of trapped water closest to the body provides a layer of insulation that slows the loss of heat. Keep the head out of the water and put on a hat or hood.
- Get out of the water as quickly as possible or climb on anything floating. DO NOT attempt to swim unless a floating object can be reached because swimming or other physical activity uses the body's heat and reduces survival time by about 50 percent.
- If getting out of the water is not possible, wait quietly and conserve body heat by folding arms across the chest, keeping thighs together, bending knees, and crossing ankles. If another person is in the water, huddle together with chests held closely.

Remove any wet or tight clothing that may cut off blood flow to the affected area.

4.3 Trench foot

Trench foot, also known as immersion foot, is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Trench foot can occur at temperatures as high as 60 degrees F if the feet are constantly wet. Injury occurs because wet feet lose heat 25-times faster than dry feet. Therefore, to prevent heat loss, the body constricts blood vessels to shut down circulation in the feet. Skin tissue begins to die because of lack of oxygen, nutrients, and the buildup of toxic products.

4.3.1 Symptoms

Symptoms of trench foot include:

- Reddening of the skin
- Numbness
- Leg cramps
- Swelling
- Tingling pain
- Blisters or ulcers
- Bleeding under the skin
- Gangrene (the foot may turn dark purple, blue, or gray)

4.3.2 First Aid

Employees suffering from trench foot should:

- Remove shoes/boots and wet socks.
- Dry their feet.
- Avoid walking on feet, as this may cause tissue damage.

5.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Employees should avoid exposure to extremely cold temperatures when possible. When cold environments or temperatures cannot be avoided, employees should follow these recommendations to protect themselves from cold stress:

- Wear appropriate clothing.
  - Dress appropriately for expected weather conditions. Dress in a minimum of three layers (a skin layer to absorb moisture and keep the skin dry, an insulating layer, and an outer protective layer), wear a hat and gloves, in addition to underwear that will keep water away from the skin.
  - Wear several layers of loose clothing. Layering provides better insulation.
  - Tight clothing reduces blood circulation. Warm blood needs to be circulated to the extremities.
  - When choosing clothing, be aware that some clothing may restrict movement resulting in a hazardous situation.
- Make sure to protect the ears, face, hands and feet in extremely cold weather.
  - Boots should be waterproof and insulated.
  - Wear a hat; it will keep your whole body warmer. (Hats reduce the amount of body heat that escapes from your head.)
- Move into warm locations during work breaks; limit the amount of time outside on extremely cold days.
- Carry cold weather gear, such as extra socks, gloves, hats, jacket, blankets, a change of clothes and a thermos of hot liquid.
- Include a thermometer and chemical hot packs in your first aid kit.
- Avoid touching cold metal surfaces with bare skin.

6.0 OTHER CONTROL MEASURES FOR COLD EXPOSURE

6.1 Use the buddy system

Employees must not work alone on any project location where there is potential for cold stress. Monitor your physical condition and that of your coworkers. Recognize the environment and workplace conditions that lead to potential cold-induced illnesses and injuries. Through training and on-going conversations, learn the signs and symptoms of cold induced illnesses/injuries and what to do to help your coworkers.

6.2 Work/Rest Regimen

When working in cold environments it is best to keep active. Take frequent short breaks in warm dry shelters to allow the body to warm up. When resting in a warm location, remove or at least open the outer

layer of clothing to warm the body core. Make every effort to perform work during the warmest part of the day.

6.3 Consumption of Food and Drink

When working in or around a cold environment, eat warm, high calorie foods like hot pasta dishes. Avoid vasodilators, which allow the body to lose heat faster, which can accelerate hypothermia. These include alcohol and drugs. Avoid vasoconstrictors, including tobacco products, which constrict blood vessels and can accelerate the onset of frostbite.

7.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.027 SWP Fatigue Management.
- GAI HSE 200.031 SWP Cold Water Operations.

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Jane Mills	Revision Date	February 2, 2015

1.0 SCOPE

This Standard Work Procedures (SWP) applies to all Golder Associates Inc. (Golder) employees who work in locations where potential inclement weather conditions may develop.

2.0 INTRODUCTION

Severe weather can occur at any hour of the day, and any day of the year. Hurricanes, hailstorms, tornadoes, snowstorms, ice storms, wind storms, floods, severe cold, heat waves and drought occur daily.

3.0 LIGHTNING

Lightning is a rapid discharge of electrical energy in the atmosphere. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. Lightning is extremely dangerous and according to the National Weather Service there are an estimated 25 million lightning flashes each year with an average of 58 fatalities per year and about 300 injuries per year. A lightning flash can travel horizontally many miles away from the thunderstorm and then strike the ground. These types of lightning flashes are called “Bolts from the Blue” because they seem to come out of a clear blue sky. Even when blue sky may exist overhead (or in part of the sky overhead) a thunderstorm could be located 5 to 10 miles away (and sometimes even farther). **If you can hear thunder, you are within striking distance. Seek safe shelter immediately.**

The 30/30 Lightning Rule is a good rule of thumb for anyone who finds themselves outside with a storm on the horizon. The best way to gauge the distance from a thunderstorm to your location is to measure the elapsed time from the flash of the lightning to the bang of the thunder. The 30/30 Rule says to stop outdoor activities when lightning is six miles away. Use the “flash to bang” (lightning to thunder) count in which five seconds equals one mile (10 sec. = 2 miles, 20 sec. = 4 miles, 30 sec. = 6 miles). Conditions are usually considered to be safe after no thunder and no lightning have been observed for thirty minutes. The best places to take cover (in order from what is considered to be the safest to least safe) are as follows:

1. Sturdy Building: A sturdy building is an enclosed building with metal plumbing or wiring to ground the structure. While inside a sturdy building, the following areas should be avoided: open doors and windows; close proximity to electrical equipment and appliances that are plugged into an electrical socket; near pools, tubs, showers, and other plumbing; and land line phones. Do not lie on concrete floors or lean against concrete walls.
2. Vehicle: An enclosed vehicle such as a car, truck, van, or bus with a metal roof and widows that are completely shut. Avoid touching anything metal or any conducting path to the outside such as a steering wheel, ignition, radio, gear shifter, etc. while inside the

car. While inside a safe vehicle, do not use electronic devices such as radio communications. Lightning striking the vehicle, especially the antenna(s), could cause serious injury if you are talking on the radio or holding the microphone at the time of the flash.

3. In the open or unsafe buildings and vehicles: If option 1 or 2 are not available, you may have to stay in the open. Avoid all water, metal objects, high ground, isolated trees, and telephone poles. If lightning is striking nearby, avoid all direct contact with other people; remove all metal objects from your person, and crouch down with feet together and hands on knees making sure that only your feet are touching the ground. Do not lay flat on the ground because it will increase your chance of being struck by a ground current. Unsafe buildings include things like a car ports, open garages, covered patios, picnic shelters, beach pavilions, golf shelters, tents of any kinds, baseball dugouts, sheds and greenhouses. Unsafe vehicles include convertibles, motorcycles, golf carts, 4 wheelers, riding mowers, open cab construction equipment, and boats without cabins.

4.0 TORNADOES

Tornadoes are nature's most violent storms. They are most frequently reported east of the Rocky Mountains during spring and summer months. Peak tornado season in the southern states is March through May; in the northern states, it is late spring through early summer. Tornadoes are most likely to occur between 3 p.m. and 9 p.m., but can occur at any time. However, tornados are often products of power storm systems associated with thunderstorms and hurricanes that can cause high winds, flying debris, heavy rain, and hail.

The Federal Emergency Management Agency (FEMA) reports that tornados generally develop rapidly and can strike with little or no warning and can last for a few minutes to several hours. The forward speeds of tornados range from approximately 0 miles per hour (mph) to 70 mph, with the average being approximately 30 mph. Tornadoes generally occur near the trailing edge of a thunderstorm; however, it is not uncommon to see clear, sunlit skies behind a tornado. Some tornadoes are clearly visible, while rain or nearby low-hanging clouds obscure others. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible. Before a tornado hits, the wind may die down and the air may become very still. A cloud of debris can mark the location of a tornado even if a funnel is not visible. Winds are generally in excess of 100 mph but can be as high as 300 mph.

Whenever weather conditions develop that indicate tornadoes are expected, the National Weather Service may issue a tornado watch to alert people in a designated area for a specific time period. The tornado watch is upgraded to a tornado warning when a funnel cloud is actually sighted. Tornadoes are often preceded by large hail, which follows shortly after the heavy rains and gusts from a thunderstorm have passed.

4.1.1 What to do before a Tornado:

Be alert to changing weather conditions. If you see approaching storms or any of the danger signs, be prepared to take shelter immediately. Look for the following danger signs:

- Dark, often greenish sky.
- Large hail.
- A large, dark, low-lying cloud (particularly if rotating).
- Loud roar, similar to a freight train.

4.1.2 Hazards and Possible Consequences:

Some of the hazards associated with tornadoes include:

- Lightning.
- High winds.
- Heavy rain.
- Hail.

The most serious hazard caused by severe weather is lightning and heavy winds. The most serious hazard caused by tornadoes is from the force of violent wind strength and the fact that these same winds project dangerous debris through the air. Secondary hazards include the following:

- Flash flooding.
- Electric power outages.
- Transportation-system and communication-system disruption.
- Fires.

4.1.3 Control Measures (actions to be taken during severe weather include):

- If severe weather strikes without warning, take cover immediately.
- Seek shelter in designated shelters, basement, storm cellar, hallways or under furniture or other solid structure; or the lowest building level. If there is no basement, go to the center of an interior room on the lowest level away from corners, windows, doors, and outside walls. Put as many walls as possible between you and the outside.
- Remain calm. Do not run, push, or panic.
- Do not open windows.
- Do not use telephones except to report a site emergency.
- Use a battery operated radio in case of a power failure.
- Do not leave the shelter unless directed to do so by your Supervisor (if applicable).

- Wait for the "All Clear" announcement, (30 minutes after last thunder/lightning event), if applicable.

5.0 HURRICANES

A hurricane is a type of tropical cyclone, the generic term for a low pressure system that generally forms in the tropics. The Atlantic hurricane season lasts from June to November, with the peak season from mid-August to late October. Hurricanes and tropical storms can also spawn tornadoes and micro bursts, create storm surges along the coast, and cause extensive damage from heavy rainfall. Winds can exceed 155 mph. The wind scale used by the National Weather Service is based on the Saffir-Simpson Hurricane Wind Scale of Category 1 though Category 5 with Category 1 being the weakest in sustained winds and Category 5 being the strongest in sustained winds. Category Three and higher hurricanes are considered major hurricanes, though Categories One and Two are still extremely dangerous and warrant your full attention.

5.1.1 Hazards and Possible Consequences:

- Hurricane Winds.
- Rainfall and Flooding.
- Flying Debris.
- Storm Surge.
- Tornadoes.

6.0 WINTER STORMS

Heavy snowfall and extreme cold can immobilize an entire region. Even areas that normally experience mild winters can be hit with a major snowstorm or extreme cold. Winter storms can result in flooding, storm surge, closed highways, blocked roads, downed power lines, and hypothermia. Some indicators of a winter storm are freezing rain, sleet, frost/freeze, and blizzards.

- **Freezing Rain**: Rain that freezes when it hits the ground, creating a coating of ice on roads, walkways, trees, and power lines.
- **Sleet**: Rain that turns to ice pellets before reaching the ground. Sleet also causes moisture on roads to freeze and become slippery.
- **Blizzard**: Sustained winds or frequent gusts to 35 miles per hour or greater and considerable amounts of falling or blowing snow (reducing visibility to less than a quarter mile) are expected to prevail for a period of three hours or longer. Add the following supplies to your disaster supplies kit:
  - Rock salt to melt ice on walkways.
  - Sand to improve traction.
  - Snow shovels and other snow removal equipment.

6.1.1 Control Measures (actions to be taken during winter storms) include:

- Listen to your radio, television, or National Oceanic and Atmospheric Administration (NOAA) Weather Radio for weather reports and emergency information.
- Eat regularly and drink ample fluids, but avoid caffeine and alcohol.
- Conserve fuel.
- Maintain ventilation when using kerosene heaters to avoid build-up of toxic fumes. Refuel kerosene heaters outside and keep them at least three feet from flammable objects.

6.1.2 If you are outdoors:

- Avoid overexertion when shoveling snow. Overexertion can bring on a heart attack-a major cause of death in the winter. If you must shovel snow, stretch before going outside.
- Cover your mouth. Protect your lungs from extremely cold air by covering your mouth when outdoors. Try not to speak unless absolutely necessary.
- Keep dry. Change wet clothing frequently to prevent a loss of body heat. Wet clothing loses all of its insulating value and transmits heat rapidly.
- Watch for signs of frostbite. These include loss of feeling and white or pale appearance in extremities such as fingers, toes, ear lobes, and the tip of the nose. If symptoms are detected, get medical help immediately.
- Watch for signs of hypothermia. These include uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness, and apparent exhaustion.

6.1.3 If you are driving:

- Drive only if it is absolutely necessary. If you must drive, consider the following:
- Travel in the day, don't travel alone, and keep others informed of your schedule. Stay on main roads; avoid back road shortcuts.

6.1.4 If a blizzard traps you in the car:

- Pull off the highway. Turn on hazard lights and hang a distress flag from the radio antenna or window.
- Remain in your vehicle where rescuers are most likely to find you. Do not set out on foot unless you can see a building close by where you know you can take shelter. Be careful; distances are distorted by blowing snow. A building may seem close, but be too far to walk to in deep snow.
- Run the engine and heater about 10 minutes each hour to keep warm. When the engine is running, open a downwind window slightly for ventilation and periodically clear snow from the exhaust pipe. This will protect you from possible carbon monoxide poisoning.
- Exercise to maintain body heat, but avoid overexertion. In extreme cold, use road maps, seat covers, and floor mats for insulation. Huddle with passengers and use your coat for a blanket.
- Take turns sleeping. One person should be awake at all times to look for rescue crews.

- Drink fluids to avoid dehydration.
- Be careful not to waste battery power. Balance electrical energy needs - the use of lights, heat, and radio - with supply.
- Turn on the inside light at night so work crews or rescuers can see you.
- Leave the car and proceed on foot - if necessary - once the blizzard passes.

7.0 COMMUNICATIONS

The Site Safety Officer will act as the Golder Incident Coordinator during all inclement weather events. They will monitor the NOAA broadcasts and the instructions of local authorities. They will notify all facility site staff of the weather status, shutdown orders, and evacuation orders. If a hurricane is likely in your area, you should:

- Listen to the radio or TV for information.
- Secure the building, close storm shutters, and secure outdoor objects or bring them indoors.
- Turn off utilities if instructed to do so. Otherwise, turn the refrigerator thermostat to its coldest setting and keep its doors closed.
- Turn off propane tanks. Avoid using the phone, except for serious emergencies.
- Obtain a supply of water for sanitary purposes such as cleaning and flushing toilets. Fill large containers with water.

If you're at the site 36 hours before the predicted arrival of a hurricane:

- Survey site grounds and pick up all loose items and debris.
- Move all barricading materials, such as sandbags and plywood to areas where they will be installed.
- Notify contractors to secure their areas.
- Remove all trailers and scaffolding from site.
- Review hurricane preparedness plan with all personnel.
- Dismiss all site personnel.
- Secure vehicles as needed.
- Bring in outdoor equipment and anchor items that cannot be brought in.
- Close and board up windows.

8.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.004 SWP Heat Stress
- GAI HSE 200.005 SWP Cold Environment Cold Stress

Approved by	Jane Mills	Issue Date	August 31, 2012
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1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees working in areas where there is potential for harmful exposure to benzene, carbon dioxide (CO_2), carbon monoxide (CO), hydrogen sulfide (H_2S), methane (CH_4), nitrogen (N), and 1,3-Butadiene (butadiene**)**. For the purposes of this SWP, gas refers to these six gases only, unless otherwise specified. This SWP replaces Golder's SWP #8 (Landfill Gas Sampling and Monitoring) and #48 (Gas Hazards).

Work areas where potential hazardous gas exposures could be anticipated include, but are not limited to, landfill gas (LFG) extraction wells, monitoring well, gas probes, blower/flare stations, gas-to-energy plants, petroleum refining sites, refinery operations (including tanks, production pipelines), and petroleum field maintenance locations. The presence of the varying concentrations of gases encountered while working on/around remediation and monitoring sites (primarily LFG sites) may expose Golder employees to hazardous situations.

2.0 HEALTH EFFECTS AND EXPOSURE LIMITS

Commonly encountered hazardous gases on Golder project sites includes benzene, CO_2, CO, H_2S, CH_4, N, and butadiene. Health effects and exposures limits for each of these gasses are presented below.

Benzene

Benzene is a colorless to light-yellow liquid with an aromatic odor. As a gas it is typically a lighter than air gas. The affects to the employee can include irritation eyes, skin, nose, respiratory system; dizziness; headache, nausea, staggered gait; anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression. Upon exposure, the gas targets the eyes, skin, respiratory system, blood, central nervous system, bone marrow (potential carcinogen – Leukemia).

- Permissible Exposure Limit (PEL) – 1 ppm or 3.19 mg/m^3 with a STEL of 5 ppm (15.95 mg/m^3) for a 15-minute TWA exposure (OSHA - construction and maritime).
- Recommended Exposure Limit (REL) – 0.1 ppm (0.319 mg/m^3) with a STEL of 1 ppm (3.19 mg/m^3) for a 15-minute TWA exposure. *(NIOSH)*
- Immediately Dangerous to Life and Health (IDLH) – 500 ppm (1,595 mg/m^3) for a single event. *(NIOSH)*

Golder has adopted the following LEL and UEL for H_2S:

- Lower Explosive Limit (LEL) – 1.2% (12,000 ppm).
- Upper Explosive Limit (UEL) – 7.8% (78,000 ppm).

CO_2

CO_2 displaces oxygen and can become an asphyxiant. It can affect the cardiovascular system, lungs, blood, and central nervous system resulting in headaches, dizziness, restlessness, paresthesia (tingling, pricking, or numbness of the skin), shortness of breath, sweating, increased heart rate, elevated blood pressure or pulse, coma, convulsions, and possible death.

- PEL) 5,000 ppm (9000 mg/m^3) Time Weighted Average (TWA) *(OSHA: General, Construction, and Maritime Industry)*
- REL) 5,000 ppm (9,000 mg/m^3) TWA. *(NIOSH)*
- Ceiling – 30,000 ppm (54,000 mg/m^3) for a 10 minute period. *(NIOSH)*
- IDLH – 40,000 ppm (72,000 mg/m3). (NIOSH)
- There is no LEL or UEL for CO2.

CO

CO displaces oxygen, inhibits the blood's ability to carry oxygen, and is considered an asphyxiant. It can affect the respiratory system and cardiovascular system. At low concentrations, symptoms include shortness of breath, mild nausea, dizziness, and mild headaches. As the concentration increases the exposure symptoms include headaches, dizziness, nausea, rapid breathing or pulse, and light-headedness, vision problems, convulsions, seizures, loss of consciousness followed by death within minutes.

- PEL – 50 ppm (55 mg/m^3) TWA. *(OSHA: General, Construction, and Maritime Industry)*
- REL – 35 ppm (40 mg/m^3) TWA. *(NIOSH)*
- Ceiling – 200 ppm (229 mg/m^3). *(NIOSH)*
- IDLH – 1,200 ppm (single event). *(NIOSH)*

Golder has adopted the following LEL and UEL for CO:

- LEL – 12.5% (125,000 ppm). With an action level is 10% of LEL or 12,500 ppm.
- UEL – 74.0% (740,000 ppm).

H_2S

H_2S displaces oxygen, inhibits the blood's ability to carry oxygen, and is considered an asphyxiant. It is a colorless and flammable hazardous gas, associated with a "rotten egg" smell, and is soluble in water. H_2S occurs naturally in crude petroleum and natural gas, and is also produced by the breakdown of organic matter and human/animal waste. H_2S is heavier than air (i.e. collecting in low-lying and enclosed areas such as basements, manholes, sewer lines, underground vaults, etc.). At low concentrations one can exhibit shortness of breath, mild nausea, dizziness, and mild headaches and the concentration increases the symptoms can include headaches, dizziness, nausea, rapid breathing or pulse, and light-headedness, vision problems, convulsions, seizures, loss of consciousness followed by death within minutes.

- PEL – 10 ppm (14 mg/m^3) TWA (OSHA - construction and maritime).
- Ceiling – 50 ppm (70 mg/m^3) for a 10 minute period. *(NIOSH)*

- REL – 10 ppm (15 mg/m^3) for a 10 minute period. *(NIOSH)*
- IDLH – 100 ppm (140 mg/m^3) (single event). *(NIOSH)*

Golder has adopted the following LEL and UEL for H_2S:

- LEL – 4.0% (40,000 ppm) with and action level is 10% of LEL or 4,000 ppm.
- UEL – 44.0% (440,000 ppm).

CH_4

CH_4 displaces oxygen and categorized as a simple asphyxiant. CH_4 can increased breathing rate or pulse, fatigue, difficulty breathing, dizziness, headaches, nausea, and vomiting. At high concentrations (i.e. low concentrations of oxygen) symptoms include a loss of consciousness and death.

- TLV: 1,000 ppm as TLV by American Conference of Governmental Industrial Hygienists (ACGIH).

Golder has adopted the following (LEL and UEL for CH_4:

- LEL 5% (21,000 ppm).
- UEL 15% (95,000 ppm).

N_2

Nitrogen is a simple asphyxiant that is without other significant physiologic effects. Nitrogen can cause the following acute symptoms (short term) such as nausea, drowsiness, and blue coloration of the skin and lips. At high concentrations (i.e., low concentrations of oxygen) symptoms include a loss of consciousness and death.

- PEL – 5 ppm (9 mg/m^3) OSHA?
- REL – 1 ppm (1.8 mg/m^3) NIOSH?
- IDLH – 20 ppm

There is no LEL or UEL for N_2.

Butadiene[1]

Butadiene can cause irritation to the eyes, throat, nose, and lungs following acute low concentration exposures. High concentration exposures to butadiene may result in damage to the central nervous system or cause symptoms such as distorted blurred vision, vertigo, general tiredness, decreased blood pressure, headache, nausea, decreased pulse rate, and fainting. There are no recorded cases of accidental exposures at high concentration that have caused death in humans. The effects of chronic exposure to butadiene are inconclusive but can possibly include increased chances for cardiovascular diseases and cancer.

[1] Sources of 1,3-butadiene released into the air include motor vehicle exhaust, manufacturing and processing facilities, forest fires or other combustion, and cigarette smoke. Higher levels of 1,3-butadiene may be found in highly industrialized cities or near oil refineries, chemical manufacturing plants, and plastic and rubber factories

- PEL – 1 ppm TWA. *(OSHA - construction and maritime)*
- STEL – 5 ppm for a 15 minute period. *(OSHA - construction and maritime)*
- IDLH – 2,000 ppm (10% LEL). *(NIOSH)*

Golder has adopted the following LEL and UEL for Butadiene:

- LEL – 2.0% (20,000 ppm) with an action level is 10% of LEL or 2,000 ppm.
- UEL – 12.0% (120,000 ppm).

Other LFGs

Other hazardous gases typically encountered on landfills (e.g., ammonia and other non-methane organic compounds) can pose an explosion hazard. These gases are unlikely to be present at concentrations above their LELs and rarely pose an explosion hazard as individual gases. The primary gas hazard occurs at landfills when gases displace oxygen and create an oxygen-deficit atmosphere in an enclosed space.

3.0 CONTROL MEASURES INCLUDING PERSONEL PROTECTIVE EQUIPMENT (PPE)

At sites where hazardous gases are known or suspected to exist, Golder employees will conduct air monitoring to determine if employees are exposed hazardous gases at levels in excess of the PEL. Awareness of the hazards is best way to make sure appropriate controls are in place to manage safe gas levels.

During the planning and upon commencement of field activities where a hazardous gas atmosphere could exist the following procedures will be evaluated and implemented.

Project planning and preparation:

- Site Specific Health, Safety and Environment Plan (HaSEP) is required at all Golder work sites. At sites where there is known or potential hazardous gas exposure above the Action Level or PEL, the HaSEP will contain detailed information regarding respiratory protection, PPE as well as emergency action plans, etc and incorporate any components of the clients contingency plans. The plan will provide a site specific compliance program to reduce exposures to or below regulatory limits. This plan will address mechanical and administrative controls along with necessary respirator and PPE and air monitoring requirements. The plan will be reviewed by each employee before conducting field related activities and the plan will reviewed and revised to reflect the most recent exposure monitoring data.
- Engineering and work practice controls should be utilized (when feasible) to reduce exposure to the levels below the PEL. If the controls are not feasible, Golder shall use engineering/work controls to reduce employee exposure to the lowest levels achievable, and shall supplement the controls with appropriate PPE (respiratory protection).
- Employees shall complete a hazard assessment prior to starting work in an area to make sure all hazards are being accounted for, and the appropriate PPE is being utilized properly. Employees shall comply with all PPE manufacturer's guidelines, and government standards regarding personal protection.

Once onsite:

- PPE will be inspected prior to the start of work each day to make sure proper maintenance is being completed, and if the PPE is not up to standard that it is being replaced. The need for additional PPE (respirators, hard hat, gloves, coveralls, vented goggles, footwear, etc.) should be determined during the hazard assessment and made available before beginning the work begins. The PPE shall be provided and worn when appropriate to prevent eye contact and limit dermal exposure. Golder will provide this PPE at no cost to the employee.
- Before the start of any work activities all employees working on the job site must review the Emergency Action Plan (EAP) located within the site specific Health, HaSEP. The EAP and HaSEP identify the procedures, muster points, list required PPE, and emergency contact information in the event that gas levels are detected at or above appropriate action levels.
  - Employees shall familiarize themselves with any client or site specific EAP plans, if required.
  - Employees may be required to participate in client or site specific safety training, evacuation drills, and/or rescue procedures. Unless employees are specifically trained to perform rescue procedures as part of their job duties, they should follow the evacuation plan in the EAP.
- All air monitoring equipment and gas alarms shall be calibrated by the manufacture and have a certificate, sticker, or some other recognition that the equipment has been calibrated and in proper working order.
  - Prior to the start of any work activities and prior to any shift changes the air monitoring equipment shall be calibrated in the field per the manufacturer's recommendations. The calibrations must be documented with information including the date, time, and person performing the calibration.
  - Employees should test the alarms ("bump test") on the air monitoring equipment prior to the start of the work activities and before each shift to make sure the equipment is in proper working order. The alarms should be set at the appropriate action levels outlined in the section 2.0 of this document.
- In the event that a personal or fixed air gas monitors alarms, employees must vacate the area immediately. Precautions should be taken at all times to make sure exits are well marked and unobstructed.
- Personal portable gas detector shall be used in high gas hazard areas.
- In the event that planned PPE will not provide sufficient exposure protection, the site safety contact will consult with the HSC to develop an alternative approach to protect employees.
- Fire extinguishers should be readily available in areas where flammable gases are present such as butadiene, methane, H_2S, etc.
- Smoking is prohibited in areas where flammable gases are present or suspected of being present. Employees shall only smoking in designated areas.

Each of these gases can be monitored by selecting the proper monitoring device (e.g. FID, PID, multi-gas monitor, Draeger tubes); however, the key to the selection process relies on the knowledge of each of the gas and how they react in the work environment. Please consult your health and safety coordinator or a CIH before selecting the monitoring devices.

3.1 Personal Protective Equipment (PPE)

Where reasonably practicable, Golder will reduce the employee exposure through the use of engineering, and administrative controls. Each project site, where the potential for hazardous gas exposure is present, will be evaluated for best application of engineering and administrative controls. PPE will be used to protect the employee when engineering and administrative controls are not applicable or do not improve the conditions to allow work at levels below the PEL. Golder provides respiratory protection, PPE and medical monitoring for all employees who are exposed to hazardous gases, at no cost to the employee. The PPE should include, but is not limited to:

- Hard hat
- Safety glasses
- High visibility vest
- Safety boots
- Dust mask or respirator (if required)
- Rubber gloves
- Flame resistant clothing (FRC)

3.2 Medical surveillance

A medical surveillance program is available for employees who are or may be exposed to hazardous gases at or above the action level 30 or more days per year or may be exposed to above the PELs 10 or more days per year for employees.

3.3 Respiratory Protection

In the event that employees are required to use respiratory protection, they shall be trained in accordance with 29 CFR 1910.134 “Respiratory Protection”. For additional information regarding respiratory protection see Golder’s Respiratory Protection SWP.

Employee(s) who have been properly trained and fit tested for respiratory protection shall use NIOSH approved respirators and shall inspect their equipment prior to each use for possible defects. Employees must use the Assigned Protection Factors (APF) from 29 CFR 1910.134 when evaluating the proper respiratory equipment. Appendix A includes information of the selections of the appropriate respirator type that meets or exceeds the required level of employee protection based on a particular gas.

4.0 TRAINING

Employees who may be exposed to hazardous gases shall receive awareness level training on this SWP prior to any work activities and also have annual refresher classes, as required. The training shall be documented with the employee name and date of training. A copy of the training should be kept within the employee’s personnel file. In addition employees shall review any applicable Safety Data Sheet (SDS) prior

to the start of any work activities and receive awareness training on the Hazardous Communication Program. Training should include the following elements:

- Identification of the characteristics, sources, and hazards of hazardous gases.
- The proper use and handling requirements for the chemical, if applicable.
- Proper positioning of portable and fixed base monitors.
- Proper use and locations of the gas detection methods and monitoring systems (portable and fixed base monitors).
- The recognition of gas hazard warnings (oxygen deficiency, oxygen enrichment, carbon monoxide and H2S) and the proper responses.
- Recognition of symptoms of the gas hazards to which employees are exposed.
- Proper first-aid and evacuation procedures to be used in gas exposure.
- Proper use and maintenance of the PPE.
- Rescue procedures (if job duties require it).
- Wind direction awareness and routes of egress.
- Any client/plant specific training.

The training listed below is the typically required training. This training will be determined based on the type of site and the anticipated tasks to be performed. Specialized or supplemental training such as confined space, lockout/tag out, mine safety, HAZWOPER may also be required.

- On-site training with qualified personnel.
- Golder and site specific instruction.
- Emergency and First Aid/CPR Course.
- 10-hour OSHA Construction Training.
- Confined Space Training (if the excavation meets confined space criteria).
- 40-hour HAZWOPER training (as required by the Site work).
- MSHA Part 46/48 training.

5.0 SPECIAL SITUATIONS

In the event that an employee will be working on a mineral or coal mine facility additional training, air monitoring equipment, PPE, etc. will be required. The Mine Safety and Health Administration (MSHA) requires that all employees working on a surface or underground mine sites receive the appropriate level of mine safety training and compliance with additional regulations.

6.0 RELATED GOLDER DOCUMENTS

- GAI HSE 208 FRC Program
- GAI HSE 200.013 SWP Respiratory Protection

- GAI HSE 200.049 SWP Mining General Safety

7.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.134 “Respiratory Protection”
- 29 CFR 1910.1000, Table Z-2 “Air Contaminants”
- 29 CFR 1910.1200 “Hazard Communication”
- 29 CFR 1926.55 “Gases, vapors, fumes, dusts, and mists”
- 29 CFR 1910.1051 Appendix A
- NIOSH "Pocket Guide to Chemical Hazards" (latest edition)
- MSHA 30 CFR 75.1714

Appendix A

To determine the assigned protection factor (APF) for various types of respirators please refer to Golders Respirator Protection Program (Section 6.4). The APF requirements (as provided by NIOSH) for the gases discussed in the SWP are as follows:

Benzene

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

- (APF = 10,000) Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode.
- (APF = 10,000) Any supplied-air respirator that has a full face piece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

- (APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister.
- Any appropriate escape-type, self-contained breathing apparatus.

Carbon Dioxide

Up to 40000 ppm:

- (APF = 10) Any supplied-air respirator.
- (APF = 50) Any self-contained breathing apparatus with a full face piece.

Emergency or planned entry into unknown concentrations or IDLH conditions:

- (APF = 10,000) Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode.
- (APF = 10,000) Any supplied-air respirator that has a full face piece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

- Any appropriate escape-type, self-contained breathing apparatus.

Carbon Monoxide

Up to 350 ppm:

- (APF = 10) Any supplied-air respirator.

Up to 875 ppm:

- (APF = 25) Any supplied-air respirator operated in a continuous-flow mode.

Up to 1200 ppm:

- (APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern.
- (APF = 50) Any self-contained breathing apparatus with a full face piece.
- (APF = 50) Any supplied-air respirator with a full face piece.

Emergency or planned entry into unknown concentrations or IDLH conditions:

- (APF = 10,000) Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode.
- (APF = 10,000) Any supplied-air respirator that has a full face piece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

- (APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern. Any appropriate escape-type, self-contained breathing apparatus.

Hydrogen Sulfide

Up to 100 ppm:

- (APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern.
- (APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern.
- (APF = 10) Any supplied-air respirator.
- (APF = 50) Any self-contained breathing apparatus with a full face piece.

Emergency or planned entry into unknown concentrations or IDLH conditions:

- (APF = 10,000) Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode.
- (APF = 10,000) Any supplied-air respirator that has a full face piece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

- (APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern Any appropriate escape-type, self-contained breathing apparatus.
- Atmospheres with IDLH of 100 ppm or greater must use Self-Contained Breathing Apparatus (SCBA) or an airline respirator with an escape SCBA.
- If H_2S levels are below 100 ppm <u>and</u> no oxygen deficient atmosphere exists, an air-purifying full-face piece respirator may be used, assuming the filter cartridge/canister is appropriate for hydrogen sulfide. A full face piece respirator will prevent eye irritation.

Butadiene

1 ppm to 5 ppm:

- (APF = 10 to 50) Air-purifying half-mask or full-face piece respirator equipped with approved butadiene or organic vapor cartridges or canisters. Cartridges or canisters shall be replaced every 4 hours.

5 ppm to 10 ppm:

- (APF = 10 to 50) Air-purifying half-mask or full-face piece respirator equipped with approved butadiene or organic vapor cartridges or canisters. Cartridges or canisters shall be replaced every 3 hours.

10 ppm to 25 ppm:

- (APF = 10 to 50) Air-purifying half-mask or full-face piece respirator equipped with approved butadiene or organic vapor cartridges or canisters. Cartridges or canisters shall be replaced every 2 hours.

25 ppm to 50 ppm:

- (APF = 50) Air-purifying full-face piece respirator equipped with approved butadiene or organic vapor cartridges or canisters. Cartridges or canisters shall be replaced every 1 hour; or Powered air-purifying respirator (PAPR) equipped with a tight-fitting face piece and approved butadiene or organic vapor cartridges. PAPR cartridges shall be replaced every 1 hour.

50 ppm and up:

- (APF = 10,000) Supplied-air respirator equipped with a half-mask or full face piece and operated in a pressure-demand or other positive-pressure mode.

Escape:

- (APF = 10,000) Any positive-pressure self-contained breathing apparatus with an appropriate service life; or any air-purifying full-face piece respirator equipped with a front- or back-mounted butadiene or organic vapor canister.

Approved by	Steve Kogon	Issue Date	September 2012
Revision by	Renee Weaver	Revision Date	December 19, 2016

1.0 SCOPE

This Standard Work Procedures (SWP) applies to all Golder Associates Inc. and (Golder) staff working on project sites where overhead hazards, including overhead electricalal hazards are present.

These procedures are not intended to conflict with or supersede regulatory requirements.

2.0 OVERHEAD HAZARDS

Potential contact with overhead hazards occur whenever there is moving equipment such as aerial lifts, cranes, conveyors, drill rigs, mobile equipment, etc., protrusions from machinery, or structural members present above eye level, or whenever an employee must work where there are other work activities being conducted above.

3.0 PRECAUTIONS

- Be alert for potential overhead hazards, “look up and live”.
- Crane booms, excavator arms and high voltage transmission lines do not mix. If a crane or other aerial equipmemt must be used, the operator must maintain the minimum specified clearance from all active power lines.
- If an excavation must be performed in the vicinity of overhead lines, an alternative method should be considered. If an excavator must be used, maintain the minimum specified clearance from all active power lines.
- Spotters shall be used when equipment is being maneuvered around overhead hazards.
- Post and maintain in clear view of an equipment operator, a warning sign identifying an overhead hazard or otherwise communicate the hazard to the equipment operatorWhen working below ground level or where activities may be conducted above your work area, be sure to keep all hand-tools, equipment and materials such as pipe, braces, timber, etc. well back from the edge of the trench or hole so as not to become a falling hazard.
- When working on elevated platforms (ie scaffolds, man-lifts), toe boards must be in place to prevent tools and equipment from being accidentally knocked over the edge.
- .
- Always wear a hard hat when working in areas where there is a potential for injury to the head from falling objects or other potential overhead hazards, whether it is a "hard-hat area" or not.
- A chin strap should be worn on a hard hat in high wind conditions to prevent the hard hat from being blown off.

As with any field project, a HaSEP that includes a worksite hazard assessment/risk register is required. As a supplement to the HaSEP, a Job Safety Analysis (JSA) or Job Hazard Analysis (JHA) should be conducted on-site at the start of the work day and prior to moving equipment to new locations where

overhead hazards may be present. The JSA is used to assess specific HSE hazards and controls at the work locations for individual tasks and are created or revised on the project site by the employees performing the work.

During project planning and proposal/budget preparation, work areas should be visited to observe potential overhead hazards to allow appropriate project-specific planning and arrangements with local utilities before mobilization to the site. It is important that project-specific awareness and risk mitigation for overhead hazards be incorporated into each JSA when work area locations are known.

4.0 OVERHEAD ELECTRICAL HAZARDS

If work must be performed near overhead lines, the lines shall be de-energized and grounded (if feasible). If electrical lines are to be de-energized, arrangements shall be made with the person or organization that operates or controls the electric circuits. Verification must be obtained. Lockout Tagout requirements apply. If lines cannot be de-energized, other protective measures shall be provided before work is started.

- Protective measures such as guarding, isolating, or insulating help to prevent employees from contacting such electrical lines directly with any part of their body or indirectly through conductive materials, tools or equipment.
- Maintain minimum clearance distances between equipment and power lines (see below).

In many situations, a combination of controls may be required. A formal hazard evaluation must establish controls for each situation.

4.1 Clearance Between Mobile Equipment and Power Lines

Unless deenergized, grounded, or insulated to prevent physical contact with the lines, equipment shall maintain the minimum clearance distances in accordance with the table below.

Voltage	Minimum Distance*
Less than 50 kV	10 ft
More than 50 kV	10 ft plus 4 inches for every 10 kV over 50 kV*

*OSHA 29 CFR 1910.333(c)(3)(i)(A) and (B). Local utility companies may have more stringent offset requirements.

If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft for less than or equal to 50 kV. If the voltage is higher than 50 kV, the clearance shall be increased 4 inches for every 10 kV over 50 kV.

Note for work in California, the Occupational Safety and Health Administration (CAL:-OSHA) has different minimum requirements for clearance from power lines. *See 8 CCR 2946.*

These distances apply, but are not limited to, the following types of equipment:

- Drill rigs
- Power shovels
- Excavators
- Wheel loaders
- Backhoes
- Loader backhoes
- Track loaders
- Boom platforms
- Aerial lifts
- Artivulating boom platforms
- Vertical towers

4.2 Clearance Between Scaffolds and Power Lines

A scaffold is defined by OSHA as any temporary elevated platform (supported or suspended) and its supporting structure (including points of anchorage), used for supporting employees or materials or both. The clearance between scaffolds and power lines shall be as follows: Scaffolds shall not be erected, used, dismantled, altered, or moved such that they or any conductive material handled on them might come closer to exposed and energized power lines than as defined in the below table. Note that these values do not apply to crane or derrick suspended personnel platforms.

Insulated Lines		
Voltage	**Minimum Distance* (Feet)**	**Alternatives**
Less than 300 volts	3	
300 volts to 50 kV	10	
More than 50 kV	10 plus 0.4 inches for every 1 kV over 50 kV	2 times the length of the line insulator, but never less than 10 feet.

Uninsulated Lines		
Voltage	**Minimum Distance* (Feet)**	**Alternatives**
Less than 50 kV	10	
More than 50 kV	10 plus 0.4 inches for every 1 kV over 50 kV	2 times the length of the line insulator, but never less than 10 feet.

*OSHA 29 CFR 1926.451(f)(6)

4.3 Clearance Between Cranes/Derricks and Power Lines

This section applies to power-operated equipment, that can hoist, lower and horizontally move a suspended load and includes, but is not limited to:

- Cranes and derricks
- Multi-purpose machines when configured to hoist and lower (by means of a winch or hook) and horizontally move a suspended load
- Dedicated pile drivers
- Service/mechanic trucks with a hoisting device

If work must be performed near overhead lines, one of the following requirements must be met:

- Deenergize and ground. Confirm from the utility owner/operator that the power line has been deenergized and visibly grounded at the worksite.
- Meet the clearance distances in the table below.

Table A	
Voltage	**Minimum Distance***
Up to 50 kV	10 ft
50 kV to 200 kV	15 ft
200 kV to 350 kV	20 ft
350 kV to 500 kV	25 ft
500 kV to 750 kV	35 ft
750 kV to 1000 kV	45 ft
Over 1000 kV	Established by the utility owner/operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution

*29 CFR 1926.1408, Table A

- As an alternative to meeting Table A clearances, ensure that no part of the equipment, load line, or load (including rigging and lifting accessories), gets closer than 20 ft to the power line by implementing the following measures:
  - Conduct a planning meeting with the operator and the other workers who will be in the area of the equipment or load to review the location of the power line(s), and the steps that will be implemented to prevent encroachment/electrocution.
  - Erect and maintain an elevated warning line, barricade, or line of signs, in view of the operator, equipped with flags or similar high-visibility markings, at 20 ft from the power line:
    - If the operator is unable to see the elevated warning line, a dedicated spotter must be used who is in continuous contact with operator. The spotter must be equipped with a visual aid to assist in identifying the minimum clearance distance and be positioned to effectively gauge the clearance distance.
    - In addition to a spotter meeting the above requirements, one of the following must be implemented:
      - A proximity alarm set to give the operator sufficient warning to prevent encroachment.
      - A device that automatically warns the operator when to stop movement, such as a range control warning device.
      - A device that automatically limits range of movement.
      - An insulating link/device installed at a point between the end of the load line and the load.

Per OSHA Standard 29 CFR 1926.1400(c), drill rigs, power shovels, excavators, wheel loaders, backhoes, loader backhoes, and track loaders are exempt from the power line safety requirements in the table above for Cranes and Derricks in Construction. Therefore, General Industry, 29 CFR 1910.333, electrical safety work practices apply. See Clearance Between Mobile Equipment and Power Lines in Section 4.1 above.

5.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.135 Subpart I “Personal Protective Equipment – Head Protection”:
  - Hard Hats for the protection of employees against impact and penetration of falling and flying objects shall meet the specifications contained in American National Standards Institute, ANSI Z89.1-1969, *Safety Requirements for Industrial Head Protection*.
  - Hard Hats for the head protection of employees exposed to high voltage electrical shock and burns shall meet the specifications contained in American National Standards Institute, ANSI Z89.2-1971.
- 29 CFR 1910.333 Subpart S “Electrical – Selection and Use of Work Practices”
- 29 CFR 1910.67 Subpart F “Vehicle - mounted elevating and rotating work platforms”
- 29 CFR 1926.451 Subpart L “Scaffolds – General Requirements”
- 29 CFR 1926.1408 Subpart CC “Cranes and Derricks in Construction – Power Line Safety Equipment Operations”

6.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.001 SWP Drilling
- GAI HSE 200.018 SWP Working Around Heavy Equipment
- GAI HSE 200.030 SWP Ladder Safety
- GAI HSE 200.042 SWP Electrical Safety
- GAI HSE 200.046 SWP Scaffold Safety
- GAI HSE 206 Crane and Rigging Safety

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Renee Weaver	Revision Date	October 1, 2015

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees working on project sites where respiratory protection is or may be required.

2.0 INTRODUCTION

Respiratory protection is required where atmospheric hazards cannot be reduced to acceptable levels through the use of engineering or administrative controls. Respiratory protection is used to prevent inhalation of airborne toxic or harmful materials (liquids, vapors, dusts). All respiratory protection must be utilized in accordance with Golder's Respiratory Protection Program, which is compliant with 29 CFR 1910.134.

This SWP serves as a summary of Golder's written Respiratory Protection Program (GAI HSE 202).

3.0 RESPONSIBILITIES

This section defines the responsibilities to meet the requirements of Golder's Respiratory Protection Program at each applicable level of the organization.

3.1 National Leader of Health Safety and Environment

The National Leader of Health Safety and Environment (NLHSE) is designated as the Respiratory Protection Program Administrator. The NLHSE will establish and implement the Respiratory Protection Program, and is responsible for annual review of the program, preparation of necessary training for delivery at the local office or project level, and technical support for project-specific assessments.

3.2 Project Managers and Site Safety Officers

Each Project Manager (PM) is responsible for recognizing the potential need for respiratory protection at the planning stage of a project and shall address this need when completing the project-specific Health, Safety, and Environment Plan (HaSEP). The PM must either act as or designate a Site Safety Officer (SSO) for the project. The SSO is responsible for implementing applicable standard work procedures in the field. Whenever respiratory protection equipment is utilized, the SSO shall record who wore respiratory protective equipment, when the equipment was worn, where the individual was working at the site, and any other relevant information in the comment section of the air monitoring data sheet or in the project field book.

3.3 Office Health and Safety Coordinators

Each office has a designated Health and Safety Coordinator (HSC) who is responsible for the implementation of the Respiratory Protection Program at the office level. The office HSC is responsible for evaluating the appropriate level of respiratory protection and may assist in the preparation of project-specific HaSEPs in conjunction with the PM or SSO. The HaSEP shall include the type of respiratory protection necessary, the action levels to be observed, the cartridge change out schedule, and other appropriate information. SSO or Field Team Leader.

3.4 Employees

All employees to whom this program applies must review the program prior to their first assignment and annually thereafter. Affected employees must participate in medical surveillance. Employees must come to work prepared to properly wear a respirator (e.g., clean shaven face for men, alternative corrective lenses for eyeglass wearers).

4.0 RESPIRATORY HAZARD RECOGNITION AND EVALUATION

Golder has the responsibility to evaluate the hazards associated with any and all field activities associated with its work. The PM or their designee shall investigate the history of a site to the extent necessary to assess and/or characterize potential hazards. Situations that may require the use of respiratory protection include:

- Oxygen deficient atmospheres;
- Hazardous substances in the air;
- Confined space entry; and
- Face/eye splash hazards (full-face respirator).

The nature of the potential hazard (constituent makeup, concentration, and exposure periods) shall be considered in order to establish employee protection procedures. The identified hazards and protection procedures will be incorporated into the HaSEP.

5.0 CONTROL MEASURES AND PPE

Different types of respirators are available for use depending on the nature of the hazard and the degree of required protection. All respirators must be selected from those approved by the National Institute for Occupational Safety and Health (NIOSH). Common respirator types include:

- **Air-Purifying Respirator (APR) -** (also referred to as Negative Pressure Cartridge Respirator) - work by filtering the air before it is inhaled. APRs can be either full-face or half-face. Hazardous vapors/dusts are removed in special filter cartridges that are attached to the respirator. The specific exposures at the work area must be known to ensure correct

cartridge selection. Cartridges must not be used beyond their stated useful life. These respirators **do not** provide protection in oxygen deficient atmospheres.

- **Powered Air Purifying Respirator (PAPR)** - work by mechanically drawing air through attached filters and blowing the cleaned air into the face mask. PAPRs are generally a full-face type mask and consist of a helmet/hood, filter, power source and a face piece. PAPRs **do not** provide protection in oxygen deficient atmospheres and have the same limitations of other APRs.
- **Supplied Air Respirators (SAR) –** An atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user. All use of SAR system require prior approval of the NLHSE.
- **Airline Respirator** - provides air from a stationary tank or other source through air lines. Air lines cannot exceed 300 feet in length. Required when working in extremely toxic, oxygen deficient or unknown atmospheres. Air quality must be at least Grade D as defined by the Compressed Gas Association. When using a SAR, employees must wear an 'escape bottle' containing at least 5 minutes of air.
- **Self-Contained Breathing Apparatus (SCBA)** is used when complete independence of airlines is required such as emergency response - SCBAs consist of an air cylinder, carrying harness, gauge, safety valve and a full face mask. Only pressure demand versions of SCBAs will be utilized.

Respiratory protection equipment will be provided to all employees that may be exposed to harmful vapors or particulates above regulatory allowable levels, and in oxygen deficient atmospheres. This PPE will be provided to all affected employees at no cost to the employee. Respirators are to be used when engineering control measures are not feasible or during emergency situations with high exposure. Respirators shall be provided that are applicable and suitable for purpose intended.

When wearing respirator protection equipment, employees must leave the respirator use area to:

- Wash their faces and respirator face pieces as necessary to prevent eye or skin irritation associated with respirator use;
- Change cartridges or filters; and
- Replace or repair the respirator if they detect vapor or gas break-through or resistance, or leakage of the face piece.

6.0 MEDICAL SURVEILLANCE

Medical surveillance will be conducted prior to fit-testing employees. The medical surveillance will be confidential, during normal working hours, convenient, understandable, and the employee will be given a chance to discuss the results with the physician.

No employee shall be required to use respiratory protection, including air purifying and/or supplied air respirators, unless they have been approved by a physician, are included in Golder's on-going medical

surveillance program, are adequately trained in the usage, limitations, maintenance, storage, donning the respirators, and have been properly fit-tested.

6.1 Exception for Voluntary Use of Respirators by Employees

In the event that Golder has determined that there is no respiratory hazard present in the workplace, and an employee chooses to voluntarily wear a respirator; no medical evaluation is required. The medical evaluation exception only applies to the voluntary use of filtering facepieces (dust mask). Golder must provide the employee with Appendix D of the Respiratory Protection Standard and make sure that the use of the respirator by the employee does not cause any additional hazard, with the exception of voluntary use of filtering facepieces (dust masks). All other parts of this program still apply to the use of a respirator. Appendix D of the Respiratory Protection Standard is provided in Golder's Respiratory Protection Program.

7.0 FIT TESTING

A respirator should be selected for use after either initial qualitative or initial quantitative fit testing. Employees who wear respirators must be fit tested within the previous year. The fit test must be documented. Sample documentation is provided in Appendix D of Golder's Respiratory Protection Program. Fit test type is dependent on the type of respirator. All tight fitting SAR's and SCBA's respirators must be fit tested using quantitative means (e.g., TSI Porta Count). Fit testing is also required if any changes are noted, such as cosmetic/dental surgery or significant weight change. Once the user has passed the fit test, the corresponding respirator brand, model and size must be utilized. If the user wishes to change brand or size, a new fit test must be performed. Before donning the mask each time, positive and negative pressure seal checks should be conducted, according to the manufacturer.

Anything that can affect the seal must be prohibited and include facial hair, glasses, etc. Respirators with tight-fitting face pieces shall not be worn by employees who have facial hair that comes between the sealing surface of the face piece and the face or that interferes with valve function.

8.0 RESPIRATOR MAINTENANCE

The respirator shall be inspected by the wearer prior to each use to determine that it's clean and in proper working condition. Inspections include:

- Check of respirator function and overall condition;
- Check of tightness of connections;
- Check of condition of the face piece, head straps, valves, and cartridges (cracks, tears, holes, distortion, loose pieces, residues, gaskets);
- Check of condition of flexible (rubber/elastomeric) parts (pliability, deterioration); and

- Verification of appropriate cartridge type and expiration date and date the cartridge was first opened, if applicable.

Emergency escape-only respirators are inspected before being carried into the work area for potential use.

In the case of a SCBA, the employee will follow the monthly inspection procedures specified by the manufacturer. The date and results of the inspection shall be recorded and maintained with the respirator. Respirators that have failed inspection are taken out of service and returned to the SSO or responsible party.

Each employee shall be responsible for the proper cleaning and routine maintenance of their respirator. Respirators are cleaned and disinfected using the procedures specified in Appendix B-2 of the standard (29 CFR 1910.134, Appendix B-2).

Respirators are cleaned and disinfected:

- As often as necessary;
- Before being worn by different individuals;
- After each use for emergency use respirators; and
- After each use for respirators used for fit testing and training.

9.0 TRAINING

Respiratory protection training must be completed initially and annually thereafter. The training program must address employee knowledge of respirators, fit, use, limitations, emergency situations, wearing, fit checks, maintenance and storage, medical signs and symptoms of effective use, and general requirements of the OSHA standard. The training must be provided before requiring the employee to use the respirator. A written outline of the training program can be found in Appendix B of Golder's Respiratory Protection Program.

10.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.134 "Respiratory Protection"

11.0 RELATED GOLDER DOCUMENTS

- GAI HSE 202 Respiratory Protection Program

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Brian Tuccillo	Revision Date	August 2013

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) staff. The majority of falls occur on slippery, uneven, defective, cluttered or obstructed walking surfaces. A significant number of debilitating falls are the result of a person falling out of his or her own chair, typically while in the process of sitting down, or leaning back. Falls from elevations while reaching for an overhead object are also common, and frequently cause severe injuries.

2.0 SLIPS, TRIPS, AND FALLS

Slips are primarily caused by a slippery surface and compounded by wearing the wrong footwear.

Providing dry walking and working surfaces and slip-resistant footwear can minimize slips and their resultant falls and injuries. Shoes with rubber-cleated, soft soles and heels are recommended for most field work.

In work areas where the walking and working surface is likely to be slippery, non-skid strips, mats, or floor coatings should be used.

As little as a 3/8" rise in a walkway can cause a “stubbed” toe resulting in a trip and fall. The same thing can happen when going up a flight of stairs: Only a slight difference in the height of subsequent steps could cause a person to trip and fall. Be aware of uneven surfaces.

3.0 TYPES OF FALLS

Falls are of two basic types: elevated falls and same-level falls. Same-level falls are most frequent, but elevated falls are more severe.

- Same-Level Falls: high frequency--low severity.
- Elevated Falls: lower frequency--high severity.

Same-level falls are generally slips or trips. Injury results when the individual hits a walking or working surface or strikes some other object during the fall. Over 60 percent of elevated falls are from less than 10 feet.

4.0 CONTRIBUTING FACTORS

Proper housekeeping in work and walking areas can contribute to safety and the prevention of falls. It is important to maintain a safe working environment and walking surface. Work areas must remain free of obstacles that might cause slips and trips. One action which promotes good housekeeping in work

environments is the painting of yellow lines to identify working and walking areas. Working and walking areas should never be obstructed by objects of any kind.

Adequate lighting can improve visibility in an area and is an important factor in the prevention of slips and falls. Moving from light to dark areas, or vice versa, can cause temporary vision problems, that might be just enough to cause a person to slip on an oil spill, or trip over a misplaced object.

Carrying an oversized object can also obstruct one's vision and result in a slip or a trip. This is a particularly serious problem on stairs.

If a material spills on the floor, promptly clean it up and post the necessary precautionary signs until it is dry and free of slip hazards.

In addition to wearing the wrong footwear, there are specific behaviors which can lead to slips, trips, and falls. Walking too fast or running can cause major problems. Rapid changes in direction or walking backwards can create a similar problem.

Other problems that can lead to slips, trips and falls are: distractions; not watching where one is going; carrying materials which obstruct view; wearing sunglasses in low-light areas; and failure to use handrails. These and other behaviors, caused by lack of knowledge, impatience, or bad habits developed from past experiences, can lead to falls, injuries, or even death.

5.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.022 SWP Housekeeping.

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Amanda Cote	Revision Date	August 2013

1.0 SCOPE

This Standard Work Procedure (SWP) applies to Golder Associates Inc. (Golder) staff working on a project where groundwater sampling is conducted.

2.0 DEFINITIONS

FID Flame ionizing air monitoring instrument. A direct reading air monitoring instrument equipped with a hydrogen flame that ionizes (through combustion) all combustible organic vapors.

GFCI Ground Fault Circuit Interrupter

HASEP Health, Safety, and Environment Plan

IDW Investigation Derived Waste

MSDS Material Safety Data Sheets

PID Photo ionizing air monitoring instrument. A direct reading air monitoring instrument equipped with an ultraviolet light source that ionizes organic vapors with ionization potentials less than that of the lamp.

PPM Parts Per Million

SDS Safety Data Sheets

SWP Standard Work Procedure

3.0 KEY HAZARDS

- Potential skin, inhalation or eye exposure to contaminated sampling water
- Potential exposure to chemicals including sample preservatives
- Ergonomic hazards including lifting heavy objects such as sample coolers or buckets of purge water

- Ergonomic hazards including repetitive motions such as opening drum bungs or manual bailing
- Insect or snake stings or bites from creatures nesting in wells, well houses or well casings
- Electrical hazards associated with groundwater sampling pumps

If any of these hazards are anticipated on the project site, the corresponding SWP must be included in the Health, Safety and Environment Plan (HASEP).

4.0 PREPARING FOR THE WORK

The site-specific HASEP addressing both known and reasonably anticipated hazards should be prepared prior to the commencement of work. Chemical hazards and their means of detection and control should be reviewed prior to field mobilization. Employees should understand how to use all monitoring equipment including calibration and field check procedures.

5.0 CHEMICAL HAZARD CONTROL

Before sampling any groundwater well, employees must become familiar with the contaminants of concern and review previous sampling data (if available) to understand potential site contaminants and exposure levels. If the groundwater is not expected to contain contaminants, air monitoring, as described below, is not necessary.

5.1 Potential Volatile Chemical Exposure

When initially opening the well, position yourself upwind if possible and keep your face as far from the opening to avoid inhaling volatile contaminants. Avoid any direct contact with a skin surface or eyes with groundwater. Continuous air monitoring should be performed utilizing a photo ionizing or flame ionizing instrument that can measure a minimum of 0.5 parts per million (PPM) organic vapor. Calibrate the air monitoring instrument daily as described by the manufacturer. In general, total organic vapor readings of less than 1 PPM are safe. Steady breathing zone measurements at 1 PPM or above warrant an exposure assessment and re-evaluation of control measures. It may be necessary to implement engineering controls (ventilation) or upgrade personal protective equipment (respiratory protection) to reduce exposure.

5.2 Dry Ice Exposure

Occasionally samples are kept cool with dry ice instead of regular ice, and this presents a special hazard to employees.

5.2.1 Handling

Dry Ice temperature is extremely cold at -109.3°F or -78.5°C. Always handle dry ice with care and wear protective cloth or leather gloves whenever touching it. An oven mitt or towel will work. If touched briefly it is harmless, but prolonged contact with the skin will freeze cells and cause injury similar to a burn.

5.2.2 Storage

Store dry ice in an insulated container. The thicker the insulation, the slower it will sublimate. Do not store dry ice in a completely airtight container. The sublimation of dry ice to carbon dioxide gas will cause any airtight container to expand or possibly explode. Keep proper air ventilation wherever dry ice is stored. The sublimated carbon dioxide gas will sink to low areas and replace oxygenated air. This could cause suffocation if breathed exclusively. Do not store dry ice in a refrigerator freezer.

5.2.3 Ventilation

If dry ice has been in a closed cooler for more than 10 minutes, open the lid and allow adequate ventilation before putting things into or taking things out of the cooler. Leave the area containing dry ice if you start to pant and breath quickly develop a headache or your fingernails or lips start to turn blue. This is the sign that you have breathed in too much CO2 and not enough oxygen. Dry ice CO2 is heavier than air and will accumulate in low spaces.

5.3 Air Monitoring

Action levels for each potential contaminant of concern should be established in the site-specific HASEP. Employees should understand how to respond when action levels are detected. Some organic compounds at high concentrations pose significant flammability or explosive risks. If these concentrations may be encountered at the project site, controls must be established which could include sampling with a minimum of ferrous tools or other sources of ignition.

5.4 Sample Preservative Hazards

Sample preservatives are usually acidic, and handling these preservatives and the containers they are stored in must be done carefully. At all times, when handling containers with preservatives, you must be wearing appropriate gloves and eye protection to protect yourself from splashes and spills. Appropriate gloves and eye protection will be selected based on the preservatives used at the project site and any other anticipated hazards.

5.5 Hazard Communication

Maintain material safety data sheets (MSDS) or Safety Data Sheets (SDS) or equivalent for all chemicals of concern at the site including any chemicals required as part of the sampling program (i.e. calibration gas, sample preservatives, etc.).

5.6 Wastewater Disposal

Collect development or purge water in containers as required for proper disposal. Use secure areas for waste storage to protect the public and client staff from investigation derived waste (IDW). All containers containing IDW must be properly labeled and dated.

6.0 ERGONOMIC HAZARD CONTROL

Many of the activities associated with groundwater sampling represent potential ergonomic hazards. The list below represents a few of the activities that may be associated with this type of sampling.

- Carrying coolers with empty sample containers
- Carrying coolers with full sample containers and/or dry ice
- Lifting and carrying buckets with purge water
- Pouring liquids into a larger drum for storage
- Opening bungs on drums
- Manually bailing water from a well

For any of the activities listed above, consider proper body positioning, scheduling rest breaks, and alternative methods for lifting any object that you cannot lift safely.

7.0 BIOLOGIC HAZARD CONTROL

Well houses, well casings and wells are favorite places for snakes, bees, wasps and similar animals to rest or build homes. Use great care when opening any of these locations to access a well head for sampling. Remember that snakes and insects can relocate overnight, so check before you open them every time.

When first approaching the sampling location, listen for sounds such as the hum of a hive or the rattle of a snake. Look for signs of habitation. Slowly opening doors or covers, and be prepared to close it again quickly, or to run in the event that an insect, snake or other animal is present. Sampling should not proceed until the insect, snake or other animal has been removed from the sampling location.

If you are injured by an insect, snake or other animal, follow the recommendations of HSE 200.003 Biological Hazards.

8.0 ELECTRICAL HAZARD CONTROL

Groundwater sampling often involves using line-operated pumps to extract water from the subsurface. Pumps can be powered by battery, electric generator or compressed gases.

If using an electric generator, employees shall check that it is equipped with ground fault circuit interrupter (GFCI) to prevent possible shock hazards. Batteries and compressed gas cylinders should be safely transported to the sampling location and properly stored, with secondary containment where appropriate.

The process to connect the power supply (battery) to the sampling pump must be strictly followed:

1. Use the correct battery for your particular sampling pump. Check the pump operator's manual for information
2. Check that the pump is **not** plugged in to an electric outlet and that the power switch is off.
3. Connect the positive (usually red) charger cable to the positive (+) battery terminal and the negative (usually black) cable to the negative (-) battery terminal.
4. When use of the pump is complete, disconnect the cables, starting with the negative cable, and then moving on to the positive cable.

Do not allow the battery cable or battery to lie in water.

If internal combustion engines (generators) are used, they must be in an area with adequate ventilation, and free of combustible materials (i.e., dry grass, gasoline, etc.).

9.0 PERSONAL PROTECTIVE EQUIPMENT

- Hard hat, where overhead hazards are present
- Safety glasses (splash goggles should be made available depending on the known hazards that may be present in the groundwater)
- Respirator with appropriate cartridges, as required by potential site conditions
- High visibility clothing (reflective vest)
- Steel-toed safety boots
- Nitrile gloves (or appropriate gloves depending on the known hazards that may be present in the groundwater)

10.0 TRAINING

- 40-hour HAZWOPER (8-hour annual refresher required) if groundwater is known or suspected to be contaminated
- OSHA 10-hour Construction Safety

11.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1926.59: Hazard Communication

- 29 CFR 1926 Subpart E: Personal Protective and Life Saving Equipment

12.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200-026 SWP Compressed Gas Cylinders
- GAI HSE 204 Electrical Safety Program
- GAI HSE 200.003 Biological Exposure

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Brian Tuccillo	Revision Date	December 2013

1.0 SCOPE

This Standard Work Practice (SWP) applies to all Golder Associates Inc. (Golder) staff that will be operating and/or working around heavy or mobile equipment such as drill rigs, cranes, dozers, excavators, compactors, front end loaders, graders, tractors, flatbeds, trucks (dump and haul), aerial lifts, vacuum trucks, etc. Such sites include surface and underground mines, remediation areas, and construction sites. Heavy equipment activity may change daily or hourly, with differing potential hazards that need to be identified and addressed. The purpose of this SWP to provide employees with the basic information needed to safely work on or around mobile equipment.

2.0 DEFINITIONS

Competent Person A competent person is one who is capable of identifying existing and possible hazards in the workplace. A competent person must also have authority to take any corrective action necessary to safely complete the task.

Mobile Equipment Equipment propelled/powered by gasoline, propane, natural gas, diesel or electricity that is used to haul, transport, excavate, move, maneuver, drill, or hoist materials, equipment, products or personnel.

PPE Personal protective equipment.

ROPS Rollover protective structures.

Shall or must Means mandatory.

Should or may Means recommended.

Qualified Person A qualified person is one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience in a technical or engineering has successfully demonstrated his ability to solve or resolve problems relating to the operation, maintenance, and/or the safety controls of the equipment, the work, and/or the project.

3.0 MOBILE EQUIPMENT SAFETY

Only authorized and qualified personnel shall be allowed to operate mobile or electrical equipment. All mobile equipment operators must supply proof of training or show evidence of experience (work history) prior to initially operating equipment.

One of the most important points to remember about working around any piece of heavy equipment is that the operator has a limited field of vision. Always make eye contact with the operator of the equipment prior to moving into swing/operating radius.

3.1 Reviewing Safety Information

Prior to the start of work activities, employees shall review the site-specific Health, Safety, and Environment Plan (HASEP) and/or task-specific Job Safety Analysis (JSA). Employees must acknowledge having read and understood the information presented within the HASEP and/or JSA by signing the job safety briefing form located in the HASEP.

Prior to the work activities and/or in the event of any site or scope of work changes, employees and subcontractors shall conduct a safety meeting (i.e. toolbox meeting). Traffic control procedures regarding the equipment shall be included within that meeting where relevant.

3.2 Daily Inspections/Maintenance

The mobile equipment operator will complete a daily inspection of the equipment that they will be working on prior to its use. The inspections should be documented, and documentation should be maintained with the equipment being inspected and/or to meet any other additional site/client specific requirements.

- If any of the safety equipment (i.e. rollover protective structures, back up alarms functioning and audible above surrounding noise levels, shut off switches, lights, etc.) is not in proper working order and/or in the event of any defects or equipment failures (tires, braking, hydraulic, steering, or other critical systems), the equipment shall be removed from service and locked/tagged out until it can be fixed by a person qualified to make the repairs.
- Preventive maintenance procedures recommended by the manufacturer must be followed.
- Repairs shall not be made unless the equipment is turned off and properly blocked off from movement, such as choking off the wheels. In the event that an adjustment is necessary for the repair the equipment can be moved or turn on temporary.
- Use of any machinery or equipment found to be defective or potentially unsafe is prohibited until unsafe conditions have been corrected.
- In the event of change in shift or operator, the new operator is required to perform their own equipment inspection prior to operating the machine.
- Perform a walk around the equipment to identify any nearby hazards.

3.3 General Operation

- Machinery and mechanized equipment may be operated only by qualified, designated personnel.
- Do not solely rely on your mirrors when turning, swiveling, or backing up the equipment. Turn your head to look around the surrounding area. If necessary, get out of the vehicle to perform a check of the blind spots. Operators shall inform any people working around

the equipment of the potential blind spots and equipment swing radii so they can avoid those areas.

- Operators are to obey the signalers who are assisting with the loading or unloading of equipment from a transportation vehicle, performing traffic control duties, and/or otherwise assisting the operator in moving the equipment. Signalers are to maintain a clear line of site with the operator at all times. Signalers and operators shall have a radio for additional and/or emergency communications.
- Workers around the mobile equipment shall make periodic eye contact with the operator. Remember if you cannot see them then they cannot see you.
- Be alert at all times, the working area and equipment are constantly moving and changing. Listen and identify any back up alarms, periodically scan the area for moving equipment, and never stand next to operating equipment unless the operator has indicated for you to approach the equipment.
- Maintain high visibility when working around mobile equipment. Do not work around or operate equipment in dense fog or other inclement weather that reduces visibility around the immediate work area.
- Never lay on the ground.
- Wear high visibility PPE or clothing.
- Stay out of the blind spots of the equipment operator.

3.4 Roadways

- All pieces of haulage equipment and large mobile equipment will have the right-of-way on all roadways. All other equipment will give way and will keep a safe distance until the roadway is cleared.
- In areas of traffic congestion and narrow travel-ways, the smallest vehicle shall always yield to larger vehicles.
- When following heavy equipment, a safe travelling distance should be maintained at all times. The driver's side mirror should always be visible to you, and hence you to the operator.
- On the majority of operating surface mines, all traffic travels on the left-hand side of the road. However practices may vary between sites. Check with the site superintendent/foreman before travelling on site roadways.
- Overtaking hauling and dump trucks should be done only when the truck operator tells you to do so. Visual and/or radio contact must be made with the operator.
- Road or ground surfaces must be able to support the weight of the load. During slippery, icy, or muddy conditions the operator shall slow down to maintain control of the equipment. If ground conditions cannot be made safe through maintenance or reduced speeds, operations shall cease until such time as the conditions improve to allow safe operation of equipment.
- Mobile equipment operators shall obey all traffic signs and signals, and keep the equipment under control.
- Equipment operators shall maintain a minimum safe distance behind another piece of equipment. At a minimum you should follow behind 10 foot per 10 mph increasing distance with increased speed.
- Machinery or equipment must not be operated in a manner that will endanger persons or property. Do not exceed safe operating speeds and loads.

3.5 Approaching Mobile Equipment

- Never approach an operational piece of heavy equipment until the operator is aware of your presence, your desire to approach, and signals the OK – where possible use radio contact.
- Stand in a safe location well outside the maximum extended reach of the shovel, dragline, or excavator arm, and out of the way of other mobile equipment. With an excavator, the optimum location is within the quadrant of the operator's visual coverage.
- When contact is made either by radio or visual contact, advise the operator of your wish to approach the equipment. The operator may want to complete a task prior to shutting down. If so, remain at the same location until the operator signals the OK to advance. Usually this will involve lowering the bucket to the ground; however practices may vary between sites. It is advisable to check with the site superintendent/foreman before entering areas where heavy equipment is in operation.
- Advise the operator of your task and requirements. Complete your task, advise the operator that you have completed your work, and depart the work area.

3.6 Overhead Hazards

When elevating or lifting equipment near energized overhead lines, the following safety precautions shall be followed (see Overhead Hazards SWP):

- The operator of the lifting equipment shall post and maintain in plain view of the operator and driver on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, a durable warning sign legible at 12 feet. The sign shall read "Unlawful To Operate This Equipment Within 10 Feet of High-Voltage Lines of 50,000 Volts or Less." **This is only required by California Occupational Safety and Health Administration (OSHA).**

4.0 CONTROL OR OPERATING MEASURES

- Mobile equipment operators shall give an audible warning prior to starting up the equipment.
- No personnel shall ride on or in the mobile equipment unless it is designed to seat passengers.
  - Employees are to keep all parts of their bodies within the protective confines of the equipment while the equipment is in motion.
  - Equipment shall not travel on the highway or other public roads unless it is specifically designed and licensed to do so.
- All personnel shall wear a seat belt while the equipment is in operation. Prior to the start of the equipment the seat belt(s) shall be fastened and properly adjusted. Unless the equipment is designed for the operator to be unrestrained/standing, no Golder personnel shall operate equipment that is not outfitted with functioning seatbelts.
- Modification to the equipment is not permitted unless the manufacturer approves of any modifications. The equipment shall be used in the manner it was designed and intended to be used.
- Operators shall not exceed the manufacturer's recommended equipment rating capacity found within the operations and maintenance (O&M) manual.
- All mobile equipment shall be equipped with a functioning back up alarm system.

- Rollover Protective Structures (ROPS) shall be in use on all mobile equipment unless specifically not required in 29 CFR 1926 Subpart O.
- Windshields or protective side glass/windows shall be free of cracks, damage, or any debris which could impair the vision of the operator. Windshields must be equipped with powered wipers, unless specifically designed otherwise. Vehicles that operate under conditions that cause fogging or frosting of windshields must be equipped with operable defogging or defrosting devices
- Loads for transportation shall be properly secured in a manner that will not allow the load to shift, slide, or fall. Loads should be properly centered to provide balance for the transportation vehicle.
    - Mobile loading and haulage equipment shall be inspected by a competent person prior to operation.
- Equipment shall only be fitted with counterweights approved by the equipment manufacturer and shall be installed and used in accordance with the information found within the O&M manual of the machine, Excess counter weighting is not permitted.
- Lift trucks, stackers, etc., must have the rated capacity posted on the vehicle so as to be clearly visible to the operator. When auxiliary removable counterweights are provided by the manufacturer, corresponding alternate rated capacities will also be clearly shown on the vehicle. The ratings are not to be exceeded.
- Unstable loads shall be restacked and secured until they are stable.
- Operators shall not use cell phones, eat, drink, read, or any other activity that would distract their attention from the proper operation of the equipment.
- During fueling activities the equipment shall be turned off, the filler nozzle in contact with the tank, an appropriately sized spill kit nearby, and no smoking within the immediate area of the equipment and fuel source.
- Preventative maintenance activities (fluid changes) shall be conducted in location that will minimize the impacts of any spills and appropriate spill response equipment shall be made available during these activities.
- In the event the equipment is parked on an incline, the wheels shall be properly chocked off to prevent unintended movement.
- Operator(s) and passengers shall use pre-designated access/egress points for the machine.

5.0 ADDITIONAL SPECIFIC REQUIREMENTS

5.1 Underground Mining Requirements

Employees that may be working in underground mining operations and working with the specific equipment outlined below shall follow these additional procedures:

- Before underground mobile equipment is trammed (box-shaped wagon or iron car run on tracks), the operator shall make sure all personnel in the area are clear and in a safe location away from harm. All employees shall notify the operator prior to approaching the equipment.
- When mobile trolley or battery equipment is not in use and unattended (out of sight), the trolley pole shall be removed from the wire or the battery breaker switches must be in the off position. The driveline directional controller must be in the neutral or centered position.

5.2 Suspended Loads

Employees that may be working under suspended loads shall follow these additional procedures:

- During the lifting or hoisting of equipment and materials, employees are to stay clear of the area during the lift and should never position themselves directly under a lifted or suspended load.
- Employees shall not work or pass under the buckets or booms of loaders in operation.
- Dippers, buckets, loading booms, or heavy suspended loads shall not be swung over the cabs of haulage vehicles until the drivers are out of the cabs and out of the area, unless the trucks are designed specifically to protect the drivers from falling material.

5.3 Aerial Lifts

Employees that may be using this type of equipment shall refer to the Aerial Lift SWP (GAI HSE 200.042) for use.

6.0 TRAINING

Any employee or subcontractor that will be operating mobile equipment shall be trained and certified to operate that specific piece of equipment by a qualified person. Training at a minimum should cover, but not limited to the operation procedures, equipment controls, safety work instructions, safety controls, and be conducted by a competent person. The training shall be evaluated through observation of practical operating skills, training and certification by an approved vendor, or documented work history. The training records shall be maintained in employee files, and at a minimum contain the name of the employee, date of training, the name of the trainer (i.e. competent person). Re-certification and/or re-evaluation of the training shall be conducted as required (new machines, change in process, near miss/accident, etc.).

7.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following PPE may be required for work on or around mobile equipment. Additional PPE may be necessary depending on project site conditions and client requirements.

- Hard hat (except within enclosed cab).
- Steel toe boots.
- High visibility safety vest.
- Safety glasses (except within an enclosed cab).
- Work gloves, as needed.
- Hearing protection, as needed.

8.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910 Subpart F Powered Platforms, Manlifts, and Vehicle Mounted Platforms.

- 29 CFR 1910 Subpart N Materials Handling (section related to powered industrial trucks).
- 29 CFR 1926 Subpart O Motorized Vehicles.
- 29 CFR 1926 Subpart N Cranes.
- 29 CFR 1926 Subpart L Scaffolds (sections related to mobile scaffolds and aerial lifts).

9.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.001 SWP Drilling.
- GAI HSE 200.011 SWP Overhead Hazards.
- GAI HSE 200.037 SWP Traffic Safety.
- GAI HSE 205 Forklift Safety.
- GAI HSE 206 Crane and Rigging Safety.

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Jane Mills	Revision Date	August 2013

1.0 SCOPE

This Standard Work Procedures (SWP) applies to all Golder Associates Inc. (Golder) staff working in high noise environments.

2.0 DEFINITION

Noise induced hearing loss is an insidious, debilitating disease. Employees are advised of the potentially harmful effects of excessive noise and should make every effort to limit their exposure both at work and at home. Although noise-induced hearing loss is one of the most common occupational illnesses, it is often ignored because there are no visible effects, it usually develops over a long period of time, and, except in very rare cases, there is no pain. What does occur is a progressive loss of communication, socialization, and responsiveness to the environment.

Work-related hearing loss continues to be a critical workplace safety and health issue. Noise-induced hearing loss is preventable, but once acquired, hearing loss is permanent and irreversible. Prevention measures must be taken by employers and workers to maintain the protection of workers' hearing. The following table below is the Occupational Safety and Health Administrations (OSHA) permissible sound exposure limits found in 29 Code of Federal Regulations (CFR) 1910.95 Table G-16.

Duration per day (hours of exposure)	Sound level (dBA, slow response)
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

3.0 HAZARDS

Golder shall administer a hearing conservation program when employees are exposed to sounds equal or greater than 85 dB(A) on an 8 hour Time-Weighted Average (TWA) bases. Golder will provide earplugs and/or earmuffs to all employees who work where peak noise levels may equal or exceed 85 dB(A) at no

cost to the employee. Unless specific noise readings are available to demonstrate otherwise, noise levels near heavy equipment, drill rigs, pile drivers, concrete coring devices, etc. should be assumed to equal or exceed 85 dB(A). Employees shall use the issued hearing protection devices when in any of the following situations:

- When work area safety requirements include hearing protection.
- When working in an area of steady state (continuous) noise that interferes with normal speech between individuals who are standing at a distance of three feet apart.
- When working in an area of any impact noise (such as driving casing or piles) where the noise is loud enough to cause discomfort.
- When in areas where signs are posted requiring hearing protection.
- When noise levels measured with a properly calibrated sound level meter equal or exceed 85 dB(A).
- At sound levels at or above 105dB dual hearing protection must be implemented.
- At no time shall employees be exposed to sounds either protected or unprotected above 115dB continuously or 140dB with impact/impulsive pressure.

4.0 POSSIBLE CONSEQUENCES

Permanent hearing loss or impairment can result from prolonged exposure to noise at levels above 85 dB(A) on an 8 hour TWA basis. Hearing loss or impairment can also result from shorter exposures at higher sound levels.

5.0 TRAINING

Employees required to work in areas where peak noise levels may equal or exceed 85 dB(A) will be provided with appropriate training regarding hearing conservation before commencing work in these areas. Training will include addressing ambient conditions, as well as changed conditions. Refresher training will be provided as conditions change, or, at a minimum, on an annual basis. Records of training will be maintained in the employee's personnel file, as required in 29 CFR 1910.95 and 1910.120.

6.0 MEDICAL MONITORING

All Golder technical employees participate in the company's medical monitoring program which includes annual or biennial physicals. The medical monitoring program consists of regular, annual, biennial, or periodic physical examinations including audiometric testing in accordance with 29 CFR 1910.95 and 29 CFR 1910.120(f). Prior to beginning employment with Golder, all new employees complete a pre-employment physical examination at no cost to the prospective employee that, among other items, includes a baseline audiogram for the employee. Prior to the baseline audiogram the employee must not be exposed to workplace noise by at least 14 hours. In the event that a standard threshold shift is determined during a regular, periodic audiogram, the employee will be notified within 21 days of the

determination. In addition, employee work habits, Personal Protective Equipment (PPE) and site situations will be evaluated to determine what alternative hearing conservation methods would be appropriate. This evaluation will be conducted in consultation with a qualified medical professional.

Medical monitoring results (including audiograms) are provided to the employee after completion of the physical examination and evaluation of the data by Golder's occupational medical physician or other licensed physician. Audiogram results are retained by Golder with the employee's medical monitoring records for a period of time in accordance with the provisions of 29 CFR 1910.95(m) and 1910.1020(d).

7.0 CONTROL MEASURES

- Where reasonable and practicable, Golder will reduce the worker's exposure to high noise situations through the use of engineering, and administrative controls. Should these controls not be sufficient or effective, PPE will be used to protect the worker.
- Employees shall complete a hazard assessment prior to starting work in an area of high noise, to make sure all hazards are accounted for, and the appropriate PPE is utilized. Employees shall comply with all ear plugs/muffs manufacturer's guidelines, and government standards regarding ear protection.
- Noise levels will be monitored at regular intervals throughout the work period to maintain worker safety. If the noise monitoring confirms excessive noise at a worksite, sound level measurements will be used to evaluate the efficacy of the planned PPE. In the event that planned PPE will not provide sufficient hearing protection, the site safety contact will consult with the office or regional Health and Safety Coordinator to develop an alternative approach to protect worker hearing.
- Hearing protection PPE will be inspected prior to the start of work each day to make sure the PPE is functioning as designed, and if the PPE is in anyway compromised, it is replaced. Hearing PPE will be provided by Golder at no cost to the employee.

8.0 PERSONAL PROTECTIVE EQUIPMENT

Employees shall have the opportunity to select their hearing protection in order to ensure a proper fit for the individual.

9.0 JOB STEPS & PRECAUTIONS

- Workers shall read and understand the SWPs regarding Hearing Protection and PPE.
- A site specific Health, Safety and Environment Plan (HASEP) will contain a hazard assessment that will be completed prior to work commencing to determine the hazards as well as the required PPE.
- PPE will be inspected daily to make sure it is in good working order.

10.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.95 “Occupational Noise Exposure”.
- 29 CFR 1910.120 “Hazardous Waste Operations and Emergency Response”.
- 29 CFR 1910.1020 “Access to Employee Exposure and Medical Records”.
- Ear plugs (Compliant with American National Standards Institute (ANSI) S3.19-1974.)
- Ear muffs (Compliant with ANSI S3.19-1974.)

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Renee Weaver	Revision Date	March 9, 2018

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees who are responsible for housekeeping activities in their workplace, in the office, or on a project site.

2.0 HOUSEKEEPING - GENERAL

The Occupational Safety and Health Administration (OSHA) requires that all places of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition. The floor of every workroom shall be maintained in a clean and, so far as possible, a dry condition. Where wet processes are used, drainage shall be maintained and false floors, platforms, mats, or other dry standing places should be provided where practicable. To facilitate cleaning, every floor, working place, and passageway shall be kept free from protruding nails, splinters, holes, or loose boards.

3.0 HOUSEKEEPING IN THE OFFICE

Housekeeping in office areas is very important because these spaces are almost always occupied during work hours, and conditions in a work area can change depending on the activities being conducted.

- Tools, extension cords, fans, furniture, and loose materials should be located so as not to cause tripping or other hazards. Any tools, materials, and/or equipment subject to displacement or falling must be adequately secured.
- All walkways, stairways, access ways must be kept free of materials, supplies, and obstructions at all times. Be alert to tripping hazards. If you see one, correct it.
- If there is a spill of water, coffee, or other liquids; clean the spill up immediately.

A link to Golder's office inspection form is provided in the reference section of this document.

4.0 HOUSEKEEPING ON THE PROJECT SITE

Housekeeping on project sites is challenging because there are often employees from multiple companies, different tasks are being performed, and because conditions in a work area can change rapidly depending on the activities being conducted.

- Tools, extension cords, hoses, and loose debris/materials should be located so as not to cause tripping or other hazards. Any tools, materials, and/or equipment subject to displacement or falling must be adequately secured.
- Site conditions, vegetation, roadways, pathways must be maintained.
- Collect all waste generated by your work activities daily, and dispose in appropriate containers at the end of each day. Schedule appropriate pick-up and disposal as needed.

- Consolidate and minimize all waste materials, including Investigation Derived Waste (IDW) on a daily basis. Properly label IDW drums and containers and schedule appropriate disposal (as needed).
- Know and follow the site safety plan, practice good housekeeping, follow recommended work practices, and promptly report and/or correct hazards at the worksite.
- Keep the Golder worksite free of unnecessary clutter and debris that could cause an injury or accident. Limit the amount of materials and chemicals onsite to the quantities that you will need. Place trash and debris in the proper receptacles located throughout the job site. Promptly remove combustible materials such as wood and paper from the site.
- Keep storage, staging, and work areas, along with all access/egress points, stairs, and walkways on the construction site, free of obstructions and debris. Store tools and materials neatly and out of the way in storage bins or lockers and keep flammable or hazardous wastes in covered, segregated waste containers. Make sure materials stored on roofs or at heights are secured. Never throw waste, materials, or tools from a building or structure.

5.0 HYGIENE

- An adequate supply of potable water shall be provided at all worksites.
- Non-potable water, such as water for industrial or firefighting purposes only, shall be identified by signs to indicate clearly that the water is unsafe and is not to be used for drinking, washing, or cooking purposes.
- Lavatories and washing facilities shall be maintained in a sanitary condition.
- No employee shall be allowed to consume food or beverages in a toilet room nor in any area exposed to a toxic material.

6.0 GENERAL WASTE MANAGEMENT

If Golder produces or is responsible for management of large amounts of project waste, trash, and/or scrap metal, a plan shall be made prior to the start of work that details any required disposal procedures and equipment. Additional responsibilities may include:

- The materials and waste shall be handled, stored, and transported to minimize the potential for a spill or impact on the environment.
- Outdoor waste receptacles shall be covered to prevent possible waste run-off.
- Project related wastes must be stored and maintained in an organized fashion and the proper waste shall be deposited within the proper receptacle.
- Employees shall follow the site established disposal methods. If waste generated is classified as hazardous, employees must be trained to make sure the proper handling, disposal, and transport of the hazardous waste.
- The client may have recycling programs on the site. Employees are encouraged to recycle waste to the extent practical.

7.0 SPILL PREVENTION

Proper housekeeping practices can help eliminate spills when storing and using chemicals. Good housekeeping best management practices include maintaining clean and organized storage areas, proper labeling, secondary containment, etc. In the event that the chemicals are hazardous by definition, employees shall refer to the Hazardous Waste and Emergency Response SWP (GAI 200.041) and Golder's Hazard Communication Program (GAI HSE 203).

- Chemical substances should be stored in the proper containers to minimize the potential for a spill. Chemicals should be kept in closed containers and stored in such a way that unintended releases can be contained.
- Prior to the initiation of work, the site Health, Safety and Environment Plan (HaSEP) shall identify the chemicals that are being used by Golder and those that may be present around the work area. A copy of the Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) should accompany any chemical. Employees should be familiar with the information on each relevant MSDS or SDS.
- Employees working with chemicals shall have the appropriate spill kit(s). The spill kit(s) must be easily accessible when required in the event of an emergency. Employees must make sure adequate spill response is available by the estimates for the quantity of chemicals being used. The spill kits shall be periodically inspected to make sure the kit(s) have the appropriate materials to contain a spill.
- Employees responsible for cleanup of a spill must have the proper training on the equipment, materials, communication procedures, waste disposal and spill response procedures.
- The HaSEP shall outline the proper communication or emergency measures in the event of a spill. Communication procedures should be based on the type and quantity of materials involved.

8.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.22 "General Requirements"
- 29 CFR 1926.51 "Sanitation"

9.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.014 SWP Slips Trips and Falls
- GAI HSE 200.041 SWP Hazardous Waste and Emergency Response
- GAI HSE 203 Hazard Communication Program (HAZCOM)
- Golder Office Inspection Form

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Jane Mills	Revision Date	August 26, 2015

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees working on Company-Related Business.

2.0 GUIDELINES FOR CELLULAR TELEPHONE USE

Cellular telephones are considered a vital communication link between field personnel, contractors, and clients. Their most important function is to allow us to check in with the office, communicate when we need assistance, and/or provide information from and/or to a remote location. Cell phones also represent a significant risk to users if they are not used with due care and attention. Statistics have shown significantly higher accident rates by drivers using cell phones (whether or not they have hands-free). While conducting Company-Related Business, it is not acceptable to endanger your health and safety or the safety of others by distracting attention from the task at hand to use a cell phone.

3.0 DEFINITIONS

Company Driver Any Employee of the Company who is operating a Company Vehicle at any time; or, any Employee who operates his or her Personal Vehicle on Company-Related Business.

Company-Related Business Any act performed by Employees that is within the scope or the duties of employment for which the Employee was engaged by the Company. This definition does not include an act committed during an Employee's employment which is not in the ordinary course of Company's business or not within the scope of the Employee's workplace authority. Generally, operating one's Personal Vehicle from home to work and back does not constitute Company-Related Business.

Company Vehicle(s) Any vehicle owned, leased, rented and/or insured by the Company. For the purposes of this SWP, this also includes any vehicle that has been rented or leased in either the Company's or the Employee's name for use on Company-Related Business.

Operating a Motor Vehicle A person "operates" a motor vehicle when, while in the vehicle, they make use of any mechanical or electrical system that alone or in sequence sets the vehicle in motion. If the vehicle is parked in a designated parking space and turned on for the purpose of cooling or heating, this does not constitute “operating a motor vehicle”.

4.0 CELLULAR TELEPHONE USE DURING PROJECT WORK

Golder’s Motor Vehicle Policy prohibits the use of cellular telephones while operating a motor vehicle for Company-Related Business. All employees must comply with Golder’s Motor Vehicle Policy.

If your phone rings, no matter what your activity, first consider if the distraction of answering the phone may place you or others in danger. If it does present a hazard, do not answer the phone. The caller can call back or leave a message on your voice mail.

When appropriate, return the call after you have moved to a safe location on the project site that is away from heavy equipment, moving vehicles, and other hazardous conditions. Frequently information from a call must be written, and the act of transcribing information to a notebook reduces your visual connection with project site hazards.

Do not walk around the project site when you are talking on your cell phone. Stand in one place during the call. If you must move to another location, terminate the call, move to the other location, and re-establish the call.

For employees routinely in the field, we recommend you silence your phone when you are on the project site. You can look at your phone when you have time and return the calls when it is safe.

5.0 CELLULAR TELEPHONE USE WHILE DRIVING

The use of Portable Electronic Devices by a Company Driver in a Golder Motor Vehicle Policy-Covered Vehicle is prohibited while operating a Policy-Covered Vehicle. Portable Electronic Devices may remain in the “on” mode while operating a Policy-Covered Vehicle. However, answering calls, placing calls, texting, emailing, accessing the internet, and using headphones are all prohibited. Employees are strongly discouraged from performing other activities that result in taking away meaningful attention to operating a vehicle safely (e.g., eating, reading, applying makeup, shaving, etc.). Portable GPS units are allowed, if permitted by applicable local law and client policy, but the units must not obscure forward vision and care should be taken to prevent their use from distracting the Employee while driving.

6.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.024 SWP Motor Vehicles and Driving on Company Business.
- GAI Motor Vehicle Policy

SWP Motor Vehicles and Driving on Company Business – GAI HSE 200.024

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Brian Tuccillo	Revision Date	April 2014

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) company drivers who operate motor vehicles (company owned, leased, private, or hired) on company business. All employees must comply with Golder's Motor Vehicle Policy, contained within the Employee Handbook. Definitions of the terms in this SWP are the same as the terms in that Policy. In the event of conflict, Golder's Motor Vehicle Policy takes precedence over this SWP.

2.0 MOTOR VEHICLES AND DRIVING ON COMPANY-RELATED BUSINESS

Preventing work-related roadway crashes requires strategies that combine traffic safety principles and sound safety management practices. Although Golder cannot control roadway conditions, the company can provide safety information to employees and set and enforce driver safety policies to promote safe driving behavior.

3.0 GENERAL GUIDELINES

- Company drivers are authorized to operate a motor vehicle (company owned, leased, private, or hired) while on company business.
- Seat belts shall be worn by all drivers and passengers in vehicles on company business.
- Employees must carry legally required insurance if using private vehicles for work purposes.
- For restrictions relating to the use of portable electronic devices reference Golder's Motor Vehicle Policy and the HSE 200.023 SWP Cellular Telephone.
  - While operating a vehicle on company related business, employees shall not use any electronic devices, with the exception of Global Positioning System (GPS) devices. If the employee needs to operate an electronic device, they shall first park the vehicle in a designated and safe parking location.
  - Employees are strongly discouraged from performing other activities that result in taking away meaningful attention to operating a vehicle safely.
- Only operate vehicles for the designed intended purpose.
- Do not drive when fatigued, and follow the driving limitations of Golder's Fitness for Duty and Fatigue policy. Follow applicable hours-of-service regulations.
- Develop work schedules that allow employees to obey speed limits.
- Observe all the rules and regulations pertaining to the use of public land. Always ask permission before crossing pastoral land. Leave gates in the same position as they were found. Keep to constructed vehicle tracks. Avoid areas that are easily damaged, such as swamps, alpine snow plains and vegetated sand dunes. Exercise caution when operating a motor vehicle in a railroad right-of-way.

- Do not operate any vehicle while under the influence of alcohol, illegal drugs, or medications (prescription or over the counter) that might impair the ability to safely operate the vehicle.
- Consider fire safety when parking vehicles in areas with dried grasses, leaves, or other plant material. Hot engine fluids, catalytic converters or other vehicle equipment could ignite dry plant material, and cause a fire. Observe all fire restrictions.

4.0 VEHICLE MAINTENANCE AND FLEET MANAGEMENT

- To keep the vehicle in a safe working order, follow the maintenance requirements prescribed in Golder's fleet management program for company owned or leased vehicles.
- Maintain a Vehicle Condition Check-out/Check-in list for company owned or leased vehicles.
- Test the brakes, wipers, tires (including pressure, this information can be found on the inside of the driver's side door frame), lights, and turn signals, and verify that the vehicle has an inflated spare tire and jack prior to use (in company, private, or rented vehicles). Address any notes or oral warnings concerning vehicle deficiencies. If any safety concerns are identified, the vehicle must not be used.
- Report vehicle deficiencies to the Operations Manager as soon as they are noticed. The Operations Manager, or his/her delegate, will arrange for maintenance of the vehicle.
- Equip company-owned, leased, rented, or private vehicles used for on-site work with fire extinguishers and first aid kits, when appropriate for the work. For example, a journey to a client's office in a populated area would not necessitate a fire extinguisher or first aid kit in the vehicle (unless client requires this equipment).
- Make sure rented or client-provided vehicles are in a roadworthy condition.

5.0 SAFETY TRAINING PROGRAMS

- Teach employees strategies for recognizing and managing driver fatigue and in-vehicle distractions via the Learning Management System (LMS) at least annually.
- Provide appropriate training to employees operating specialized motor vehicles or equipment.
- Emphasize the need to follow safe driving practices on and off the job, through annual training programs.

6.0 DRIVER PERFORMANCE EVALUATION

- Employees must report any traffic violations and/or vehicle accidents or damage that occurred when driving on company related business to the Project Manager or the Human Resource Representative.
- Human Resources Representatives are responsible to make sure each driver of a vehicle being used on company business (company owned, leased, private, or hired) possesses a valid driver's license. The Project Manager is required to verify that the license is appropriate for the type of vehicle to be driven.
- Human Resources will check driving records of prospective employees, and perform periodic rechecks after hiring.
- Human Resources will maintain complete and accurate records of employees' driving performance.

7.0 SECURING LOADS

Unsecured and poorly secured items inside or outside of a vehicle can be extremely dangerous if they are loose or become airborne. They can harm the vehicle driver and passenger, and/or occupants in following vehicles. The following recommendations should be followed:

- Use tie-down straps that are in good condition and rated for the load that the vehicle will carry. Ratcheting tie downs are preferred over bungee cords. Bungee cords have caused numerous serious injuries and even fatalities when over-stretching has resulted in the hook opening or losing grip on the strap resulting in the strap springing back and contacting the user's face. If bungee cords must be used, seek cords with non-metal hook ends to reduce the risk of eye injuries.
- Install mounts to secure loads that are hauled frequently in the same vehicle or trailer.
- Secure tarps covering loads so they are snug and do not flap.
- Check all loads after driving for 30 minutes to make sure that they have not shifted and remain properly secured.
- Loads shall not exceed the manufactures specifications and legal limits for the vehicle.

8.0 VEHICLE SAFETY EQUIPMENT AND EMERGENCY PREPARATION

Be prepared for a driving emergency by ensuring that the vehicle is equipped with roadside emergency supplies. Consider carrying items such as the following, and know how to use them properly:

- Flashlight
- Reflective safety vest
- Light sticks
- Fire extinguisher
- Tire inflator or sealant
- Reflective triangles or flares
- Spill response kit (for company owned or leased vehicles and rentals >30 days) appropriate for the cargo carried in your vehicle.

9.0 SAFE DRIVING TECHNIQUES FOR 4-WHEEL DRIVING

9.1 Driving In Heavy Vegetation

- Check road conditions before proceeding if the ground conditions are unknown or if there is mud or water.
- Do not change transmission gears in the middle of a hazardous area. If in doubt, always choose the lower gear.
- Setting the correct tire pressure when driving off-road is important. Lowering tire pressures helps in soft ground areas. For soft tracks, 140-180 kPa or 20-26 pounds per square inch (psi) is a good tire pressure. The vehicle must be operated at a lower speed when the tires are at lower pressure. Remember to re-inflate the tires as soon as the vehicle is back on hard ground.

- Cross small ridges 'square on' and cross ditches at a slight angle.
- Turn the steering wheel from side to side to maintain traction and move forward if the vehicle begins to lose traction going uphill, along a rutted track, or in mud.

9.2 Driving On Steep Hills

- Use low second or third gear for going uphill and low first gear for going downhill.
- Use the footbrake sparingly and with caution.
- Avoid turning the vehicle sideways on a hill. If the vehicle begins to slide sideways, very slightly accelerate and steer into the slide. This will usually straighten the vehicle's descent.
- Allow sufficient stopping distance between vehicles.
- Do not touch the clutch or accelerator if the vehicle stalls going uphill.

9.3 Sand Driving

- Speed and flotation are important for successful driving on sand. High transmission gear ratio is best, if possible.
- Lower the tire pressure to 20 psi to increase the surface area of tire on the road. When a lower tire pressure is used, the vehicle must be operated at a lower speed. Remember to re-inflate the vehicle tires as soon as the vehicle is back on hard ground.
- Drive in existing wheel tracks if they are present, because the sand in those locations may be more compacted.
- Avoid sudden changes in direction or acceleration. Coast to a stop if possible.
- Approach dunes head on.
- Avoid braking when descending a dune. Point the front of the vehicle downhill. Do not go fast, but also do not go so slow that the wheels stop rolling, or the vehicle begins to slide sideways. A touch on the throttle will keep the wheels moving and the vehicle pointing in the right direction. Be aware that anti-locking braking systems (ABS) may engage which could cause the vehicle to continue to slide down a hill or slope.
- Try to rock the vehicle backwards or forwards, building up a small stretch of hardpack sand from which the vehicle can accelerate if it gets stuck. Do not spin the wheels.
- Be sure that recovery gear is always in the vehicle in these driving conditions.

9.4 Snow, Rain, and Ice Driving

- Carry chains and install them on the tires when required.
- Prepare the vehicle with appropriate safety gear (see section 8 for a preliminary list).
- Travel only on roads and tracks that are open to traffic.
- Do not travel when visibility is poor.
- Vehicles travelling uphill in snow and ice conditions have right of way.
- Park only where directed and as close to the bank as possible. When parking, leave the vehicle in gear. Do not use the handbrake - it could freeze in the "on" position.
- Lift the wiper blades off the windshield when leaving the vehicle parked.

- Watch for other travelers and animals and drive slowly in areas where they may be present. In the event that an animal is encountered on a road where driving conditions are poor due to the presence of snow, ice, or rain, do not over steer to avoid hitting the animal. The act of over steering may cause the vehicle to slide or roll. Most of the time the animal will move out of the road before the vehicle reaches it.
- Consider increasing the load or weight on the rear axle of front-wheel drive vehicles to improve traction when driving in snow, ice, or rain.

9.5 Driving in Mud

- Good tires with deep tread are helpful when driving in muddy conditions.
- Low second or third gears are the best gears for vehicle operation.
- Where appropriate, move the steering wheel rapidly from side to side to improve traction.
- Keep a steady pace.
- Stay out of ruts if possible.
- Rock the vehicle backwards or forwards by alternating between first and reverse if it becomes stuck.

9.6 Driving in Fog/Limited Visibility

- Drive with low beam lights on.
- Drive slowly and carefully.
- If visibility is poor, pull over to a safe location until weather improves if the vehicles in front or behind cannot be seen.

10.0 RELATED GOLDER DOCUMENTS

- Golder Motor Vehicle Policy
- HSE 200.023 SWP Cellular Telephone
- SWP 200.012. SWP Remote Work-Working Alone
- HSE 200.028 SWP All-Terrain Vehicles
- HSE 200.049 SWP Mine General Safety
- HSE 200.043 SWP Snowmobile Safety
- Golder Associates Inc. DOT Driver and Vehicle Program

Approved by	Jane Mills	Issue Date	August 31, 2012
Revision by	Renee Weaver	Revision Date	April 23, 2018

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees who transport or use compressed gas cylinders during work-related activities. Before using a compressed gas cylinder you must have proper training and knowledge of their safe handling and use. All references in this document to cylinders are intended to mean portable compressed gas cylinders.

2.0 KEY HAZARDS

Hazards associated with compressed gas cylinders include oxygen displacement, fires, explosions, and toxic gas exposures, as well as the physical hazards associated with high pressure systems. Special storage, use, and handling precautions are necessary in order to control these hazards.

Additional hazards include:

- Leaks can develop due to corrosion, cracking, poor maintenance and care, or damage;
- Leaks can occur from extended confinement in a closed compartment (trunk or passenger compartment) that is subjected to excessive heating;
- Leaking flammable gases can present a serious fire and/or explosion hazard;
- Oxidizing gases are non-flammable gases that can support and accelerate combustion in the presence of an ignition source and a fuel. Common oxidizing gases include oxygen, chlorine, fluorine and nitrous oxide. Oxidizing gases stored in the presence of an ignition source or fuel can support and vigorously accelerate combustion in an enclosed vehicle;
- Asphyxiant gases include any gas that has the potential to displace oxygen in sufficient quantities to cause asphyxiation. Inert gases include argon, nitrogen, and helium. Inert gases can cause asphyxiation in an enclosed vehicle by displacing the oxygen in air that is necessary to sustain life; and
- Many toxic and corrosive gases create additional hazards other than fire, oxygen displacement, or combustion acceleration and exposure can present serious hazards to unprotected employees.

3.0 HAZARD CONTROL

3.1 Safe Storage

3.1.1 General precautions

- Hazard warnings (e.g., hazard class or name of stored gas) shall be posted in the cylinder storage area in accordance with applicable federal, state and local regulations.
- Storage areas shall be designed to accommodate the various containers of gases. Segregation by partitioning or by spacing in accordance with applicable codes must be provided so that cylinders can be grouped together by the hazard class of the gas.

- Cylinders must be stored in an area that is dry, well ventilated and away from sources of electricity, ignition, or excessive heat (> 125°F). Vehicles, enclosures or other storage areas used to store cylinders shall not be allowed to exceed 125 °F.
- Cylinders stored or used in public areas must be protected against tampering and damage.
- Gas cylinders shall not be stored:
  - Where heavy moving objects can strike or fall on them.
  - In hallways, near exits, under stairways, or other unprotected areas.
  - Where they obstruct walkways, exit routes, or other areas normally used or intended for the safe exit of personnel.
  - Near elevators.
  - At unprotected platform edges.

3.1.2 Outdoor storage

- Outdoor storage areas for compressed gas cylinders should have good drainage, should be secured against general access (locked in protective enclosures), and shall be protected from direct sunlight.
- Cylinders stored outside should be protected from the ground beneath to prevent corrosion.

3.1.3 Cylinder positions in storage

- All compressed gas cylinders in service or in storage shall be secured to prevent falling or rolling. The method used to secure cylinders can be dependent on the seismic risk and shall be in accordance with local building and fire prevention codes.
- While in storage, regulators shall be removed and stored appropriately and cylinder valve-protection caps must be firmly in place.
- Always store nitrogen, argon, acetylene, or cryogenic liquid cylinders in an upright position.

3.1.4 Cylinder labeling and segregation

- All compressed gas cylinders must be clearly marked with the name of the compressed gas or liquid it contains. If the labeling on a cylinder becomes unclear, the cylinder should be marked “contents unknown” and returned to the supplier
- Empty cylinders should be stored separately and labeled “empty”, full cylinders shall be labeled “full”. Consider segregating full cylinders from empty cylinders.
- Cylinders must be segregated in hazard classes while in storage (e.g., oxidizers (oxygen) separated from flammable gases).
- Oxygen cylinders - minimum of 20 feet maintained between flammable gas cylinders and oxygen cylinder or separated by a 5 foot firewall with a fire rating of 30 minutes.
- Do not store cylinders near highly flammable substances such as oil, gasoline, or waste.

3.2 Safe Handling of Compressed Gases

Employees handling or using compressed gas cylinders, or working in areas where gas cylinders are present, shall have an adequate knowledge of the cylinders contents and the methods necessary to maintain safe operating conditions.

3.2.1 General safe practices

- Always read the label and SDS for information on the hazards.
- Do not refill a cylinder due to the risk of mixing gases. Contact a vendor for service.
- Use soapy water to detect a leak. If a leak is detected and cannot be remedied, attach a tag stating "Cylinder is unserviceable" and move cylinder to a well-ventilated location. Warn of appropriate hazards with signage.
- Do not use compressed air for cleaning purposes; unless the pressure at the nozzle is reduced to less than 30 psi and is OSHA-compliant (29 CFR 1910.242(b)).
- Never use compressed gas to dust off clothing, as this may cause injury to the eyes or body.
- Cylinders are not to be rolled in the horizontal position or dragged. For large, awkward, or heavy (e.g., >40 lbs) cylinders, a suitable hand truck or cart should be used with the cylinder secured to the device.
- Caution should be used to guard against dropping or permitting the cylinders to violently strike against each other or other surfaces.

3.2.2 Compressed gas cylinder contents

3.2.2.1 Flammable gases

- Flammable gases shall be stored in a well-ventilated area and must be segregated from highly flammable solvents, combustible waste material, and sources of ignition.
- NO SMOKING signs shall be posted around the storage area or at entrances to storage rooms containing flammable gases.
- Flammable gases stored outdoors where ambient temperatures exceed 125°F (including in the unprotected bed of a truck) shall be protected from direct sunlight.
- Acetylene containers shall be positioned with the valve end up to lessen the possibility of solvent being discharged.
- All lines and equipment associated with flammable gas systems shall be grounded and bonded.
- Portable fire extinguishers (carbon dioxide or dry chemical types) or other fire protection or suppression systems or devices shall be available for fire emergency at storage areas. Only trained personnel shall be allowed to operate fire extinguishers.

3.2.2.2 Asphyxiant gases (including inert)

- Always maintain fresh air ventilation when using or storing asphyxiant gases.
- Only trained and qualified persons shall respond to an inert gas leak.

3.2.2.3 Oxidizing gases

- Equipment used for oxygen and nitrous oxide must be cleaned with oxygen-compatible materials that are free from oils, greases and other contaminants.
- Oxidizers shall be stored separately from flammable gas containers or combustible materials especially oil or grease. Inside buildings, segregate oxygen cylinders from flammable gas cylinders by a minimum of 20 feet, or by a 5-ft high fire-resistive partition.

3.2.2.4 Corrosive and Toxic Gases

- Keep exposure as low as possible and do not exceed established OSHA exposure limits. Don the appropriate PPE, including respiratory protection, as applicable.
- Only use in areas of forced ventilation or outdoors.

3.2.2.5 Air

- Air receivers shall be equipped with a visible indicating pressure gauge and with one or more spring-loaded safety valves.
- Safety valves shall be tested frequently and at regular intervals to determine whether they are in good operating condition.
- A drain pipe and valve shall be installed at the lowest point of every air receiver to provide for the removal of accumulated oil and water and shall be drained frequently to prevent the accumulation of excessive amounts of liquid in the receiver.

3.2.3 Valve Protection Caps

- Valve protection caps for a non-empty cylinder (designed for a cap) shall be in place and hand tight except when in use.
- Before removing the valve-protection cap, gas cylinders should be properly secured by using a floor stand, wall bracket, or bench bracket.
- After removing the protective cap, inspect the cylinder valve for damaged threads, dirt, oil, or grease. Remove any dust or dirt with a clean cloth.
- Never lift a cylinder by its valve protection cap.

3.2.4 Pressure Regulators

- Select a pressure regulator that is chemically compatible with the intended gas service and has the proper Compressed Gas Association (CGA) connection and appropriate pressure gauges.
- Never use oil or grease to lubricate regulators or valves because they may introduce an explosion hazard.
- Install the regulator securely on the cylinder valve using a proper tool (approved by the gas manufacturer).
- When connecting the regulator, the regulator adjusting knob (counter-clockwise) and pressure outlet valve (clockwise) must be in the closed position. Refer to the operating instructions for the regulator for further safety guidelines.
- Never leave pressure in a regulator when not in use.
- When turning off the cylinder, the valve shall be closed hand-tight to retain residual pressure and restrict backflow of atmospheric air or other contaminants.

3.2.5 Gas delivery lines

- All gas lines leading from a compressed gas supply should be clearly labeled to identify the gas and the area served.

3.2.6 Fire protection

- Fire extinguisher equipment shall be readily available in cylinder storage areas, when using flammable gases, and when combustible materials can be exposed to welding or cutting operations.
- Flammable/oxygen lines shall be equipped with a spark arresting device between the torch and the regulator to prevent any flame from reaching cylinders.

3.3 Transporting Compressed Gas Cylinders

Follow the safety precautions below:

- Review the product label to identify the related hazards before loading the cylinder. Listen for leaks. DO NOT transport a leaking cylinder. Visually inspect the cylinder for dents, gouges, or pits. Ensure that valve protection, where provided, remains in place until the cylinder is ready for use;
- Make sure that the cylinder is secured within the vehicle to prevent the cylinder from shifting during transportation or in case of an accident. Valve leaks can occur from improper blocking;
- Transport cylinders in the upright position, unless they are designed for horizontal orientation;
- Transporting flammable gases and oxidizers in the same passenger vehicle creates a risk for an explosion. It is recommended that flammable gases, such as propane, acetylene, etc. not be transported in the same vehicle with any containers of oxygen or other oxidizing materials;
- Maintain maximum ventilation in the area where the cylinder is stored by keeping windows or storage compartment securely open;
- DO NOT SMOKE when handling or transporting these products;
- Be aware of environmental conditions such as heat exposure from sunlight that can cause the temperature of the cylinder to increase above 125°F, leading to an increase in pressure and a possible release of product;
- Never put gas cylinders in trunks of cars or unventilated areas of passenger vehicles. Leaks can occur from extended confinement in a closed compartment (trunk or passenger compartment) that is subjected to excessive heating;
- When transporting liquid cryogenic containers, always maintain fresh air ventilation and ensure that the container's vent and pressure relief device are not blocked or covered;
- When the destination is reached, immediately remove the cylinder from the vehicle;
- Follow the equipment supplier's instructions for proper use and storage for the cylinder;
- Empty or partially full cylinders being returned to the supplier shall be transported with the same precautions as indicated above; and
- Avoid riding in an elevator with a compressed gas cylinder, if possible.

4.0 PERSONAL PROTECTIVE EQUIPMENT

- Safety boots (to protect feet from dropped cylinders).

- Safety glasses (to protect from unanticipated gas releases).
- Gloves.
- Other task-specific personal protective equipment or clothing as needed (respiratory protection, welding shield, face shield, flame resistant clothing, etc.).

5.0 TRAINING

- Hazard Communications.
- Training on use of the gaseous material and pressurized systems.
- Emergency response.

6.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910 Subpart H – Hazardous Materials, Sections 101-105 compressed gases.
- Compressed Gas Association (CGA) pamphlets (incorporated by reference in 1910 Subpart H):
  - P-1-1965/2015 CGA Standard for Safe Handling of Compressed Gases in Containers
  - PS-7 CGA position statement on the safe transportation of compressed gas cylinders and cryogenic liquid containers in passenger vehicles
- NFPA 55 Compressed Gases and Cryogenic Fluids.
- 29 CFR 1910 Subpart M – Air Receivers

1.0 RELATED GOLDER DOCUMENTS

- GAI HSE SWP Fire Protection
- GAI HSE Gas Hazards and Exposure

Approved by	Jane Mills	Issue Date	December 10, 2009
Revision by	Brian Tuccillo	Revision Date	April 4, 2014

1.0 INTRODUCTION

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees and contractors to evaluate if they are fit for duty. This SWP follows the minimum standards set forth in Golder's Global Procedure 6 (GP 6) Management of Health and Safety.

2.0 DEFINITIONS

Company-Related Business – Any act performed by a Golder employee within the scope of the employee's duties. Generally, operating one's personal vehicle from home to work and/or from work to home does not constitute company-related business. However, this travel time is included in the calculation of working hours for fatigue management purposes.

Downtime - Work Break – Non-work periods within a work day allowing time for eating, drinking and relaxation. Rest Period – Non-work periods outside of the 12 hour work day.

Emergency Situation – Where life and/or property are in danger of immediate harm.

Fit for Duty/Fitness for Duty – Physically, mentally and emotionally able to perform all assigned duties and in a manner which does not compromise or threaten the safety and health of themselves or others while preserving the integrity of property and the environment. An individual may be unfit for duty for a variety of reasons, including the adverse effects of fatigue, alcohol or drug use, or a range of physical, psychological or emotional limitations.

Fatigue – Physical, mental or emotional exhaustion resulting from a number of causes including, but not limited to, work, physical, mental or emotional exertion, lack of sleep, various stressors, or a combination of these factors.

Fatigue Leave – Time off to be taken immediately after completing 14 consecutive 12 hour days or at the end of the scheduled shift rotation if longer.

Golder's Contractor – A third-party retained by Golder to perform services at any location where Golder employees are engaged in company-related business. The term contractor includes all sub-consultants and subcontractors and their employees. A contractor representative is the person responsible for directing, controlling and/or supervising the contractors who perform or provide contractor services.

Standard Working Day/Shift – Working up to 12 hours including travel time, for fatigue management purposes.

Sufficient Rest – Rest period is the time away from work when an employee has the opportunity to eat, relax and sleep. Sufficient rest period is typically a period of between 8 and 10 hours between the time work is ceased and returning to work. In some instances travel can be considered as a rest period, providing the employee can ensure effective sleep during the time of travel.

Supervisor – For the purposes of this SWP, a Supervisor is the person who reviews an employee's weekly time record and has the authority to direct their work schedule, among other responsibilities.

Work Hours – Work Hours - A maximum of 12 hours worked per day. Shift Rotation - A maximum of 14 consecutive 12 hour days without two days off of fatigue leave.

3.0 GOLDER'S RESPONSIBILITIES UNDER THIS SWP

Golder is responsible for implementing and enforcing this SWP. The responsibilities for Golder employees in their different roles are detailed below:

3.1 Operations Manager

It is the responsibility of the **Operations Manager** to:

- Communicate the fitness for duty SWP to employees and refresh with annual training as appropriate to ensure that all employees are familiar with the SWP and with their duties and responsibilities under the SWP.
- Inform Golder employees of situations that might affect their fitness for duty through education sessions and during project planning.
- Provide training to supervisors who review timesheets in appropriate response measures for employees with excessive weekly hours.
- Determine who is fit for duty under this SWP, and respond as appropriate to employees who are unfit for duty.
- Conduct a risk assessment with affected employees for office work when required by this SWP.
- Review and, when appropriate, approve task-specific risk assessments for office assignments.
- Discipline violations of this SWP in accordance with Section 9 of this SWP.

3.2 Supervisor

It is the responsibility of the **Supervisor** to:

- Review employee weekly timecards and evaluate compliance with this SWP.
- If deviations from the SWP (relative to hours worked) are noted, contact the employee to discuss the deviations, and make immediate corrections, as necessary, involving the Project Director (when applicable).

3.3 Project Director

It is the responsibility of the **Project Director** to:

- Consider the requirements of this SWP when determining work shifts.
- Review and, if appropriate, approve task-specific risk assessments for field assignments.

3.4 Project Manager

It is the responsibility of the **Project Manager** to:

- Advise employees and contractors of situations that may impact their safety at their worksite through hazard analysis conducted during project planning (HASEP).
- Inform Golder employees of situations that may affect their fitness for duty through education sessions and during project planning.
- Provide a copy of this SWP to the contractor representatives.
- Conduct a risk assessment with affected employees for field work when required by this SWP.
- Respond as appropriate to employees who are unfit for duty.
- Provide a copy of this SWP to the contractor representatives.

3.5 Human Resources Representative

It is the responsibility of the **Human Resources Representative (HRR)** to:

- Respond to confidential fitness for duty inquiries from employees.
- Communicate, as necessary, with Project Managers or Supervisors on behalf of the employee.
- Understand federal, state and/or local laws as they may relate to work hours.

4.0 EMPLOYEE RESPONSIBILITY UNDER THIS SWP

- Arrive at work each day fit for duty.
- Comply at all times with Golder's Code of Conduct, employee handbook, all Golder policies, procedures, and safe work practices.
- Notify your HRR, your supervisor, or any designated company representative immediately if:
  - You have any doubts or concerns about your fitness for duty, or about your ability to safely perform your assigned responsibilities.
  - For any reason, you become unfit for duty during the course of the workday.
  - You observe another employee or Golder contractor who might appear to be unfit for duty.
  - You observe another employee or Golder contractor engaging in unsafe behavior.
  - You believe the work you are assigned to perform is unsafe, or if you feel you are not adequately trained to safely perform any of your assigned responsibilities.
  - You are using drugs, alcohol, and other substances that might impair your fitness for duty.

- Schedule sufficient rest (as defined in Section 8.3) before arriving at work.
- Ensure non-work activities allow for sufficient rest.
- Ensure illnesses that might affect your fitness for duty are managed.
- Refrain from using drugs, alcohol, and other substances that might impair your fitness for duty.

5.0 FACTORS THAT CAN AFFECT AN INDIVIDUAL'S FITNESS FOR DUTY

A number of factors can affect an individual's fitness for duty. Among the most common factors are fatigue, temporary physical or psychological conditions, alcohol consumption, and the use of prescription medication and illegal drugs and substances. Many symptoms are commonly associated with fatigue. Because these symptoms might not be recognized by the fatigued employee, it is important for all employees to watch for symptoms of fatigue in each other during long work shifts.

6.0 KEY HAZARDS

Employees who are unfit for duty have a significantly higher risk than others do of suffering a serious injury or death, causing serious injury or death to others, and committing mistakes in performing their job responsibilities. Individuals who are unfit for duty:

- Tend to overestimate their ability to perform tasks safely, underestimate potential hazards in the workplace, and often disregard the use of appropriate personal protective equipment.
- Tend to be less efficient, less productive, and more prone to making technical errors.

7.0 WORK HOURS

Golder acknowledges flexible working hours might be required to ensure business continuity and delivery of client service. Golder has established the following work hour limits that all employees must adhere to, and all employees must follow when establishing work schedules:

All activities at Golder should be designed to fit into the standard working day of 12 hours (including travel time). In addition, all activities at Golder should be designed and managed so that no employee works more than fourteen consecutive 12-hour days without experiencing two days of fatigue leave.

The standard working-day guidelines rely on each employee to monitor their own fitness for duty in preparation for work periods of up to 12 hours in duration.

If under extreme or unforeseen circumstances a project or office activity requires an extended working day (greater than 12 hours), a project-specific or activity-specific fatigue risk assessment (Section 8) must be conducted and permission must be obtained from either the Project Director or Operations Manager. If

permission to work in excess of 12 hours is granted, the following minimum control measures must be implemented:

- A "buddy" system so the employees are not working the extended work day alone. Work at home or in a hotel room after the extended work day represents a lower safety risk, because driving while fatigued is eliminated.
- The Project Director (for field work) or Supervisor (for office work) and the affected employees shall identify factors that might impact the employees' ability to work safely beyond the standard working day. During this consultation, the employees must notify the Project Manager and supervisor of any personal or other matters that might affect their fitness for duty or their ability to safely work the extended hours.

If international or remote site work requires employees to be onsite for greater than the two-week period, a project-specific or activity-specific risk assessment must be conducted, and permission for the extended (>14 days) rotation is required from either the Project Director (for field work) or the Operations Manager (for office work). If permission is granted, the following minimum control measures must be implemented:

- All effort must be made to ensure breaks are taken during the work period so that 14 consecutive 12-hour days in a row are not exceeded.
- The working plan must allow for flexibility in work hours such as half-day breaks for rest.
- During downtime in operation (such as equipment breakdowns), employees must be given the opportunity to rest.

A modified standard working day might be established based on environmental factors and the specific nature of the work to be performed. These factors include, for example, extreme weather conditions, remoteness, and degree of the physical exertion required.

Work schedules for projects involving employees from multiple operating companies must be defined in advance of employee deployment to the site. GAI employees will only be deployed to a project site where compliance with this SWP is assured. A GAI employee working for another Golder operating company would still need to follow GAI's Fitness For Duty SWP (this document), if the other Golder operating company's Fitness For Duty requirements are less stringent.

7.1 Compliance With Federal, State and Local Laws Governing Working Hours

Certain federal, state and/or local laws or client requirements can impose specific requirements with respect to the maximum number of hours an employee is permitted to work at any one time. Golder will comply with applicable laws governing working hours (MSHA and DOT, where applicable) or client requirements. Any questions regarding these laws or client requirements should be directed to your HRR or Project Manager as appropriate.

8.0 FATIGUE RISK ASSESSMENT

If operational requirements necessitate staff exceeding the work-hour guidelines, a risk assessment shall be conducted that can demonstrate all risks are adequately controlled. The risk assessment process is detailed in the toolkit associated with this SWP.

8.1 Fatigue Risk Assessments for Field Work

The risk assessment must be conducted by the employee and the Project Manager for work outside of the office. The risk assessment must be documented on the form provided in the toolkit associated with this SWP. Work cannot proceed until this risk assessment has been reviewed and authorized by the Project Director or Operations Manager. Work schedules/activities to minimize risks associated with fatigue will be incorporated into the project HASEP as identified through the risk assessment process.

8.2 Fatigue Risk Assessments for Office Work

The risk assessment must be conducted by the employee and the employee's supervisor for office work whether conducted at the office or at a remote location like a hotel. This assessment can take the form of a conversation that includes the elements defined in the toolkit associated with this SWP.

8.3 Breaks

Breaks are an important part of managing fatigue. Time spent away from work allows individuals to recover from mental and physical fatigue and improve safety, work performance, efficiency. Factors such as the physical demands of the task or weather conditions must be considered.

Consistent with applicable federal, state or local laws, breaks during a standard working day should be adequate and regular. Rest during your lunch break. At other times this could be as simple as taking a break while demobilizing from a project site. There should be a minimum of one 30-minute break in each 8-hour work period.

As a guide, the amount of sleep required in the previous 48-hours needs to be no less than the length of the next intended work period. For example, if you plan to work 12 hours in any given day, you need to have had at least 12 hours sleep over the previous 48-hours.

For extended working days/shifts:

- If an employee has worked at least 12 hours (excluding breaks), the employee must rest for at least 8 hours before returning to work.
- On rare occasions when an employee has worked more than 12 hours, the employee is required to rest for at least 10 hours before returning to work.

8.4 Travel/Transport

- When an employee has worked consecutively for 14 hours or more in a single day they shall not operate a vehicle. Arrangements must be made, not at the employee's expense, for alternative transportation or accommodations. In unforeseen situations, an employee may complete their journey without being in violation of the provisions of this procedure, provided the planned journey could reasonably have been completed within the provisions of this procedure in the absence of the unforeseen situation.

9.0 COMPLIANCE

All individuals are required to comply with this SWP. For employees, failure to comply with this SWP will result in disciplinary action up to, and including termination of employment. Contractors who fail to comply with this SWP can be removed from the worksite or prohibited from engaging in any further Company-Related Business. Supervisors, Project Managers or Project Directors who chronically fail to ensure their staff follow the SWP are subject to disciplinary action up to, and including termination of employment.

10.0 GOLDER RELATED DOCUMENTS

- GP-6 Management of Health and Safety
- Golder's Code of Conduct
- Golder's Employee Handbook

Approved by	Jane Mills	Issue Date	June 20, 2014
Revision by	Amanda Cote	Revision Date	January 12, 2015

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees working in areas where an injury that requires first-aid care may occur or where emergency medical services may be slow to respond or not available. This SWP is intended to represent minimum standards and does not supersede requirements of local agencies or jurisdictions.

2.0 FIRST-AID/CPR/AED

Golder recognizes the value of training our employees to respond to emergency situations, including those situations involving an injury. Golder employees are not required to provide first-aid as a routine part of their job duties. In the event of a life threatening emergency, Golder employees are trained to contact professionally trained Emergency Medical Technicians (EMTs) through the local 911 system or other site-specific emergency contact numbers listed in the site-specific Health, Safety, and Environment Plan (HASEP).

In accordance with OSHA General Industry and Construction standards, at least one Golder employee on every field project site shall be designated as a first-aid provider if EMT services are not readily available (less than 10 minute response). Field personnel are trained in First-Aid/CPR/AED to provide on-site first-aid in the absence of EMTs. This training is required for field personnel because many client work sites do not have an infirmary, clinic, or hospital in near proximity to the workplace that is used for the treatment of injured employees. Additionally, adequate first-aid supplies are provided to field employees, to respond to reasonably anticipated injuries.

3.0 FIRST-AID FACILITIES

3.1 Classification of First-Aid Kits

Under the American National Standards Institute (ANSI) standard, Z308.1-2009, first-aid kits are divided into four different categories or classifications:

- **Type I:** Intended for use in stationary, indoor applications where kit contents have minimal potential for damage. These kits are not intended to be portable and should have a means for mounting in a fixed position. Some applications for Type I first-aid kits are general indoor use, office use, or in a light manufacturing facility. First-aid cabinets would fall in this classification.
- **Type II:** Intended for use in portable indoor applications. Kit contents should have minimal potential for damage. These kits should be equipped with a carrying handle. Some applications for Type II first-aid kits are general indoor use, office, or manufacturing environments.

- **Type III:** Intended for portable use in mobile industries and/or outdoor applications. Kits should be moisture resistant, equipped with a carrying handle, have the means for being mounted in a fixed position, and should also be corrosion resistant. Transportation industry or construction jobs present typical applications for Type III first-aid kits.
- **Type IV:** Intended for portable use in the mobile and/or outdoor applications where the potential for damage to the kit contents due to environmental factors and rough handling is significant.

3.2 Basic Fill Contents for Type I, II, III, and IV First-Aid Kits

All first-aid kits meeting the first-aid standard of ANSI Z308.1-2009 should contain the first-aid items listed in Section 6.1, Table 1 of the standard and included in Appendix A of this SWP. The quantity and size specifications of these components are the minimum necessary to comply.

In addition to the minimum contents listed in the standard, a kit should have recommended items added based upon specific workplace hazards. Additional supplies may include oral analgesics, antibiotic treatments, compress bandages, Cardiopulmonary Resuscitation (CPR) barriers, burn dressings, cold packs, eye covers, eyewash, and a roller bandage.

3.3 Providing and Inspecting First-Aid Supplies

The contents of the first-aid kits shall be checked before being sent out to each job site by the HSC, Project Manager, or the Site Safety Officer (SSO)/Site Supervisor, and should contain at least Type III or Type IV contents. For long-term projects, weekly on-site inspections shall be conducted by the SSO to make sure the first-aid supplies are intact and/or that any expended/expired items are replaced. First-aid supplies should be stored in a weather-proof container (if being brought into the field) with individually sealed packages of each item.

First-aid stations are required when there are 50-200 persons working at a field worksite, in each permanent Golder office location, in each temporary project trailer that Golder may rent/lease, and in each Golder laboratory location. The stations must be located as close as practicable to the highest concentration of personnel. First-aid stations must be well marked and available to personnel during all working hours. One first-aid kit may be a permanent wall-mounted kit, but in all cases the station shall be equipped with at least one portable first-aid kit (kits within field vehicles may be used to meet this requirement).

- Maintenance of first-aid kits stationed within the office is the responsibility of the HSC or their designee.
- Maintenance of first-aid kits in the laboratory is the responsibility of the lab manager.
- Maintenance of first-aid kits in field vehicles, or otherwise established first-aid stations, where required, is the responsibility of the Project Manager or Site Supervisor or their designee for the project.

3.4 Emergency Eyewash and Shower Equipment

Where the eyes or body of any employee may be exposed to injurious corrosive materials, emergency eye wash provisions (eyewash station or portable kits) for quick drenching or flushing of the eyes and body must be provided. Depending on the potential hazard, facilities or bottled eyewash shall be capable of providing copious amount (15 minutes) of potable water at a suitable temperature, generally between 60 degrees F and 105 degrees F. Facilities must be provided for immediate emergency use in the laboratory and near the work area or office trailer for field-related activities. Facilities shall meet and be inspected following ANSI Z358.1-2009.

4.0 AUTOMATED EXTERNAL DEFIBRILLATORS

4.1 Definitions

Automated External Defibrillator (AED): An external defibrillator is capable of cardiac rhythm analysis and will charge and deliver a shock if needed to restore normal heart rhythm.

Cardiopulmonary Resuscitation (CPR): An emergency live-saving procedure employed when someone's breathing or heartbeat has stopped. Through CPR the heart and lungs are made to work by manually compressing the chest overlying the heart and forcing air into the lungs. CPR is used to maintain circulation when the heart stops functioning.

4.2 Using an AED

Golder's offices with more than one employee are expected to have an AED available for use, either in the office or in the building where Golder is a tenant. AEDs should be stored in locations that are easily accessed and clearly labeled. When an AED is acquired, the applicable local emergency communication center or dispatch center (such as 911) should be notified about the existence, the storage location, and type of AED(s). In some locations, written notification or registry with a state agency may be required.

Golder's AEDs will be maintained, tested, and inspected according to the manufacturer's operational guidelines. Inspections will be conducted at least every 30 days. Written inspection records will be maintained in every office with an AED.

Anyone who may use an AED must receive CPR/AED training from the American Red Cross, American Heart Association, or equivalent with a demonstrated proficiency. Where local regulations require, use of the AED will be limited to people who have received the appropriate training. Training records will be maintained for each office location.

When an AED is used to provide emergency assistance to someone experiencing cardiac arrest, the local emergency medical services must also be notified as soon as possible. A written report documenting the

incident will be prepared and submitted to Golder's supervising physician for review. If required by state regulations, a physician will review these AED procedures and recommend modifications as necessary to comply with applicable regulations.

5.0 EMERGENCY ACTION PLANS

The HASEP or office Emergency Action Plan shall identify the emergency action plan for transporting an injured person to a physician or hospital. In the event that the work area is not served by emergency services (i.e., "911"), a list of the telephone numbers and addresses of doctors, hospitals, and ambulance services shall be posted at each first-aid station or within the field vehicle(s). For field operations, the list shall also include the physical address of the worksite.

For work in remote locations or where medical care may be sub-standard, please reference GAI HSE 200.012 SWP Remote Work-Working Alone.

6.0 OSHA'S BLOODBORNE PATHOGENS REQUIREMENTS

The Occupational Safety and Health Administration (OSHA) promulgated regulations (29 CFR 1910.1030 Bloodborne Pathogens [BBP]) to protect employees who may be occupationally exposed to blood and other potentially infectious materials. The primary concerns include protection from exposure to the Human Immunodeficiency Virus (HIV) and Hepatitis B virus (HBV), which may be present in infected individuals' body fluids. For the purposes of the BBP Standard, occupational exposure means "reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of the employee's duties."

7.0 BBP EXPOSURE CONTROL PLAN

This SWP will serve as Golder's Exposure Control Plan. Where applicable, the Exposure Control Plan will be documented within the site-specific HASEP and within the corporate Health and Safety Orientation Manual and Injury and Illness Prevention Program. The Plan will also be maintained on the company intranet and will be available to any employee upon request. All employees will have access to a copy of the Exposure Control Plan in accordance with 29 CFR 1910.1020(e).

OSHA's BBP regulations require that employees "treat all human blood and other potentially infectious materials **as if they were infectious (i.e., universal precautions)**." In the event that an employee does administer CPR or render first-aid involving the presence of blood or other potentially infectious materials, occupational exposure as defined above is presumed. While there is some risk associated with any contact with another human being's body fluids, the risk associated with providing emergency first-aid is low and the measures set out below are intended to reduce the risk even further. The direct life-saving benefits of immediate emergency assistance (e.g., administering CPR to a heart attack victim or

controlling severe bleeding in traumatic injury cases), far outweigh the risks associated with properly administered assistance. First-aid providers shall take reasonable and universal precautions to limit contact with the victim's body fluids.

After providing first-aid care, do not eat anything, use tobacco products, or touch your eyes until you thoroughly wash your hands with, at a minimum, soap and water.

8.0 BBP WORK PRACTICE CONTROLS

The following work practice controls shall be used to eliminate or minimize employee exposure:

- Personal Protective Equipment (PPE) (including nitrile, neoprene, and/or latex gloves, CPR mask) will be provided at no cost to the employee. PPE will be made available within the appropriate sizes and shall be replaced as needed.
- Employees who choose to assist in a medical emergency shall wear the appropriate PPE for the treatments in which they are engaged. If an employee does not use the PPE provided, appropriate disciplinary action may be taken.
- The use of a "biohazard' bag for BBP-impacted waste is required when the waste meets the definition of "regulated waste." Regulated waste means liquid or semi-liquid blood or other potentially infectious materials, contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed, items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling, contaminated sharps, and pathological and microbiological wastes containing blood or other potentially infectious materials.
- Do not eat, drink, use tobacco products, or touch your eyes and mouth until you have thoroughly washed your hands. Hand washing facilities and/or antiseptic solutions/towelettes will be made available at all work locations for use.
- All equipment or environmental surfaces shall be cleaned and decontaminated (using disinfectant solutions or cleaners) after contact with blood or other infectious materials, and all cleaning materials shall be properly disposed of. Due to a lack of laundering facilities, contaminated clothing will be disposed of and replaced as needed. Contaminated clothing must be promptly removed and placed in the "biohazard bags" for disposal. You should also wash your skin under where the clothing was contaminated.
- Equipment and engineering controls will be evaluated and updated based on current regulations and standard medical practices. Evaluations will be performed by Golder's National Leader Health, Safety, and Environment (NLHSE) and/or their designee. Equipment or materials shall be replaced based upon use or expiration date, and medical kits will be taken out of service until necessary replacement items can be procured.

9.0 PROCEDURES FOR BBP EXPOSURE INCIDENT

Golder is required to prepare an Exposure Determination Plan for employees with occupational exposure. In the event that an Exposure Determination Plan is needed, exposure determinations shall be made without regards to the use of PPE.

9.1 BBP Exposure Incident

In the event of a BBP exposure incident, immediately report the incident to your office Human Resources Representative (HRR). Also, Golder employees should immediately report any non-life threatening work-related injury or exposure incident to WorkCare at 888-449-7787. WorkCare will communicate with the Corporate Human Resources Manager for injury or exposure reporting.

If necessary, WorkCare will request testing of the "source individual's" blood for potential BBPs. The results of the source individual's blood test will be made available to Golder's occupational physician as soon as possible through the injured person's attending physician.

If a post-exposure medical evaluation is conducted, it will include a review of the exposure incident, a review of your medical history including HBV vaccination status, a review of the source individual's blood test results if available, a baseline sample of your blood, and possibly (if appropriate in the opinion of the attending physician) a Hepatitis B vaccination or booster.

Following the post-exposure evaluation, the attending physician will provide a written opinion regarding medical clearance to the HRR. This opinion shall be limited to a statement that the employee has been informed of the results of the evaluation and told of the need, if any, for any further evaluation or treatment. Golder is required to provide the affected employees with a copy of the physician's opinion within 15 days. The physician's written opinion shall be the only information provided to Golder's HRR regarding the exposure incident; all other medical findings and records will remain confidential.

10.0 TRAINING

Field employees are required to maintain current first-aid, CPR, and AED training. The first-aid, CPR, and AED training must occur every two years and be conducted by a certified program sanctioned by the American Red Cross, American Heart Association, National Safety Council, or equivalent.

Employees who attend first-aid, CPR, and AED training will automatically be enrolled in BBP training. BBP training is required annually for employees with occupational exposure as defined in the Standard, and must be given at the time of initial assignment to tasks where occupational exposure may take place. Employees who do not attend the annual refresher shall not be authorized to provide medical care of any kind until refresher training is complete.

Training will be re-evaluated based on changes in regulations, near misses, exposures, accidents, or any other time as deemed necessary by the NLHSE or HSC.

Participation in training courses will be documented. Evidence of training will be maintained at the employee's local office. It is the responsibility of the employee to maintain adequate training records and to make sure training is kept current.

11.0 HEPATITIS B VACCINATION

All medical evaluations and procedures including the Hepatitis B vaccine and vaccination series and post-exposure evaluation and follow-up, including prophylaxis, are made available at no cost to the employee; made available to the employee at a reasonable time and place; and performed by or under the supervision of a licensed physician or by or under the supervision of another licensed healthcare professional.

Golder employees do not render medical assistance as a primary job duty and therefore will not be routinely offered the pre-exposure Hepatitis B vaccination. Employees who primarily provide first aid or emergency response duties must be vaccinated. The Bloodborne Pathogen Standard excludes employees who perform unanticipated "Good Samaritan acts" from coverage by the Standard since such an action does not constitute "occupational exposure."

In the event that a Golder employee renders first aid or performs emergency response duties involving the presence of blood or other potentially infectious materials, the Hepatitis B vaccine will be made available to that employee, unless the employee has previously received the complete Hepatitis B vaccination series, antibody testing has revealed that the employee is immune, or the vaccine is contraindicated for medical reasons.

If an employee renders first aid or performs emergency response duties involving the presence of blood or other potentially infectious materials and declines to accept the Hepatitis B vaccination offered by Golder, the employee must sign a form, which states:

> *I understand that due to my occupational exposure to blood or other potentially infectious materials I may be at risk of acquiring hepatitis B virus (HBV) infection. I have been given the opportunity to be vaccinated with hepatitis B vaccine, at no charge to myself. However, I decline hepatitis B vaccination at this time. I understand that by declining this vaccine, I continue to be at risk of acquiring hepatitis B, a serious disease. If in the future I continue to have occupational exposure to blood or other potentially infectious materials and I want to be vaccinated with hepatitis B vaccine, I can receive the vaccination series at no charge to me.*

12.0 RECORDKEEPING

Training records shall be maintained for a minimum of 3 years from the date on which the training occurred. Medical records will be maintained during the period of employment plus 30 years.

According to 29 CFR 1910.1020(h), records are available to employees, to employee representatives, and to OSHA. Employees have the right to request, transfer, or release training and exposure medical records. This process requires written authorization from the employee in question. Records can be picked up in person or mailed via certified mail to make sure they are delivered properly. All record transmittals will be compliant with the Bloodborne Pathogens Standard.

13.0 APPLICABLE REGULATIONS AND STANDARDS

- 29 CFR 1926.50 Medical Services and First Aid
- 29 CFR 1910.151 Medical Services and First Aid
- 29 CFR 1910.1030 Bloodborne Pathogens
- ANSI Standard Z308.1-2009 Minimum Requirements for Workplace First Aid Kits and Supplies
- ANSI Z358.1-2009 Emergency Eyewashes and Shower Equipment
- 29 CFR 1910.1020 “Access to Employee Exposure and Medical Records”.

14.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.012 SWP Remote Work-Working Alone

APPENDIX A

FIRST-AID KIT CHECKLIST

List of Minimum Required First-Aid Kit Equipment per ANSI Z308.1-2009

ANSI/ISEA Z308.1-2009 Type I, II, III, or IV			
Required Minimum Fill		**Recommended Supplies**	
	1 First Aid Guide		Analgesic (Oral)
	1 Absorbent Compress 4 x 8 in. min.		Bandage Compress 2 x 36 in. min.
	16 Adhesive Bandages 1 x 3 in.		Breathing Barrier, single use
	1 Adhesive Tape 2.5 yd.		Burn Dressing 12 sq. in. min.
	10 Antiseptic Treatment Applications 0.5 gm. Each		Cold Pack 4 x 5 in. min.
	6 Burn Treatment Applications 0.9 gm. Each		Eye Covering 1/4 in. thick min.
	4 Sterile Pads 3 x 3 in. min.		Eye/Face Wash, sterile 4 fl. oz. min
	2 Pair Medical Exam Gloves		Roller Bandage 2 in. x 4 yd. min.
	1 Triangular Bandage 40 x 40 x 56 in. min.		Hand Sanitizer, 0.9 gm. min
	6 Antibiotic Treatment Applications 0.5 gm. Each		Tweezers
			Surgical Scissors
			Bloodborne Pathogens Exposure Prevention Kit
The described kit may be suitable for some businesses. However, the adequacy of the contents for hazards of each work environment should always be evaluated by competent personnel. For a variety of operations, employers may find that additional first-aid supplies and kits are needed.			

Note: This kit meets ANSI Z308.1–2009 only when the minimum is maintained with first-aid products marked “ANSI Z308.1–2009.”

Approved by	Jane Mills	Issue Date	March 12, 2013
Revision by	Brian Tuccillo	Revision Date	None

1.0 SCOPE

This Standard Work Practice (SWP) applies to all Golder Associates Inc. (Golder) staff working on projects with active uncontrolled traffic conditions (e.g., in street/highway right-of-ways).

2.0 TRAFFIC SAFETY

Traffic control is required whenever the uncontrolled movement of vehicle traffic could be hazardous to workers. Working on projects with active uncontrolled traffic conditions (e.g., in street/highway right-of-ways) can be very dangerous or even life threatening without the proper safety controls, awareness, and signage. Golder's project manager and site safety officer should develop a traffic control plan that will meet local, state, and federal regulations to make sure Golder personnel are safe.

3.0 TRAFFIC CONTROLS

3.1 Precautions

- Inspections or determinations of road conditions and structures must be made in advance to assure that clearances and load capacities are safe for the passing or placing of any machinery or equipment. Check with local authorities for appropriate regulations and site-specific hazards.
- Adequate barricades, channelization cones, flashing lights, flagmen, and warning signs shall be provided at all project sites adjacent to or in public traffic lanes (based on any regulations and/or the site specific hazard assessment).
- Adequate safety precautions must be observed when parking vehicles. Whenever a vehicle or heavy equipment is parked, the parking brake must be set. Equipment parked on inclines must have the wheels chocked or track mechanism blocked and the parking brake set.
- At a minimum hard hats and reflective clothing must be worn by all employees and subcontractors at all times while working on a public right-of-way or in the vicinity of vehicular traffic.

3.2 Non-Lane Closure

These traffic controls or actions are intended to protect Golder personnel without using lane closures or restricting traffic flow. Examples of non-lane closure activities include working at commercial properties (e.g., retail petroleum stations) or observing rock slopes in a right-of-way. Best management traffic control procedures include one or more of the following practices:

- Performing work within traffic areas at off-peak hours, if possible.
- Placing orange reflective cones and caution tape around the designated work area.
- Placing high-visibility signs to warn drivers of designated work areas.

- Placing your vehicle between you and oncoming traffic.
- Wearing high-visibility safety apparel, including high visibility vest intended to provide visibility during both daytime and nighttime (Note: must meet the Performance Class 2 or 3 requirements of the ANSI/ ISEA 107–2004).
- Wearing safety glasses to prevent dust or other debris from entering your eyes.
- Parking your vehicle behind the Jersey barrier or guardrail and exiting your vehicle on the opposite side of traffic.
- Turning on your vehicle's flasher lights and/or roof-mounted flashing amber light.
- Always face traffic if possible.
- Be prepared for inclement weather and know how this may impact your work area (e.g., rain may create slippery driving conditions).
- When not engaged in the work (e.g., taking notes, talking on your cell phone, breaks) stand in a safe area behind the guard rails or Jersey barriers.
- Reducing and/or eliminating the number of times you cross the road.

3.3 Lane Closure

The *Manual on Uniform Traffic Control Devices* (**MUTCD**) defines the standards used by road managers nationwide to install and maintain traffic control devices on streets and highways. This resource should only be used as a reference.

Federal Highway Administration (FHWA) publishes MUTCD under 23 Code of Federal Regulations (CFR), Part 655, Subpart F. This resource should only be used as a reference.

Golder personnel should implement the following guidelines on projects where the fieldwork must be performed within traffic closures or lane restrictions. (The guidelines described herein have been prepared under the assumption that the set-up and control of the traffic closure is provided by an appropriately trained person or traffic control subcontractor. Traffic control procedures must meet the requirements of the local Department of Transportation (DOT) and/or local Police Department.). Golder personnel should also follow the best management traffic control procedures listed above during lane closures and/or lane restrictions.

- Make sure a Golder representative has in their possession a copy of all local, state, and federal permits to perform the lane closure and/or lane restriction.
- Field staff participating in the project must attend an orientation meeting with the person or representative of the traffic control company in charge of the lane closure or restriction (e.g., altering the traffic pattern) to discuss the particulars of each traffic closure/restriction set-up and safety requirements. Traffic closure or restrictions should only be set up by suitably trained and qualified individuals. Traffic controls must meet the requirements of the local DOT and/or Police Department requirements.
- Any work vehicle within the traffic closure or entering the work zone shall have its four-way flashers on or be equipped with a roof-mounted flashing amber light.

- Until all traffic control safety measures are in place, only the members of the field staff involved in the lane closure set–up will be allowed on-site. In the case where an outside firm is providing the lane closure, no staff shall be allowed within the closure until the closure is complete.
- Workers within the closure area must be within communicating range of each other.
- Two-way radios should be used when the workers are not within talking range of each other.
- In cases where equipment, noise and/or obstructions limit a worker's audible or visual cues to danger from traffic, a lookout person shall be stationed in these work areas to monitor traffic and signal the workers if a potential dangerous conditions arises.
- Be aware of construction equipment operating within the lane closure area.
- If working at night, understand the bright lights from the construction area may decrease, confuse, or blind the oncoming drivers; Use extreme caution when exiting and entering a lane closure (i.e., getting within the “safe” zone of the traffic closure). Allow enough time to safely accelerate your vehicle to match traffic speeds and provide enough warning and distance to drivers behind you to safely decelerate your vehicle to enter the lane closure area.
- The worker should face the on-coming traffic and position themselves away from traffic to the extent possible.

3.4 Public Access

These traffic controls or actions are intended to protect the public when working in areas where public access is permitted. Examples of areas of public access are parks, streets, public parking lots, and etc. The best management practices for protecting the public from areas of work are as follows:

- A barrier should be set up around the work area that not only physically inhibits the public, but visually provides a partition such as reflective orange devices or yellow caution tape.
- When heavy machinery is required such as drill rigs, the diameter of the area partitioned will be equal to approximately two times the height of the machinery used to protect the public in the event of toppling.
- A member of the project field team will be responsible for maintaining the barrier or partition and assuring no member of the public will enter the workspace.
- When machinery enters or leaves the workspace “spotters” will be utilized to divert the public from the path of the machinery.
- The barrier or partition will not be removed until all work has been completed in the work space.

4.0 MINE TRAFFIC SAFETY

Golder personnel working at active mines must follow the Site-specific Health, Safety and Environment Plan (HASEP) prepared in accordance with Mine Safety & Health Association (MSHA) regulations.

5.0 APPLICABLE REGULATORY REFERENCES

- American National Standard for High-Visibility Safety Apparel and Headwear", ANSI/ISEA 107-2004.
- Manual on Uniform Traffic Control Devices (MUTCD), Federal highway Administration (FHWA), 23 CFR Part 655, Subpart F.

6.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.018 SWP Working Around Heavy Equipment.

Approved by	Jane Mills	Issue Date	August 2012
Revision by	Brian Tuccillo	Revision Date	August 2013

1.0 SCOPE

This Standard Work Procedure (SWP) applies to all Golder Associates Inc. (Golder) employees who, during the course of their work, may be exposed to or encounter types or amounts of chemical or biological substances not usually encountered under normal working conditions.

2.0 CHEMICAL OR BIOLOGICAL SUBSTANCES

Chemical or biological substances may include the residues from industrial processes or commercial activities, compounds used in manufacturing, and/or materials present in specialized work environments. These substances, if present in sufficient concentrations, could potentially affect worker health and safety. Therefore, it is important to be aware that such hazards could exist and take appropriate measures to reduce and/or eliminate potential exposure.

Note

This protocol does not include exposure to ionizing radiation. Specialized safety measures, monitoring and testing is required for such environments, and is beyond the scope of this protocol.

Golder personnel will not work in chemical and/or biological environments considered Immediately Dangerous to Life or Health (IDLH), or requiring personal protective measures to US Environmental Protection Agency (USEPA) Level A (i.e., Self-Contained Breathing Apparatus (SCBA) and fully-encapsulating, chemically resistant clothing), unless specific and specialized training for working in such environments is provided to personnel, all required equipment is provided, and all required monitoring (air, exposure, medical, etc.) is undertaken.

Chemicals have the potential to cause irritating localized effects, acute or chronic toxic effects or longer term carcinogenic effects. The hazards posed by each chemical will depend on the type of chemical, the form in which it is available for exposure, the frequency of exposure, and the duration of each exposure.

Chemicals that employees can come into contact with could be in a solid, liquid or gas form. Each form of a chemical may pose its own hazards.

Pathways leading to possible health effects relate to the inhalation, ingestion, injection, or dermal contact with the chemical. As an example lead can be ingested as solid, cause burns to the skin as a liquid and inhaled as a gas following heating, or when sprayed as a component of a product such as paint. Each of these three forms will cause differing potential acute or chronic toxic health effects either immediately or over time.

For each exposure scenario, the specific physical and chemical properties of chemicals will strongly influence the hazard posed by the chemical. Factors such as boiling point, vapor pressure, flammable limits, melting point, freezing point, corrosiveness, auto ignition temperatures, and vapor density will all affect the risk of injury/illness to an exposed worker.

- Inhalation of chemical and/or biological substances.
- Ingestion of chemical and/or biological substances.
- Contact with or absorption of chemical and/or biological substances.

3.0 KEY HAZARDS

For all field projects, a site-specific Health, Safety and Environment Plan (HASEP) will be developed. The HASEP includes a risk assessment section for each of the onsite tasks and identifies hazards associated with each job. Engineering controls are identified to avoid key hazards such as:

- Short term health effects such as eye irritation, breathing difficulties, burns and/or poisoning.
- Long term health effects such as organ damage and/or possible carcinogenic related disease.
- Immediate loss of life.

4.0 PRECAUTIONS

Prior to undertaking site work Golder staff should complete the following as part of the preparation of the HASEP:

- Review the historical activities at and/or previous use of the site or environment in question to identify potential chemicals and/or biological substances that may be present. If possible, ask the client and/or former site workers for information. Review existing data from any environmental studies conducted at the site.
- If chemicals are known to be in use at a site, obtain and review Material Safety Data Sheet (MSDS) documentation.
- Once potential chemical and/or biological hazards have been identified, consult reference materials concerning health effects, allowable exposure limits and appropriate personal protective equipment to be used when encountering such substances.
- Air monitoring requirements (i.e., the selection of specific, air monitoring devices such as photo and flame ionization detectors, combustible gas meters, chemical specific meters, etc.), the calibration and maintenance requirements of such equipment, the selection and use of appropriate respiratory protection equipment, project-specific medical monitoring requirements, and other procedures deemed appropriate for the protection of human health will be detailed in the HASEP or a separate SWP.
- It is important to note that the actual conditions encountered at a site may be different from those anticipated. If levels of contamination (i.e., concentrations of chemical and/or biological substances) or physical working conditions (i.e., unstable ground, etc.) are encountered at a site that are substantially different from those originally anticipated, or if

any situation arises that is obviously beyond the scope of the monitoring, respiratory protection and/or decontamination procedures specified in the plan, work activities will be halted pending review by the Project Manager, office Health and Safety Coordinator (HSC) and/or the Site Safety Officer (SSO)

Revised procedures and protective measures, compatible with the site conditions encountered, will then be identified and implemented.

5.0 EMERGENCY RESPONSE PLAN

An Emergency Response Plan (ERP) shall be developed and included as a distinct section within each site specific HASEP. The ERP shall be developed to identify anticipated emergencies and associated responses prior to initiating any work activities. The ERP section of the HASEP is designed to identify response procedures to unexpected emergency events on the project site. The ERP shall be in writing and be made available to employees, their representatives, and OSHA. At a minimum the ERP must include the following:

- Pre-emergency planning and coordination with outside parties.
- Personnel roles, lines of authority, training, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- Personal Protective Equipment (PPE) and emergency equipment.
- Use of local or state emergency plans (to avoid duplications).

In the event of an emergency response, Golder shall identify the most senior emergency response official. This person shall assume command and responsibility for the overall emergency response operations of the site. All emergency responders and their communications shall be coordinated and controlled through this person within the Incident Command System (ICS).

6.0 PERSONAL PROTECTIVE EQUIPMENT

The proper PPE shall be selected and used to protect the employee from the hazards and potential hazards that are likely to be encountered during the work activities. PPE selection is identified through the risk assessment portion of the HASEP and is based on the duration of the work, identified risks, and site

specific conditions. Some of the minimum PPE available for field projects (but not limited to) shall be as follows:

- Steel-toed safety boots.
- Coveralls
- Hard hat
- Eye protection
- High visibility reflective vest.
- Hearing Protection

Additional Equipment (Chemical and/or Biological Substances)

- Chemically-resistant safety boots.
- Chemically-resistant gloves (latex, nitrile, neoprene etc.).
- Chemically-resistant clothing (Tyvek®, coated Tyvek® suits, etc.).
- Air purifying respirators or supplied air equipment.
- Air monitoring equipment.

6.1 Chemical PPE Selection

Chemical protective clothing and equipment is to be used by trained, organized, and designated HAZMAT team members, or to be used by the hazardous material specialists. The PPE selection shall be based on an evaluation of the performance characteristics of the PPE relative to the requirements and limitations of the site, the tasks-specific conditions and duration, and the hazards and potential hazards identified at the site. The PPE shall be selected and used to meet the requirements of 29 CFR 1910 Subpart I (Hazard Assessment) and 29 CFR 1910.120(g)(3-5). Additional information can be found in the 29 CFR 1910.120 Appendix A (test methods to evaluate PPE) and Appendix B (guidance on selecting PPE ensembles).

During site characterization field efforts at locations with suspected chemical or biological hazard posing an unknown exposure risk, employees shall wear totally-encapsulating suits capable of maintaining positive air pressure and capable of preventing inward test gas leakage of more than 0.5 percent.

6.2 PPE Program

The personal protective equipment program shall be a part of the HASEP. The PPE program shall at a minimum address the following elements:

- PPE selection (based on site hazards and potential hazards).
- PPE use and limitations.
- Work durations (length of time).
- PPE maintenance and storage.

- PPE decontamination and disposal.
- PPE training and proper fitting.
- PPE donning and doffing procedures.
- PPE inspection procedures (prior, during, and after use).
- Evaluation of the effectiveness of the PPE program.
- Limitations during temperature extremes (heat stress and/or cold stress).
- Additional medical considerations.

Note: The level of protection provided by PPE can increase or decrease as additional information on the site conditions demonstrate the changing hazards.

7.0 TRAINING

All employees, subcontractors, subconsultants, or other personnel must be properly trained by properly qualified and experienced professionals as defined by the regulation. The training will occur prior to any work activities, the start of a project, and/or before entering a work site that requires a person to be potentially exposed to or encounter chemical or biological substances not usually encountered under normal working conditions. The training shall be based on the duties and functions to be performed by each emergency responder. Those that receive training shall receive refresher training at a frequency mandated by OSHA regulations to maintain their competencies. All training records shall be documented and maintained by the HSC and uploaded by the HSC to Golder's National Training Database. The following should be the minimum training requirements. More specific training may be required.

- OSHA 10 hour Construction Safety course.
- First–aid, Cardiopulmonary Resuscitation (CPR), and Automated External Defibrillator (AED) courses.
- 8, 24 or 40-hour HAZWOPER course (as determined by job function, refer to the "First Responder Awareness", "First Responder Operation Level", "Hazardous Materials Technician", Hazardous Material Specialist", and "On Scene Incident Commander" sections of this document).
- 8 hour HAZWOPER annual refresher course.
- Specific Hazard Communication Training.

In addition, staff managing groups of field personnel may be required to have the following supervisor training:

- OSHA 30-hour Construction Supervisor Safety course.
- 8 hour HAZWOPER Supervisor course.

Anyone who encounters chemical or biological substances will have the appropriate training. Any individual who has not been appropriately trained and encounters unexpected chemical or biological

substances should stop work and locate someone with the appropriate OSHA training immediately and inform them of the hazard.

7.1 First Responder Awareness

First responders at the awareness level are those who are likely to witness or discover a hazardous substance release. Their role is to initiate an emergency response by notifying the proper authorities of the release, secure the area by directing personnel away from the hazards and to alert nearby persons of the affected area from a safe distance. Employees shall have at a minimum of 8 hours of awareness training to include but not limited to the follow subjects:

- The ability to recognize the presence of hazardous substances in an emergency.
- An understanding of what hazardous substances are.
- An understanding of the risk associated with a hazardous substance.
- An understanding of the potential outcomes associated with hazardous substances.

7.2 First Responder Operation Level

First responders at the operational level are those who respond to a release or potential release of hazardous substances as part of the initial actions. Their role is to protect nearby persons, property, and/or the environment from the effects of the release. They are to contain the release from a safe distance, keep it from spreading, and prevent exposures. They are not to attempt to actually stop or remediate the release. Employees shall have at a minimum of 8 hours of awareness training and should have knowledge equal or better than those listed for the awareness level. They also should be trained in the follow subjects:

- Knowledge of the basic hazard and risk assessment techniques.
- Know the how to select and use the proper PPE provided to the first responder operation level.
- Understand the basic hazardous materials terms.
- Know how to perform basic control, containment and/or confinement operations.
- Know how to implement basic decontamination procedures.
- Understand the relevant standard operation procedures and termination procedures.

7.3 Hazardous Materials Technician

Hazardous materials technicians are those who respond to releases or potential releases for the purpose of stopping the release. Their role is to actually stop the release at the point of origin and to clean up the affected area. Employees shall have at a minimum of 24 hours of HAZWOPER training in addition to those listed for the awareness operations level. They should be trained in the follow subjects:

- Know how to implement the site emergency response plan.
- Know how to clarify, identify, and verify known and unknown materials with field instruments and equipment.
- Be able to function within an assigned role in the ICS.
- Know how to select and use of specialized chemical PPE.
- Understand hazard and risk assessment techniques.
- Perform advance control, containment, and/or confinement operations (within the capabilities of the PPE).
- Understand and implement decontamination procedures.
- Understand termination procedures.
- Understand basic chemical and toxicological terminology and behavior.

7.4 Hazardous Materials Specialist

Hazardous materials specialists are those who respond with and provide support to hazardous materials technicians. Their role is similar to the hazardous materials technician but also require a more directed or specific knowledge of the various substances they may interact with. Employees shall have at a minimum of 24-hours of HAZWOPER training in addition to those listed for the hazardous materials technician. They should be trained in the follow subjects:

- Know how to implement the local emergency response plan.
- Understand the state emergency response plan.
- Know how to select and sue proper specialized chemical PPE.
- Understand in-depth hazard and risk techniques.
- Perform specialized control, containment, and/or confinement operations (within the capabilities of the PPE).
- Determine and implement decontamination procedures.
- Develop a site safety and control plan.
- Understand chemical, radiological and toxicological terminology and behavior.

7.5 On Scene Incident Commander

The on-scene incident commander assumes control of the incident scene beyond the first responder awareness level. Their role is to be the point of contact between the field staff, emergency services, and local, state, and federal agencies. Employees shall have at a minimum of 24-hours of HAZWOPER training in addition to those listed for the first responder operations level. They should be trained in the follow subjects:

- Know and implement the site ICS.
- Know and implement the site emergency response plan.

- Know and understand the hazards and risk associated with employees working in chemical PPE.
- Know and implement the local emergency response plan.
- Know and implement the State emergency response plan and of the Federal Regional Response Team.
- Know and understand the importance of decontamination procedures.

8.0 SITE CONTROL

Hazardous site control involves preventing anyone from entering the area without the proper training and PPE. The area will be divided into as many zones as needed to prevent unauthorized personnel from enter the contaminated area, to prevent the accidental spread of the contamination, and provide controlled access and emergency routes for authorized personnel. Most incidents will have at least three control zones and they are as follows:

- Support Zone - the uncontaminated area. The support zone will be where the emergency vehicles, emergency response personnel, the incident commander and/or the health and safety supervisor, and resources such as power, water, and shelter are staged. Regular showers and changing rooms for all personnel shall be provided in this area and meet the requirements of 29 CFR 1910.141. A point of ingress and egress will be made to the warm zone through the contamination reduction corridor.
- Contamination Reduction Zone (CRZ) - the decontamination of personnel and equipment area. The CRZ will contain the contamination reduction corridor that will be used to decontaminate all personnel and equipment, and establish the ingress and egress routes for the hot and support zones. If practical, separate decontamination routes will be established for personnel and equipment. Personnel cannot leave the CRZ into the cold zone until they are properly decontaminated and authorized to do so. Only authorized personnel with the proper PPE and training will be allowed to enter this zone.
- Hot Zone - the contaminated area. The hot zone is the primary area for all the control of the hazardous release, clean up, and/or rescue. Establish an entry and exit checkpoint for those all ingress and egress of the area. The ingress and egress must lead through the contamination reduction corridor of the warm zone. Only authorized personnel with the proper PPE and training may enter this zone.

9.0 DECONTAMINATION

Any equipment, PPE, persons, and/or clothing that have been contaminated must be decontaminated in a manner that will not accidently spread any hazardous substances. Before the start of any work activities a decontamination plan and an emergency action plan will be developed, reviewed, and communicated to all site personnel. That plan shall at a minimum include emergency contact numbers, roles and responsibilities for every personnel, PPE requirements and work procedures for the different work zones, and decontamination procedures. Decontamination shall be performed in geographical areas that will minimize the exposure of uncontaminated employees or equipment to contaminated employees or equipment.

All personnel, PPE, equipment, and clothing leaving the hot or CRZ locations must be appropriately decontaminated within the contamination reduction corridor before entering the support zone. All contaminated waste (clothing, PPE, equipment, decontamination fluids, etc.) must be put in the proper hazardous waste containers and labeled within the CRZ. The contaminated containers will then be transported and disposed of in accordance with local and federal laws.

Any reusable PPE and equipment must be properly decontaminated, cleaned, inspected, maintained, and/or parts replaced to maintain their effectiveness and condition. The cleaned or new PPE cannot be removed from the CRZ, changing rooms, or the storage area unless removed by an authorized person.

In the event that a person comes in contact with a hazardous through porous clothing (i.e. non-impermeable) or splashing, the affected clothing must be removed at once and either be properly decontaminated or discarded. Once the clothing is removed the person must then be immediately decontaminated and removed from site for medical attention.

Decontamination procedures shall be monitored by the site health and safety supervisor. The site health and safety supervisor will ensure that the decontamination procedures are effective and make the appropriate changes if the decontamination process is found to be ineffective. The site health and safety supervisor will stay in contact with the incident commander for all changes made to the decontamination plan.

10.0 MEDICAL SURVEILLANCE

Golder requires that employees involved in any hazardous waste related work activities participate in our medical surveillance program including examinations at least once annually or at least biennially as confirmed by the consulting physician, and/or after an employee is subject to some type of exposure or symptoms of exposure occur. A fitness for duty exam should be included in the examination to make sure the employee is fit to wear the required PPE under conditions that may reasonably be anticipated at the work site. The medical examinations and procedures are provided by Golder under the supervision of a licensed physician, without cost to the employee, without loss of pay, during working hours, and at a facility convenient to the employee's location. Medical surveillance documentation is kept with the employees records by the human resource representative (HRR) and is kept confidential and in accordance to 29 CFR 1910.120(i) in addition to 29 CFR 1910.120.

11.0 POST EMERGENCY OPERATIONS

In the event that Golder is to perform the duties associated with removal, transportation, and storage of hazardous substances, health hazards, and/or contaminated materials all employees shall receive the property Resource Conservation and Recovery Act (RCRA) and Department of Transportation (DOT)

training. Contractors and/or subcontractors performing these work activities on the behalf of Golder shall at a minimum comply with federal, state and local regulations.

12.0 APPLICABLE REGULATORY REFERENCES

The following are the regulations related to hazardous waste operations:

- 29 CFR 1910.120 “HAZWOPER”.
- 29 CFR 1910.120(q) “Emergency response program”.
- 29 CFR 1910.120(g)(3-5) “PPE”.
- 29 CFR 1910 Subpart I “Hazard Assessment”.
- 29 CFR 1910.1200 “Hazard Communication”.
- 29 CFR 1910.1000 Z-1 Table OSHA Permissible Exposure Limit (PEL) for General Industry:
- 29 CFR 1926.55 Appendix A OSHA PELs for Construction Industry:
- 29 CFR 1915.1000 Table Z-Shipyards OSHA PELs for Maritime:
- National Institute for Occupational Safety and Health (NIOSH) "Pocket Guide to Chemical Hazards" (latest edition)
- American Conference of Governmental Industrial Hygienists (ACGIH) "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices" (latest edition)

13.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.013 SWP Respiratory Protection.
- GAI HSE 200.022 SWP Housekeeping.
- GAI HSE 203 Hazard Communication Program (HAZCOM).

Approved by	Renee Weaver	Issue Date	August 31, 2012
Revision by	Rhiannon Filip	Revision Date	October 30, 2017

1.0 SCOPE

This Silica Exposure Control Standard Work Practice (SWP) applies to all Golder Associates Inc. (Golder) staff working in areas where the potential for exposure to crystalline silica exists. This SWP is reviewed annually. Changes are incorporate for continual improvement and are logged in a revision history table.

2.0 INTRODUCTION

Crystalline silica is a basic component of soil, sand, granite, and many other minerals. Quartz is the most common form of crystalline silica. Cristobalite and tridymite are two other forms of crystalline silica. All three forms may become respirable size particles when workers chip, cut, drill, or grind objects that contain crystalline silica.

Silica exposure remains a serious threat to employees performing work in or around abrasive blasting, foundry work, stonecutting, rock drilling, quarry work and tunneling. Crystalline silica has been classified as a human lung carcinogen. Additionally, breathing crystalline silica dust can lead to silicosis, a serious respiratory condition that in severe cases can be disabling or even fatal.

Exposure can occur during many different construction activities. The most severe exposures have occurred during abrasive blasting with sand to remove paint and rust from bridges, tanks, concrete structures, and other surfaces. Other construction activities that may result in severe exposure include: jack hammering, rock /well drilling, concrete mixing, concrete drilling, brick and concrete block cutting and sawing, tuck pointing and tunneling operations.

3.0 DEFINITIONS AND ACRONYMS

ACGIH American Conference of Governmental Industrial Hygienists

Acute An acute health hazard causes adverse health effects over a short term exposure and develops rapidly.

Chronic A chronic health hazard causes adverse health effects over a long term exposure and develops slowly.

DHHS Department of Human and Health Services

Hazard A condition, situation, or procedure likely to result in bodily harm, injury, death, or occupational disease.

HEPA High Efficiency Particulate Air

IDLH Immediately Dangerous to Life and Health

Mppcf	millions of particles per cubic foot
MSDS	Material Safety Data Sheet
MSHA	Mine Safety and Health Administration
"Must" or "shall"	Means mandatory
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
Qualified Person	Means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience in a technical or engineering. This person has successfully demonstrated his ability to solve or resolve problems relating to the operation, maintenance, and/or the safety controls of the equipment, the work, and/or the project
REL	Recommended Exposure Limit
TLV	Threshold Limit Values
TWA	Time Weighted Average
Should or may"	Means recommended

4.0 KEY HAZARDS

Silicosis is the condition caused when crystalline silica enters the lungs and causes the formation of scar tissue, thus reducing the lung's ability to take in oxygen. Since silicosis affects lung function, it makes one more susceptible to other lung diseases. There are 3 types of silicosis:

- Chronic – Exposure to low concentrations.
  - Develops over a period of 10 years or more.
- Accelerate – Exposure to high concentrations.
  - Develops 5-10 years after the initial exposure
- Acute – Exposure to extremely high concentrations.
  - Symptoms develop within a few weeks to 4 to 5 years after the initial exposure.

Acute forms of silicosis usually develop the following symptoms:

- Shortness of breath, fever, and bluish skin.
- Pulmonary edema (fluid in the lungs).
- Pneumonia or tuberculoses.

In addition, activities such as sandblasting may allow fine particles of other hazardous materials (such as lead in lead-based paint, dust, chemicals, petroleum products, etc.) to cause additional health risks through inhalation of these additional particles. Each chemical has its own associated unique health hazards. Material Safety Data Sheet (MSDS) should be reviewed for any potential chemical present on the job site.

5.0 EXPOSURE LIMITS

Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL) are based upon % crystalline silica. The PEL is based on an 8-hour Time Weighted Average (TWA). The PEL is half the value calculated from the formula for quartz shown below:

- **Construction and General Industries**: The current OSHA PEL for respirable dust containing crystalline silica (quartz) is measured by millions of particles per cubic foot (mppcf) and is calculated using the following formula:
  - Where PEL = 10 mg/m^3 / (% silica + 2) **OR**
  - Where PEL = 250 mppcf / (% silica + 5)
- Respirable crystalline silica (cristobalite):
  - PEL = half the value calculated from the formula for quartz.

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) are based on the respirable dust fraction for silica. The ACGIH TLVs is based on an 8-hour TWA. The TLVs assume that silica is a potential human carcinogen.

- 0.05 mg/m^3 for cristobalite.
  - Immediately Dangerous to Life and Health (IDLH): 25 mg/m^3.
- 0.05 mg/ m^3 for quartz.
  - IDLH: 50 mg/m^3.
- 0.05 mg/ m^3 for tridymite.
  - IDLH: 25 mg/m^3.
- 0.1 mg/ m^3 for Tripoli.
  - IDLH: 50 mg/m^3.

National Institute for Occupational Safety and Health's (NIOSH) Recommended Exposure Limit (REL) for respirable crystalline silica is based on a 10 hours/day during a 40-hour work week. The RELs assume that silica's designation as a human carcinogen.

- 0.05 mg/m^3.

The Mine Safety and Health Administration (MSHA) PEL for underground and surface metal and nonmetal mines is based on an 8 hour TWA:

- The PEL = 10 mg/m^3 / (%quartz +2).

The MSHA PEL for crystalline silica presented in concentration of >5% in underground and surface coal mines is based on an 8 hour TWA:

- The PEL = 10 mg/m^3 / %quartz.

6.0 TRAINING

Every employee who has the potential to be exposed to the effects of crystalline silica will be trained in accordance with 29 Code of Federal Regulations (CFR) 1926.21 and 29 CFR 1926.59. All Golder employees whose work requires them to encounter or potentially encounter crystalline silica exposures will receive crystalline silica training. Training is a critical part of Golder's health, safety, and environment training. Initial training will be conducted prior to the employee beginning any crystalline silica-related work and will be pertinent to the planned work. Training will present specific hazards associated with their work environment, protective measures which can be taken, the danger of crystalline silica to their bodies, and their rights under OSHA. Refresher training will be provided as needed as conditions change, or at least on an annual basis for employees covered by OSHA or State regulations. Records of training will be maintained along with employee health and safety training records in their file. The record will include the name of the employee, the signature of the trainer and the date of the training. The training will include, at a minimum, the following:

- The proper selection and use of Personal Protective Equipment (PPE).
- Instruction on marking and obeying warning signs (marked off boundaries).
- Discussion of engineering controls, personal hygiene, and work practices.
- Information on safe handling, labeling, and storage of poisons, caustics, and/or other harmful substances that could result from the silica-producing activities.
- Information about the potential adverse health effects of silica exposure.
- The handling and use of sandblasting equipment (if applicable).

7.0 EXPOSURE MONITORING

A medical examination by a licensed physician is required for employees who may be exposed to crystalline silica before the start of any work activities, and at least once every 3 years thereafter. More frequent examinations may occur for employees at risk for acute or accelerated silicosis. Medical examinations shall at a minimum include the following:

- A medical and occupational history to collect data on worker exposure and signs and symptoms of respiratory disease.
- Chest X-rays (classification of radiographs of the Pneumoconiosis).

- Pulmonary function testing (spirometry).
- Annual evaluation for tuberculosis.

NIOSH encourages the reporting of all cases of silicosis to the State health departments and to the OSHA or to the MSHA. See the NIOSH guidelines for the reporting and definition for silicosis. In addition, confirmed cases of silicosis must be recorded on the OSHA 300 Injury and Illness log as an occupational illness.

8.0 CONTROL MEASURES AND PPE

8.1 Engineering controls

Engineering controls should be implemented as the primary means of protection to minimize employee exposure to silica dust and other harmful substances. Engineering controls include, but are not limited to, the following:

- Substitution such as:
  - Silica sand containing less than 1% crystalline silica.
  - Use of alternate blasting media: glass beads, copper slag, garnet, staurolite, olivine, corundum, pumice, sawdust, slags, steel grit and shot, and/or walnut shells.
- Containment methods such as:
  - Blast cleaning machines and/or cabinets.
  - Abrasive blasting rooms.
  - Portable blast-cleaning equipment.
  - Ventilation of containment structures.
- Wet Methods such as:
  - Water spray.
  - Wet sawing/drilling/grinding.
  - Water hoses to wet down dust at point of generation.
- Dust Collection Systems:
  - High Efficiency Particulate Air (HEPA)-filtered local exhaust systems.
  - Dust collection attached to equipment.

8.2 Administrative Controls

Appropriate warning signs will be posted to warn employees about the silica hazard and PPE requirements. The signs should contain the following information.

WARNING!

CRYSTALLINE SILICA WORK AREA

Exposure may cause silicosis
(a serious lung disease),
cancer, and death

RESPIRATOR REQUIRED

8.3 Personal Hygiene

Employees shall follow personal hygiene practices to protect against exposure to crystalline silica and/or other harmful contaminants. Personal hygiene practices include the following:

- Washing hands and face before eating, drinking, or use of tobacco products.
- Not eating, drinking, or using tobacco products in the work areas.
- Showering before leaving the worksite where silica is present.
- Parking cars where they will not be contaminated with silica and other substances.

8.4 Protective Clothing

The following measures should be taken to assure that the employees' clothes do not contaminate cars, homes, or worksites (outside of the blasting area).

- Employees should change into disposable or washable work clothes at the worksite.
- Employees should change into clean clothes before leaving the worksite.

8.5 Air Monitoring

Air monitoring should be performed by a qualified person to measure the employee exposure to airborne crystalline silica. If there is a recognized or potential silica exposure then OSHA requires that an initial air sample is taken to determine if further monitoring may be required.

Air samples should be collected and analyzed according to NIOSH Method number 7500 and 7602 (1984) or an equivalent. Air monitoring should be used as the basis for evaluating and selecting appropriate engineering controls or respiratory protection.

8.6 Respiratory Protection

Effective source controls such as substitution, containment, wet methods, dust collection, and good work practices should be implemented to minimize worker exposure to silica dust. When source controls cannot keep silica exposures below acceptable exposure limits, controls will be supplemented with the use of respiratory protection meeting the requirements of Golder's "US_SWP 13 Respiratory Protection". Elements of this program include:

- An evaluation of the employee's ability to perform the work while wearing a respirator.
- Regular training of personnel.
- Periodic environmental monitoring.
- Respirator fit testing.
- Maintenance, inspection, cleaning, and storage.
- Selection of proper NIOSH-approved respirators.

Respiratory protection will be recommended when engineering controls are not adequate to maintain employee exposure levels to crystalline silica below the levels indicated in the "Exposure Limits" section of this document.

In addition, NIOSH recommends that employees wear the type CE abrasive blasting respirator operated in the positive-pressure mode during abrasive blasting operations involving crystalline silica. Table1 below provides the minimum respiratory equipment required to meet the NIOSH REL.

Table 1.--NIOSH-recommended respiratory protection for workers exposed to respirable crystalline silica

Condition	Minimum respiratory protection required to meet the Condition NIOSH REL for crystalline silica (50 µg/m^3)
Less than or equal to 500 μg/m^3 (10 x REL)	Any air-purifying respirator with a high-efficiency particulate filter
Less than or equal to 1,250 μg/m^3 (25 x REL)	Any powered, air-purifying respirator with a high-efficiency particulate filter, or Any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode (for example, type CE abrasive blasting respirators operated in the continuous-flow)
Less than or equal to 2,500 μg/m^3 (50 x REL)	Any air-purifying, full-face piece respirator with a high-efficiency particulate filter, or Any powered, air-purifying respirator with a tight-fitting face piece and a high-efficiency particulate filter

Less than or equal to 50,000 $\mu g/m^3$ (1,000 x REL)	Any supplied-air respirator equipped with a half-mask and operated in a pressure-demand or other positive-pressure
Less than or equal to 100,000 $\mu g/m^3$ (2,000 x REL)	Any supplied-air respirator equipped with a full face piece and operated in a pressure-demand or other positive-pressure mode (for example, a type CE abrasive blasting respirator operated in a positive-pressure)
Planned or emergency entry into environments containing unknown concentrations or concentrations less than or equal to 500,000 $\mu g/m^3$ (10,000 x REL)	Any self-contained breathing apparatus equipped with a full face piece and operated in a pressure-demand or other positive-pressure, or Any supplied-air respirator equipped with a full face piece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure
Firefighting	Any self-contained breathing apparatus equipped with a full face piece and operated in a pressure-demand or other positive-pressure
Escape only	Any air-purifying, full-face piece respirator with a high-efficiency particulate filter, or Any appropriate escape-type, self-contained breathing apparatus

9.0 APPLICABLE REGULATORY REFERENCES

- 29 CFR 1910.1000 “Air Contaminants” see also Table Z-3.
- 29 CFR 1926.55 “Gases, vapors, fumes, dusts, and mists”.
- 29 CFR 1926.21 “Safety Training and Education”.
- 29 CFR 1926.59 “Hazard Communication”.
- 29 CFR 1910.134 “Respiratory Protection”.
- NIOSH Publication 92.102, Preventing Silicosis and Death From Sandblasting, 1992.
- Department of Health and Human Services (DHHS) Publication No. 2202-129 (NIOSH publication).
- MSHA 30 CFR 56, 57, 70, and 71.
- ACGIH Publications.

10.0 RELATED GOLDER DOCUMENTS

- GAI HSE 200.013 SWP Respiratory Protection.
- GAI HSE 203 Hazard Communication Program (HAZCOM).

ATTACHMENT 3

HSSE PROCEDURE 212 GROUND DISTURBANCE PREPARATION AND UTILITIES INVESTIGATION

HSSE PROCEDURE

Ground Disturbance Preparation and Utilities Investigation

May 2018

Submitted by:

Americas Health, Safety, Security, and Environment

HSSE Procedure 212

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APPENDICES

APPENDIX A
Ground Disturbance Flowchart

Approved by:	Steve Kogon	Issue Date:	May 23, 2018
Revision by:		Revision Date:	Original

1.0 SCOPE

This Procedure provides requirements and guidelines respecting the control strategies available when disturbing the ground and conducting utility locates. Any persons undertaking ground disturbance activities will locate utilities to prevent damage and to reduce the risk of a serious incident. Utility locating is an early phase of site investigation and allowances must be made at the proposal stage for required schedule, efforts, and costs.

Due to the high potential risks associated with a utility strike, Golder North America takes the position that we will utilise 'daylighting' techniques unless we can reasonably demonstrate that daylighting is not necessary. 'Reasonable demonstration' will be defined by the positive identification of all high-risk sources (gas, electrical, pipeline) on-site during site reconciliation. To help in this determination both public and private locates will be conducted for all underground investigations and all locate tickets must be valid at time of ground disturbance.

Clients may require Golder to go above and beyond this procedure. This document is not intended to supersede legislation.

2.0 DEFINITIONS AND ABBREVIATIONS

Buried Facility/Assets: anything buried or constructed below ground level such as electrical utilities, communications, water, sewage, oil, gas, including but not limited to, the pipes, conduits, ducts, cables, wires, valves, manholes, catch basins, vaults, chambers, and their associated attachments.

Private Locates: Conducted by a contracted third party utilizing utility locate equipment and techniques that go beyond Public Locate scope and capabilities. Must be an approved subcontractor to Golder. Further information can be found in HSSE Toolkit – Locate Technologies.

Public Locates: locates of public infrastructure like water, sewer, electrical, and communications. Also known as: 'One Call', 'First Call', 'Dial Before You Dig', 'Info-Excavation' or '811'. This type of locate may be limited on private property. It should be noted that the locates tickets expire and that public locates may not include all public utilities. You may need to contact individual utility owners to locate their own assets.

Crossing Agreement: A legal agreement between parties that provides permission to cross a third-party utility or work within the utility's right-of-way (RoW). Requirements to respond to request for crossing agreements can be 30 days depending on jurisdiction.

Daylighting: Exposing a utility in the immediate area of your planned disturbance by removing the earth adjacent to the utility. Sometimes referred to as non-destructive digging. This can take the form of hand digging, hydro-excavation (hydro vacuuming – V-trench, slot-trench, potholing), or air knifing. Hand augers are not considered a form of hand exposure as hand augering does not uncover the utility or potential utility of concern.

Demarcation Point: The limit of public utility owned facilities where a facility owner no longer takes responsibility for maintenance or locating. This point varies by facility, owner and geography. Public utility water locates are

often marked only up to the water valve (which is often the property limit boundary) whereas gas locates may go right up to the meter which is most often on private property.

Drawings:

As-built: Drawings that depict the final installed configurations and reflect changes made during the construction process, recording the differences between the original design and the completed installation. Many drawings that are referred to (or even labelled as) 'As-built' are truly construction/design drawings and commonly not reflective of final positioning.

Construction (blue prints): Working drawings that are used by all parties involved on a construction project. Due to conditions in the field, installations are not always completed as shown in the construction drawings.

Preliminary/Engineering: These are utility drawings maintained by individual utility owners that are constantly in the process of being updated. New information can be sent to excavators through public locate requests and available to locate service providers.

Easement: The right to use the property of another for a specific purpose. Easements are given to utility companies for the rights to bury or access utility lines.

Ground Disturbance: A work operation or activity on or under the existing surface resulting in a disturbance or displacement of the soil or ground cover below 15cm (6in). Ground disturbance also encompasses concrete and pavement coring for any depth. Activities may include, but are not limited to, drilling, trenchless (horizontal or directional) drilling, dynamic or static probing, concrete or asphalt coring, excavation, hydro-excavation (or hydrovacuuming), trenching, test pitting, and hand augering.

Ground Disturbance Plan: A Ground Disturbance Plan includes a map of the work area including planned ground disturbance areas, the results of the desktop data gathering, Work Method Statements for the planned tasks, site specific Emergency Response Plan. See HSSE SWP – GD ERP.

Proximity Agreement - Pipelines: This is a legal agreement between parties that provides permission to work within proximity to a third-party utility.

Search Area (Upstream Oil and Gas): 30 meters (98.5 feet) around the ground disturbance area in which locates must be conducted to determine if utilities or underground facilities exist.

Site Reconciliation: A comparison between the results of data gathering including locates and what is physically observed on site. This include a 3600 observation of all evidence of buried utilities on, leading into, leading off, traversing, in proximity to and surrounding the work area.

Street Furniture/Features: Features that are supplied by a gas/electrical/water utility etc. Such as street lights, signals, lamp posts, electrical signage, manholes, buss stops, vault covers, fire hydrants, electrical boxes, gas valves, meters…are all indicative of a buried asset.

Legal Land Survey: A dimensioned property plan including fixed structures (building, fences, and retaining walls) and the position of any public or municipal easements.

Utility Corridor: a passage built underground or above ground to carry utility lines such as electricity, steam, water supply pipes, and sewer pipes. Communications utilities like fiber optics, cable television, and telephone cables can also be found in a corridor (sometimes referred to as a utility tunnel, chase or utilidor).

Utility Strike: Any unplanned impact or exposure of a utility which resulted in, or could have resulted in the fatality, injury, property damage and/or a need to repair. This includes but is not limited to: impact to the protective coating, lateral support, cathodic protection, the housing for the line device or utility, or the soil surrounding a utility that is designed to support a line under pressure (e.g. water mains are designed to withstand internal pressures with the addition of compacted soil around them such that removal of the soil can cause the pipe to explode). The owner of the utility must be informed and given the opportunity to inspect/repair the utility.

Verification Call: Once the site reconciliation is complete, the site supervisor is to call the PM/PD to discuss the results. If everything has been reconciled successfully, verbal approval to proceed may be given. If there are unreconciled utilities, the PD will provide further direction on next steps via the HSSE Form – Authority to Work.

3.0 RESPONSIBILITIES

Project Director

- Review Ground Disturbance Plan (site maps, site owner interview, desktop data review, and public locate information) as best practice and as a requirement when the project team is seeking deviations from daylighting. Approve deviations.
- Take verification call / follow up from site supervisor/PM after site reconciliation is completed for all projects where a deviation was granted and/or project where there were unreconciled utilities found during site reconciliation and determine next steps.

Project Manager:

- Review this procedure in helping to prepare the project specific Ground Disturbance Plan
- Verify that all team members are familiar with this HSSE Procedure and site-specific ground disturbance plan, supporting documents and have completed the required training and competency assessments
- Attend personally or provide a Site Supervisor to oversee private utility locators (and public if possible).
- Support Site Supervisor to reconcile all site infrastructure with data gathered and coordinate with PD on next steps.
- Contribute to investigations into all utility strikes or near strikes that occur on their projects.

Site Supervisor:

- Follow this procedure and supporting documents when conducting utility locates.
- During the site investigation, confirm site/project specific ground disturbance plan is in place before commencing work and ensure work is carried out in accordance with the plan
- Be trained and deemed competent in Ground Disturbance
- Monitor utility locator subcontractor HSSE performance and provide feedback to subcontractor database.
- Initiate investigations into all utility strikes or near strikes that occur on their projects.

Employee:

- Know, understand and follow this procedure and supporting documents.

- Inform your Project Manager / Site Supervisor of any issues related to the locate process, any utility strikes or near strikes as soon as safe to do so.

4.0 EXAMPLES OF BURRIED INFRASTRUCTURE

Asset	Typical Material	Risk
Electrical (underground and overhead)	May be encased in metal or plastic conduit.	High
Gas and Oil (including pipelines and oilwells)	Metal or PVC; occassionally copper	High
Facility Process Lines (water or other chemical supply lines)	Metal, PVC, plastic.	High (depending on chemical)
Underground Storage Tanks (UST) or vaults; underground parking lots, tunnels...	Concrete, metal, fiberglass	Medium (potential high environmental risk)
Water (domestic, fire, irrigation) and Force Main	Transite, PVC, or metal	Medium
Steam		Medium
Sewer (storm and sanitary, drainage lines, septic lines)	Transite, concrete, or PVC. Occassionally brick.	Low
Communications (telephone, cable TV, closed circuit TV, computer lines, fibre optic, traffic signal lines, security, low voltage sensors...)	Electrical cable (copper or fibre optic)	Low (potential financial risk can be high)

N.B.: listed are the most common materials associated with certain utilities. Other materials include clay tile, cast iron, fiber, wood, HDPE, polyethylene or even brick in older installation.

5.0 TRAINING AND COMPETENCY

All Site Supervisors who are supervising ground disturbance activities must complete Golder's internal training;

- Supervisor training modules
- Utility Locates Training – available in Golder's Learning Management System (under development)
- Competency Requirements (under development)

Online Training

Online Ground Disturbance training will be provided to employees to support this procedure. Some clients do not recognize our internal training program. In this case, additional external course(s) may be required.

6.0 PROCEDURE

A flow chart of the procedure can be found in APPENDIX A

Data Collection/Office Preparations

Site Owner/Occupant Interview

- Obtain accurate location of the site (e.g. address, township, lot number, concession, etc.) from the client, site owner and occupant in writing agree on the scope, precise location, and purpose of the work. If possible, determine alternate work locations in advance of ground disturbance activities in case of utilities being discovered at planned locations. Enquire as to individuals who could provide best sources of information.
- Endeavour to identify and speak to those who have information that may prove helpful in investigating underground utilities (long tenured maintenance manager, plant manager, leasee, subcontractor, ex-employee, etc.)
- Request historical site data such as: as-built drawings and site plans detailing utilities on the site, fire insurance drawings, and current/historical air photos/Google Earth images. The full list of potential sources can be found in the HSSE Form – Authority to Work. Where buildings are present, both interior and exterior information should be provided.
- Identify locations of in-service or closed in-place underground storage tanks and associated buried piping. Construction or preliminary/engineering drawings or other surveys of site should also be requested.
- Consider activities and what underground (and overhead) assets may be encountered transecting your work site from adjacent properties.
- Consider multiple owners, subdivided properties, the presences of easements or right of ways that may require alternative locating strategies (highways, pipelines, access roads, etc.)

Public Locates

- Determine which public locate service is available and arrange for utility locates. ('Call Before You Dig', One Call, etc.)
  - Timelines vary locally. You will need a minimum of two days notification but should allow for up to three weeks. Complete the HSSE Form – Locates Log.
- There are often errors in the paperwork received from public locates. Review all data received for accuracy.

Desktop Data Review

- Review the culmination of the data collection and public locates to determine a ground disturbance plan.
- The Project Manager and assigned field Site Supervisor will review all locate information to confirm that all potential data sources have been collected and reviewed.
- Best practice is to always determine an alternate location, prior to conducting private locates, in the event that utilities may be impacted by the original plan.
- Confirm the plan is based on the technical documents associated with this procedure and an understanding of the locating technology limitations. Utility strikes occur even when utility locates are performed. Recognise situations that can lead to inaccurate locates.
- Check for third party locate requirements. For example, the client may require a third-party locator of their choice to verify the locates.

Ground Disturbance Plan

- A Ground Disturbance Plan is created through the completion of the office comments on the HSSE Form – Authority to Work. and project site maps detailing locations of ground disturbance.
- If public, private, and daylighting are not included in the Ground Disturbance Plan, then the plan must be approved by the Project Director prior to moving forward to next steps. If daylighting is part of the plan the PD review remains best practice.
- Include a list of relevant utility companies and their contact phone numbers on-site as well as copies of the crossing/proximity agreements
- An emergency response plan and Work Method Statement (or equivalent) provided by the drilling subcontractor should be a part of every Ground Disturbance Plan.

On Site

Private Locates

It is a Golder North America requirement that both public and private locates are completed. All deviations from this procedure are to be documented in the HSSE Form – Authority to Work and must be signed off by the Project Director. Refer to HSSE SWP – Site Reconciliation for more information.

- Contact an approved subcontractor private locator company.
- Using the HSSE Toolkit – Locate Technologies discuss and determine what type of locates technology are required with the private locate subcontractor.
- Provide private locators with all available information.
- Schedule a Golder site supervisor to be present during the private locate process to monitor and understand the capability of the chosen technology, the quality of the locates, and verify the correct work locations.
- Site Supervisor shall re-review all available information and update Ground Disturbance Plan (site plan and forms package).
- It is best practice to have the client attend the private locates with Golder and discuss levels of certainty and the Ground Disturbance plan.

Reconciliation

- Refer to HSSE SWP – Site Reconciliation.
- Site Reconciliation includes a site walk around, review of desktop data, public locates data, and all client owned infrastructure even that which is outside the ground disturbance area
- It is essential during this site visit that Golder confirms all street furniture, electrical and gas fixtures have identified sources. Know where everything is and where everything is not with enough redundancy (locates, as-builts, surface features…) to be confident. A lack of certainty around electrical and gas will negate planned deviations from daylighting and a revaluation of the ground disturbance plan
- Mark all overhead utilities on the reconciliation sketch.

- This reconciliation is critical to make sure all data sources are aligned. **Inconsistencies indicate the need to stop**, call the Project Manager / Director, and discuss the path forward. Options are:
  - Contact utility companies to verify if unmarked/located service belongs to them.
  - Conduct a second set of alternative private locates (i.e. using a different private locate subcontractor, technology or different employee(s) from the first locates subcontractor);
  - Change the location of the work so it does not impact the known or suspected utilities;
  - Daylight (Hand dig / hydrovac / air knife) if not already planned; or
  - Deactivate and/or re-route any live utilities.
- After the reconciliation checklist and sketch are complete, the Site Supervisor it is a best practice to call the Project Manager to discuss the results and agree to the path forward. Documentation of the discussion must be placed in the project file.
- If the subcontractors that perform the ground disturbance are responsible for locating utilities, or the client is locating utilities (i.e. Golder is not responsible for the ground disturbance task, we are only conducting associated tasks near the ground disturbance), the Golder site supervisor must review the locate reports and drawings before ground disturbance begins.
- If a third party conducted the utility locates (client, site owner, etc.) and Golder is supervising the ground disturbance, review the locates on site before work begins. It is preferable that Golder is present during the private locates. The Golder Site Supervisor in charge of ground disturbance must still complete the utility reconciliation checklist and sketch on the HSSE Form – Authority to Work. Do not start work until you are satisfied that up to date, quality locates were conducted and appropriate controls are in place.
- Record all locate ticket numbers in the HSSE Form – Locates Log and any client required documents.

Daylighting

- Contact an approved subcontractor daylighting company.
  - Areas that must always be daylighted based on legislation are:
  - Within 5 meters (16.4 feet) of a pipeline (Alberta and Saskatchewan by law)
  - Within 3 meters (9.8 feet) of a National Energy Board (NEB) Pipeline (Canada)
  - Within 1 meter (3.3 feet) of all other types of buried utilities
  - Or as specified in a crossing agreement
- The following areas have complex and historical underground utilities and must always be daylighted:
  - Working in urban cores (downtown or other densely populated areas of cities).
  - On oil and gas facility sites even when it is not a client requirement.
  - On industrial sites that have operated for more than 10 years and had multiple owners.

- When the property owner has private underground utilities in the work area that cannot be located by the private locator but are known to be present based on the site drawings (e.g. non-metal utilities like water, sewer pipes, or communication cables). If the utility is not gas or electricity, and the landowner has signed-off in writing on ground disturbance without daylighting, the Project Manager may consider forgoing the requirement to daylight.
- Decisions regarding daylighting depth should account for known utility depth and local frost depth. It is best practice to add an additional 30cm (1 foot) of hydrovac depth to the greater of those two depths. Beyond noting known utility depth, minimum clearance depth should be 3.0m (9'10"). In areas north of 60 degrees latitude, daylighting should be conducted to 3.65m (12').
- Client daylighting, or locating, requirements may be more stringent. Always work to the higher standard.
- Deviations from the utility locating requirements must be documented in the HSSE Form – Authority to Work.

Information regarding use of Hydrovac/Air Knifing equipment is provided in the HSSE Toolkit – Hydrovacing.

Zero Energy - Shut-Off Services

- When coring concrete achieving 'Zero Energy' is equivalent in protection to daylighting in soils. Where possible, have a qualified client and or utility representative blank and shut off any services which may be present.
- Golder, client, and utility owner should use a shared Lock Out Tag Out (LOTO) plan.
- Lines containing hazardous gasses/chemicals shall be blocked, blanked and purged.

Ground Disturbance

- Even with a review plan in place, never assume the area is clear of services.
- Review the emergency procedures daily at the tailgate meeting. Identify the location and operation of emergency shut off switches and review location of emergency response equipment with all parties on site. Secure work area with signs and barriers in place.
- Confirm locates are accurate, valid and not expired before ground disturbance at the daily tailgate meeting.
- Keep the utility locates file on-site at all times, including those by third parties. Work must not be undertaken unless this file is on-site and up-to-date. It is important to follow the instructions on your locate tickets and pay particular attention to the expiration date as they may vary from utility to utility and from jurisdiction to jurisdiction.
- Utility locates marks (flags, paint, etc.) should be kept clear throughout the ground disturbance activity. New locates may be required to remark a work area. It is recommended that flags are used in times where maintaining painted markings is difficult (e.g. snow).
- Conduct another locate review whenever the scope of the work for the day changes to make sure the utility locate information is valid.
- If the ground disturbance activities extend past the area where utility locates have been completed, stop work and conduct new locates for the extended work area.

- While work is in progress, look for signs or marker layers as you dig (pea gravel, sand, insulation, and other backfill material). On roadway jobs, inspect new road cuts for possible service trenches.
- Maintain minimum distances from utilities, corridors, and rights-of-way. If you must disturb ground within the minimum distance, try to use other locations first and/or use daylighting techniques.
- If any sign of a utility or asset is discovered during ground disturbance activities, stop, call the Project Manager and discuss how to proceed.

6.1 Deviations

To best understand where all underground assets exist Golder's standard of care is to not only conduct public and private locates but then utilise daylighting to further minimise the risk associated with an underground utility strike. Although this approach/plan (public > private > daylighting) is the only strategy that does not require PD sign off, it is still best practice for the project manager to meet with the PD to review the Ground Disturbance Plan. For all other Ground Disturbance Plans that deviate, the PD review and sign off is mandatory.

7.0 RECORDS

Field

- The following documents shall be completed and kept on site during all ground disturbance activities:
  - HSSE Plan
  - Ground Disturbance Plan
  - Applicable Work Method Statements
  - Job Safety and Environment Analysis
  - Authority To Work
  - Locates Log
  - Site maps, photos etc.

Project File

- All the above documents
- All data used for desktop review

8.0 APPLICABLE LEGISLATION AND INDUSTRY GUIDELINES

- TSSA Excavation in the Vicinity of Gas Lines
- National Energy Board Regulation
- Alberta, Saskatchewan and Canada Pipeline Acts
- ESA Guideline for Excavation in the Vicinity of Utility Lines
- 811: http://call811.com/

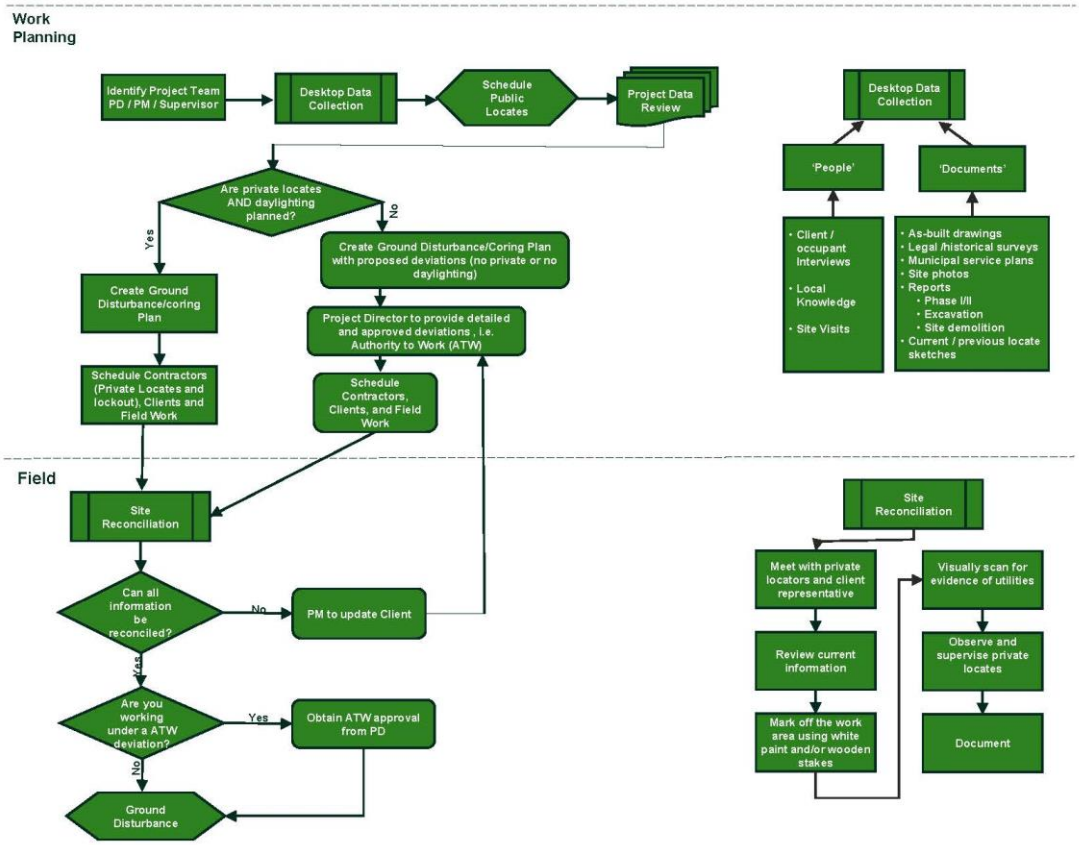
9.0 REVISION HISTORY

Revision	Change(s) Made (Section reference)	Change(s) made by	Date (mm yyyy)

APPENDIX A

Ground Disturbance Flowchart

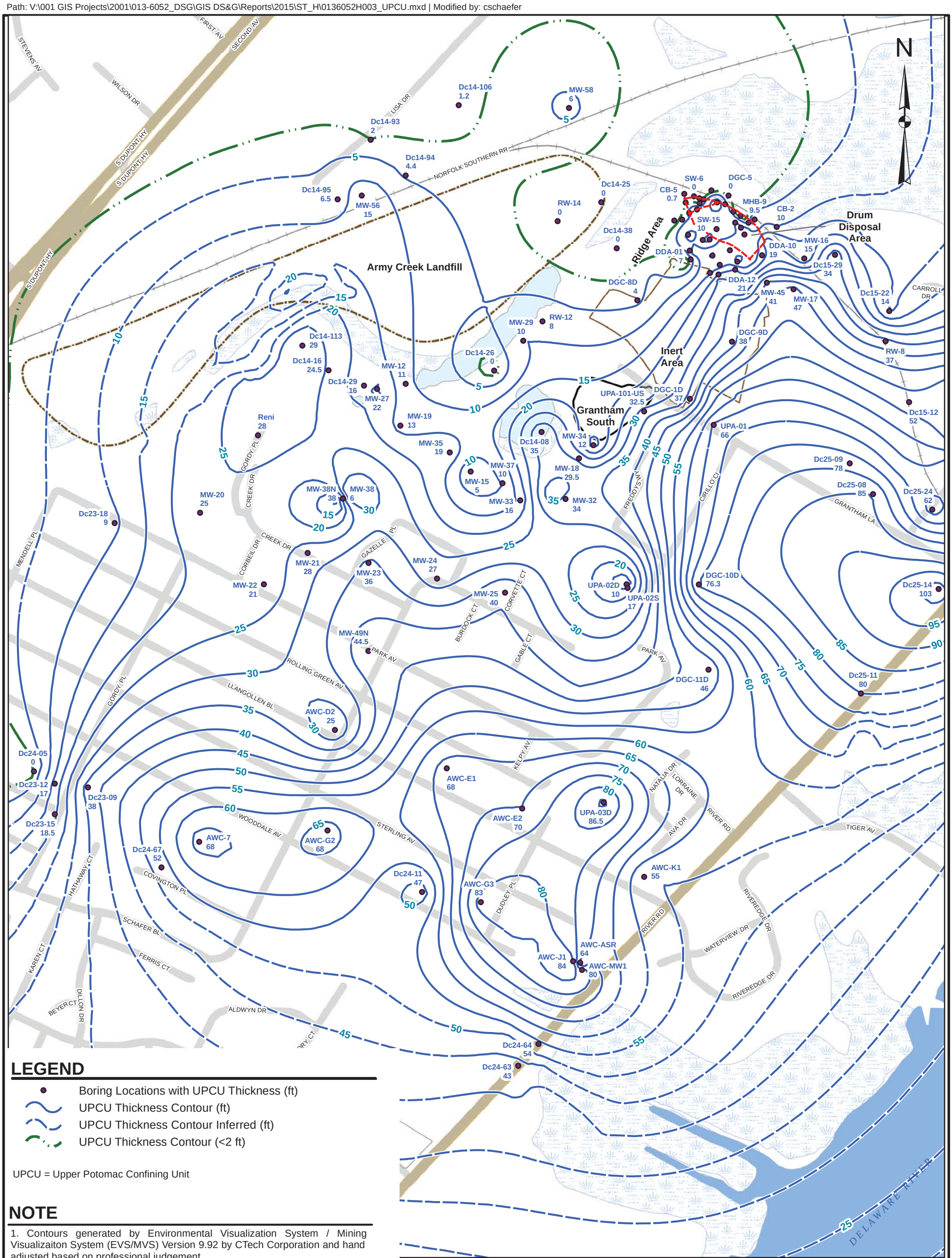
APPENDIX A- GROUND DISTURBANCE / CORING FLOWCHART



APPENDIX C

Geologic Contours and Cross Sections from SSC Rev 2

Path: V:\001 GIS Projects\2001\013-6052_DSG\GIS DS&G\Reports\2015\ST_H\0136052H003_UPCU.mxd | Modified by: cschaefer



LEGEND

- Boring Locations with UPCU Thickness (ft)
- UPCU Thickness Contour (ft)
- UPCU Thickness Contour Inferred (ft)
- UPCU Thickness Contour (<2 ft)

UPCU = Upper Potomac Confining Unit

NOTE

1. Contours generated by Environmental Visualization System / Mining Visualizaiton System (EVS/MVS) Version 9.92 by CTech Corporation and hand adjusted based on professional judgement.
2. Based on December 5, 2014 Geologic Model

REFERENCE

Base data taken from New Castle County Delaware, Department of Land Use, "eParcel View Map" web site GIS data download. Data acquired 07/29/2013.

0 300 600 1,200 Feet

1 inch = 600 feet

FIGURE 2.1

REVIEW	TAM	12/10/2015
CHECK	RWB	12/10/2015
GIS	CDS	12/10/2015
DESIGN	TAM	01/20/2012
REV. 0	SCALE: AS SHOWN	
FILE No. 0136052H003_UPCU		
PROJECT No. 013-6052.007		

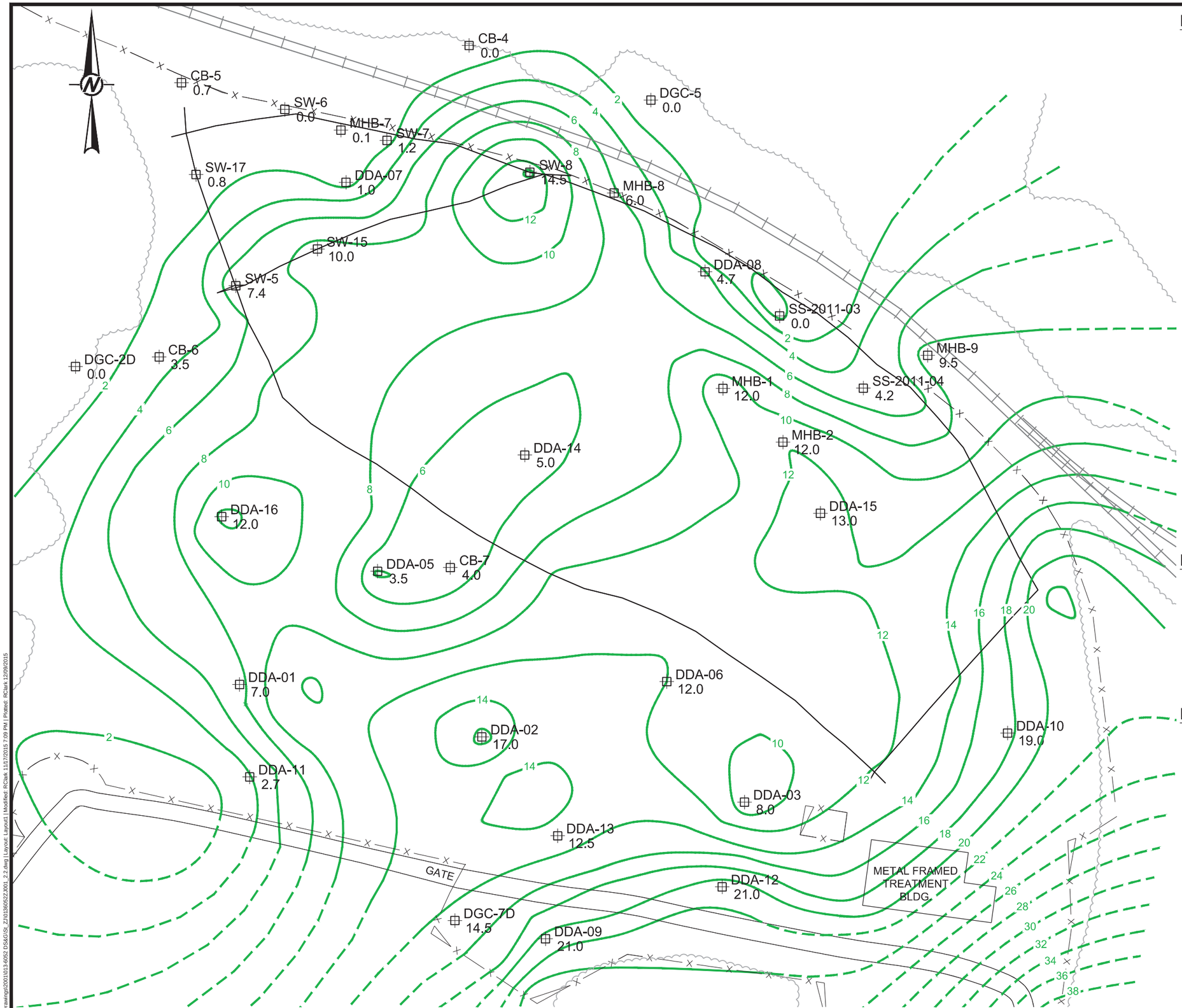
TITLE

UPCU THICKNESS CONTOURS DS&G AND ACL SITES

PROJECT

Delaware Sand and Gravel Superfund Site New Castle, Delaware

Golder Associates
Manchester, New Hampshire



LEGEND

—X—X—X—X	FENCELINE
———	CENTERLINE OF SLURRY WALL AROUND DRUM DISPOSAL AREA
++++++	RAILROAD
——16——	CONTOURS OF UPCU THICKNESS (FT) DASHED WHERE INFERRED
⊕ DGC-5 16.0	SOIL BORING LOCATION AND UPCU THICKNESS (FT)

NOTES

1.) LOCATIONS OF WELLS AND BORING ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

2.) UPCU = UPPER POTOMAC CONFINING UNIT

3.) CONTOURS GENERATED BY ENVIRONMENTAL VISUALIZATION SYSTEM / MINING VISUALIZATION SYSTEM (EVS / MVS) VERSION 9.87 BY CTECH CORPORATION AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGEMENT. NOT ALL BORINGS USED BY EVS SHOWN ON FIGURE

REFERENCES

1.) BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 30 60 90
SCALE FEET

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
UPCU THICKNESS CONTOURS
DDA VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZJ001_2.2
DESIGN	RWB	09/25/13	SCALE	AS SHOWN
CADD	MRS	09/25/13		
CHECK	DAC	09/29/13		
REVIEW	TAM	09/29/13		

FIGURE 2.2

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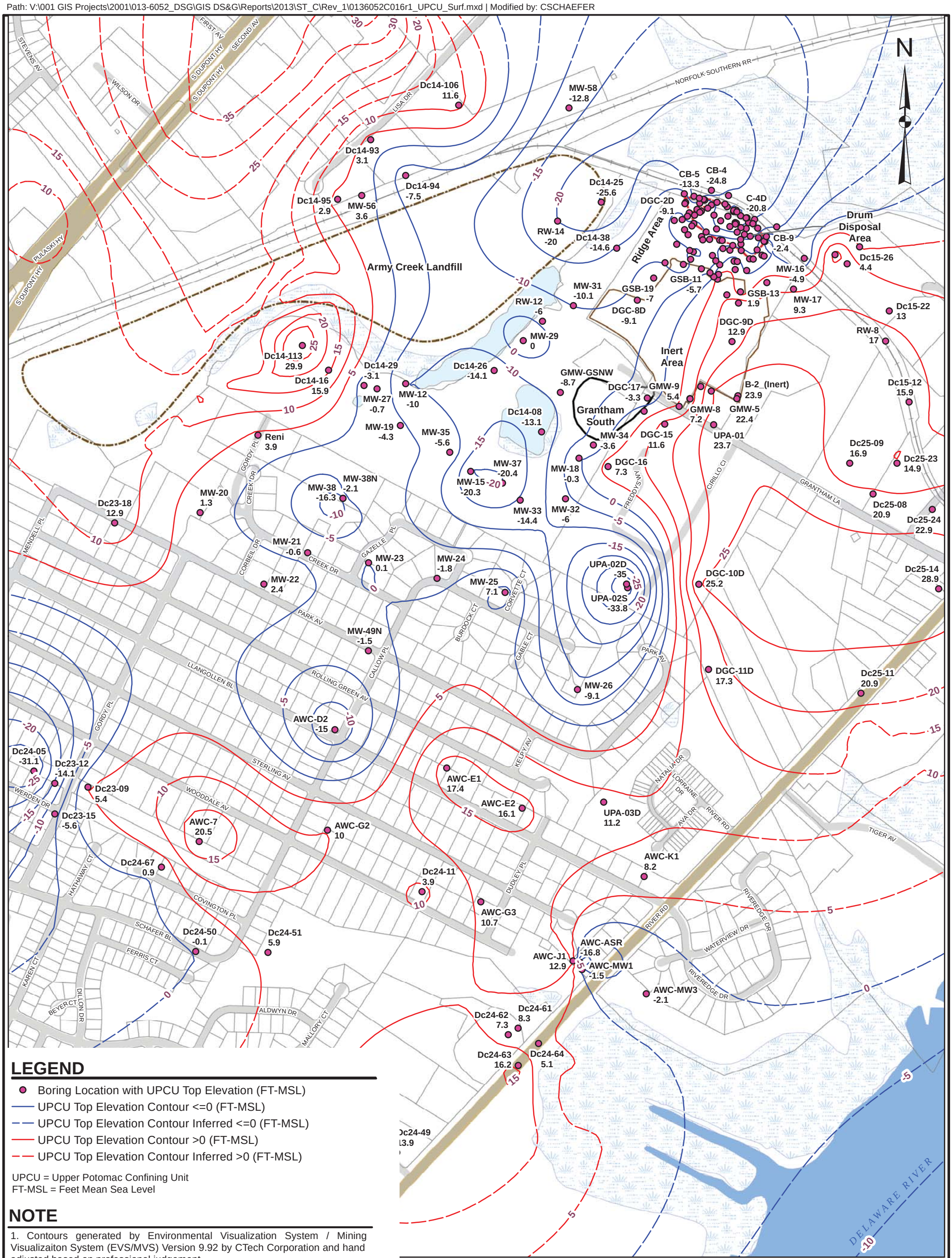
Path: V:\001 GIS Projects\2001\013-6052_DSG\GIS DS&G\Reports\2013\ST_C\Rev_1\0136052C016r1_UPCU_Surf.mxd | Modified by: CSCHAEFER



LEGEND

- Boring Location with UPCU Top Elevation (FT-MSL)
- UPCU Top Elevation Contour <=0 (FT-MSL)
- UPCU Top Elevation Contour Inferred <=0 (FT-MSL)
- UPCU Top Elevation Contour >0 (FT-MSL)
- UPCU Top Elevation Contour Inferred >0 (FT-MSL)

UPCU = Upper Potomac Confining Unit
FT-MSL = Feet Mean Sea Level

NOTE

1. Contours generated by Environmental Visualization System / Mining Visualizaiton System (EVS/MVS) Version 9.92 by CTech Corporation and hand adjusted based on professional judgement.
2. Based on December 5, 2014 Geologic Model

REFERENCE

Base data taken from New Castle County Delaware, Department of Land Use, "eParcel View Map" web site GIS data download. Data acquired 07/29/2013.

0 300 600 1,200 Feet

1 inch = 600 feet

FIGURE 2.3

REVIEW	TAM	11/20/2015
CHECK	RWB	11/20/2015
GIS	CDS	11/20/2015
DESIGN	TAM	01/20/2012
REV. 0	SCALE: AS SHOWN	
FILE No.	0136052_001	
PROJECT No.	013-6052.007	

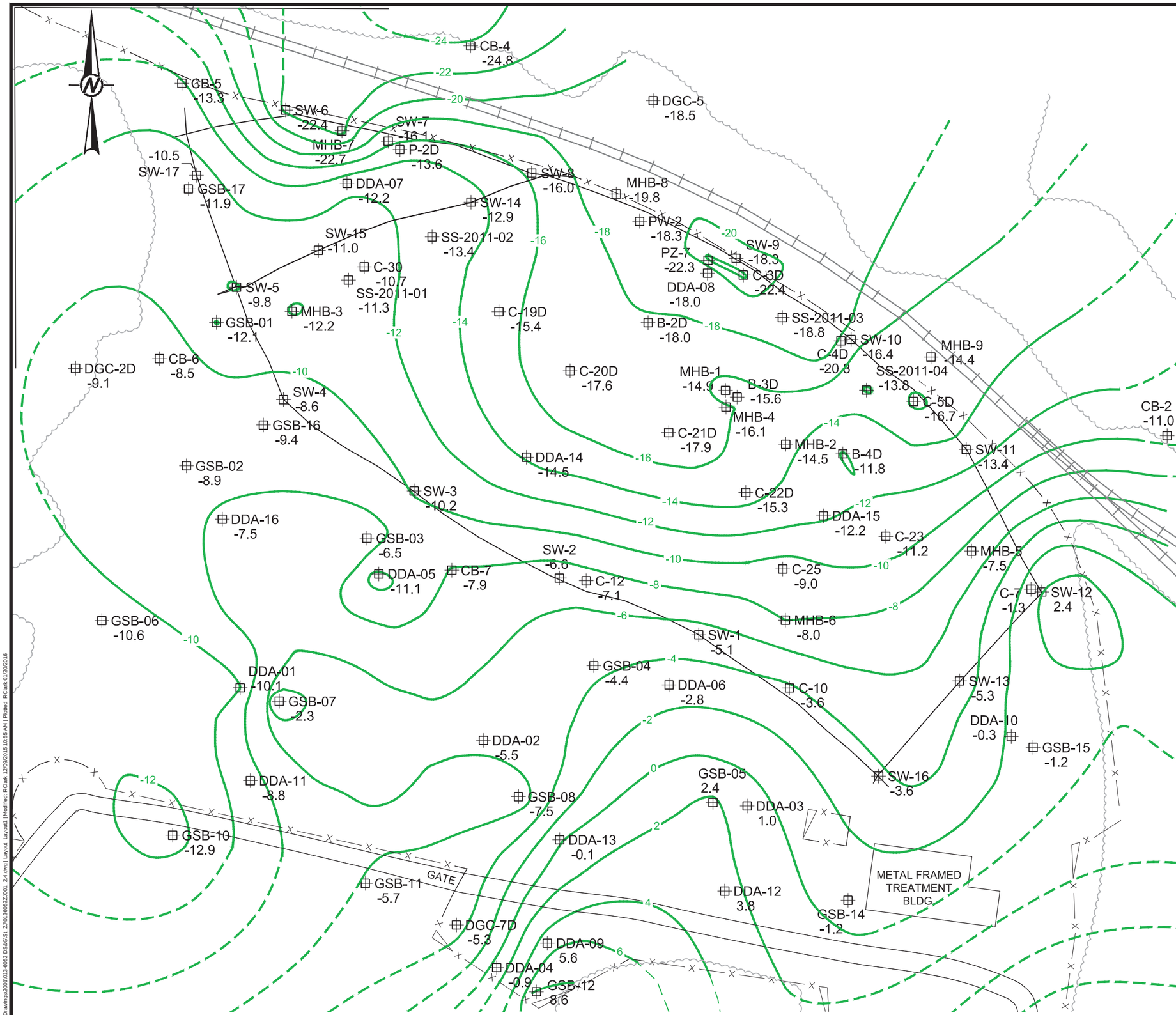
TITLE

UPCU SURFACE ELEVATION CONTOURS DS&G AND ACL SITES

PROJECT

Delaware Sand and Gravel Superfund Site New Castle, Delaware

Golder Associates
Manchester, New Hampshire



LEGEND

–X——X——X——X	FENCELINE
———	CENTERLINE OF SLURRY WALL AROUND DRUM DISPOSAL AREA
═══	RAILROAD
——-16——	CONTOURS OF UPCU SURFACE ELEVATION (ft - msl) DASHED WHERE INFERRED
⊞ DGC-5 -16.0	SOIL BORING LOCATION AND TOP OF CLAY ELEVATION (ft -msl)

NOTES

1.) LOCATIONS OF WELLS AND BORING ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

2.) UPCU = UPPER POTOMAC CONFINING UNIT

3.) CONTOURS GENERATED BY ENVIRONMENTAL VISUALIZATION SYSTEM / MINING VISUALIZATION SYSTEM (EVS / MVS) VERSION 9.87 BY CTECH CORPORATION AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGEMENT. NOT ALL BORINGS USED BY EVS SHOWN ON FIGURE

REFERENCES

1.) BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 30 60 90
SCALE FEET

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
UPCU SURFACE ELEVATION CONTOURS
DDA VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZJ001_2.4
DESIGN	RWB	09-25-13	SCALE	AS SHOWN
CADD	MRS	09/25/13		
CHECK	DAC	09/29/13		
REVIEW	TAM	09/29/13		

FIGURE 2.4

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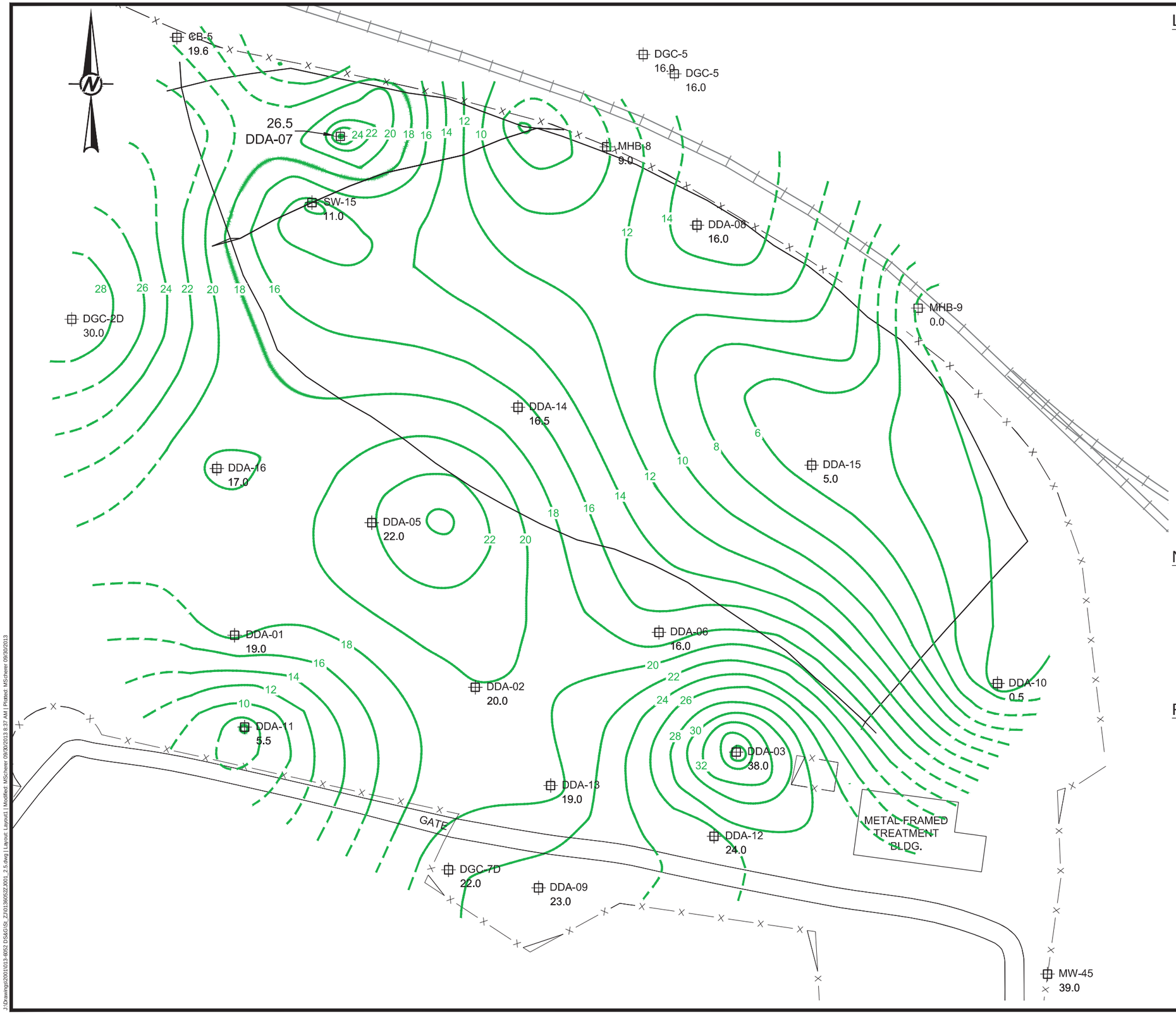

LEGEND

–X——X——X——X	FENCELINE
———	CENTERLINE OF SLURRY WALL AROUND DRUM DISPOSAL AREA
++++++	RAILROAD
——16——	CONTOURS OF UPCU TRANSITION ZONE THICKNESS (FT) DASHED WHERE INFERRED
DGC-5 16.0	SOIL BORING LOCATION AND THICKNESS OF UPCU TRANSITION ZONE (FT)

NOTES

1.) LOCATIONS OF WELLS AND BORING ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

2.) UPCU = UPPER POTOMAC CONFINING UNIT

3.) CONTOURS GENERATED BY ENVIRONMENTAL VISUALIZATION SYSTEM / MINING VISUALIZATION SYSTEM (EVS / MVS) VERSION 9.87 BY CTECH CORPORATION AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGEMENT. NOT ALL BORINGS USED BY EVS SHOWN ON FIGURE

REFERENCES

1.) BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 30 60 90
SCALE FEET

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
UPCU TRANSITION ZONE THICKNESS CONTOURS DDA VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZJ001_2.5
DESIGN	RWB	09-25-13	SCALE	AS SHOWN
CADD	MRS	09/25/13		
CHECK	DAC	09/29/13		
REVIEW	TAM	09/29/13		

FIGURE 2.5

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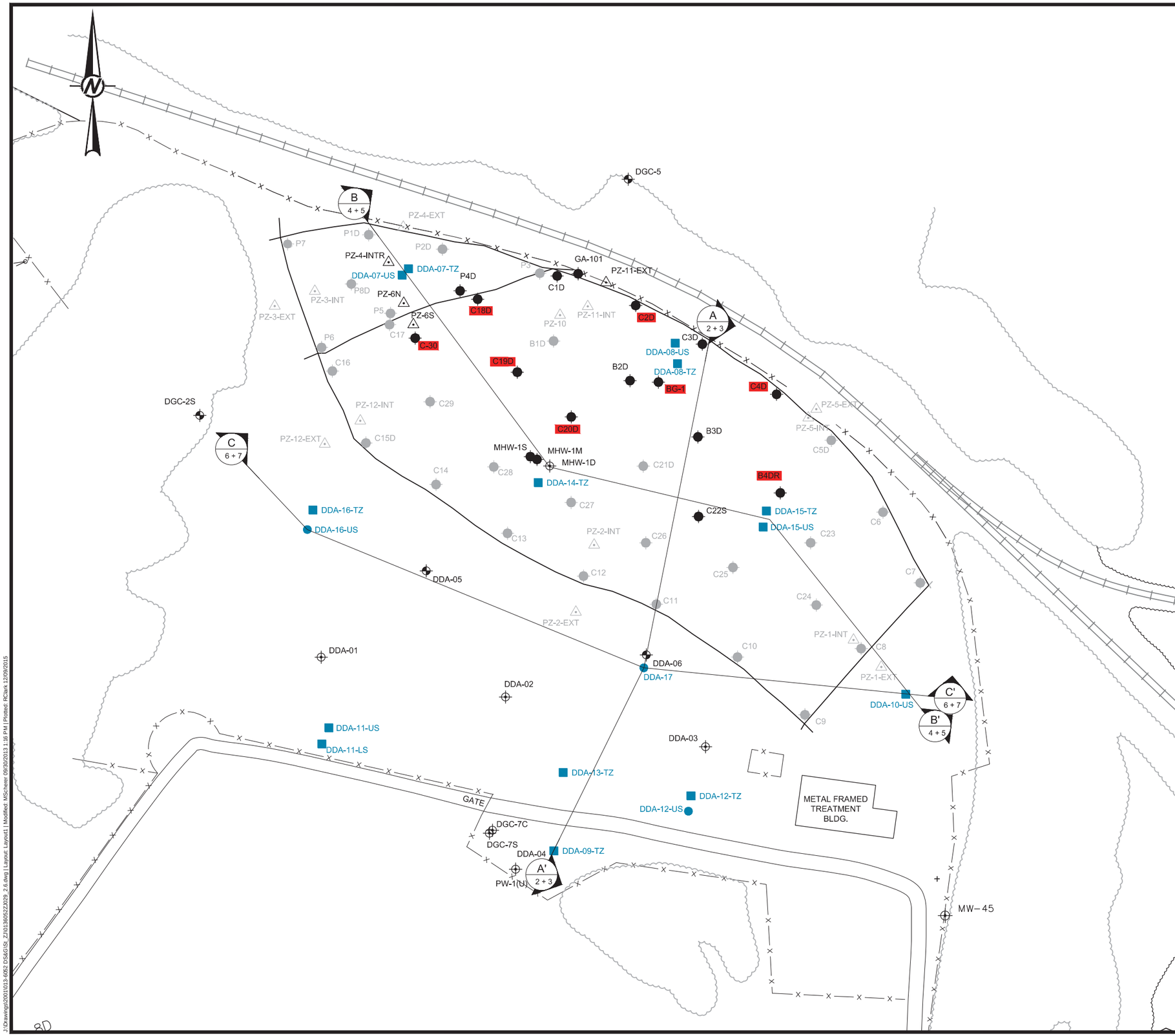

NOTES

1.) LOCATIONS OF WELLS AND BORING ARE BASED ON SURVEY BY TAYLOR WISEMAN & TAYLOR (REVISED 2012)

REFERENCE

1.) BASE MAP TAKEN FROM DIGITAL U.S.G.S. 7.5 MINUTE QUADRANGLES OF WILMINGTON SOUTH, DELAWARE/NEW JERSEY (DATED 1984), DELAWARE CITY, DELAWARE (DATED 1984), NEWARK EAST, DELAWARE (DATED 1984) AND SAINT GEORGES, DELAWARE (DATED 1984).

0 40 80 120
SCALE FEET

PROJECT
DELAWARE SAND AND GRAVEL SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
DDA TO WELL PW-1(U) CROSS SECTION LOCATION MAP

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZJ029_2.6
DESIGN	DAC	2013-09-19	SCALE	AS SHOWN
CADD	MRS	2013-09-19		
CHECK	RWB	2013-09-19		
REVIEW	TAM	2013-09-19		

FIGURE 2.6

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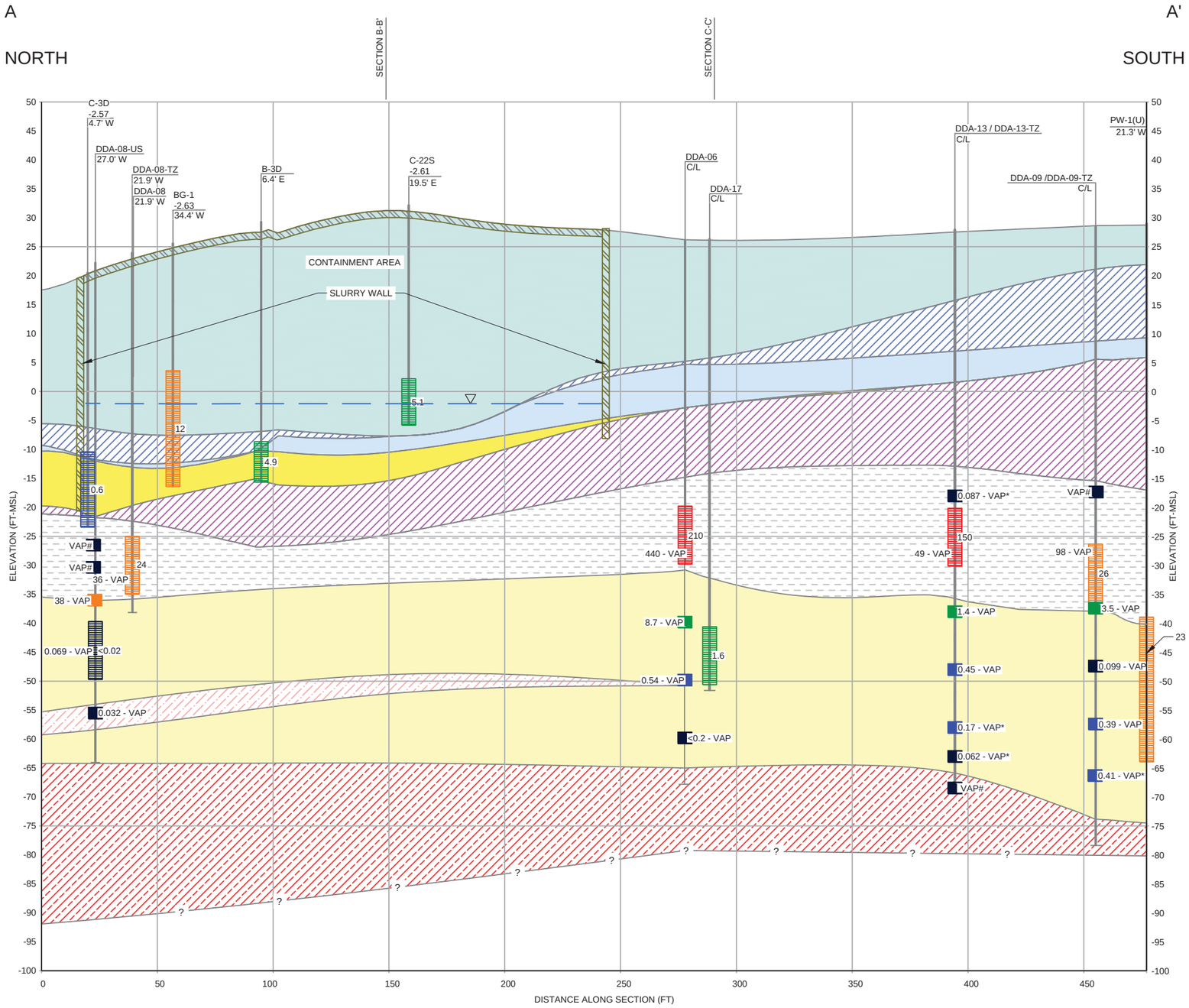

LEGEND

C-22S
-2.61
19.5' E
WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION
AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE
(AS MEASURED MARCH 18, 2013)

BCEE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA SAND 1
- COLUMBIA CLAY
- COLUMBIA SAND 2
- COLUMBIA BASAL GRAVEL
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPDC

0 25 50 75
2.5X VERTICAL EXAGGERATION FEET

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULT LIKELY BIASED LOW.

7.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

BCEE = BIS-2-CHLOROETHYLETHER

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
CROSS SECTION A-A'
BCEE
DDA TO WELL PW-1(U)

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZM006-AA BCEE
DESIGN	RWB	2016-1-19	SCALE	AS SHOWN
CADD	RWC	2016-1-19		
CHECK	RWB	2016-1-19		
REVIEW	TAM	2016-1-19		

FIGURE 2.7A

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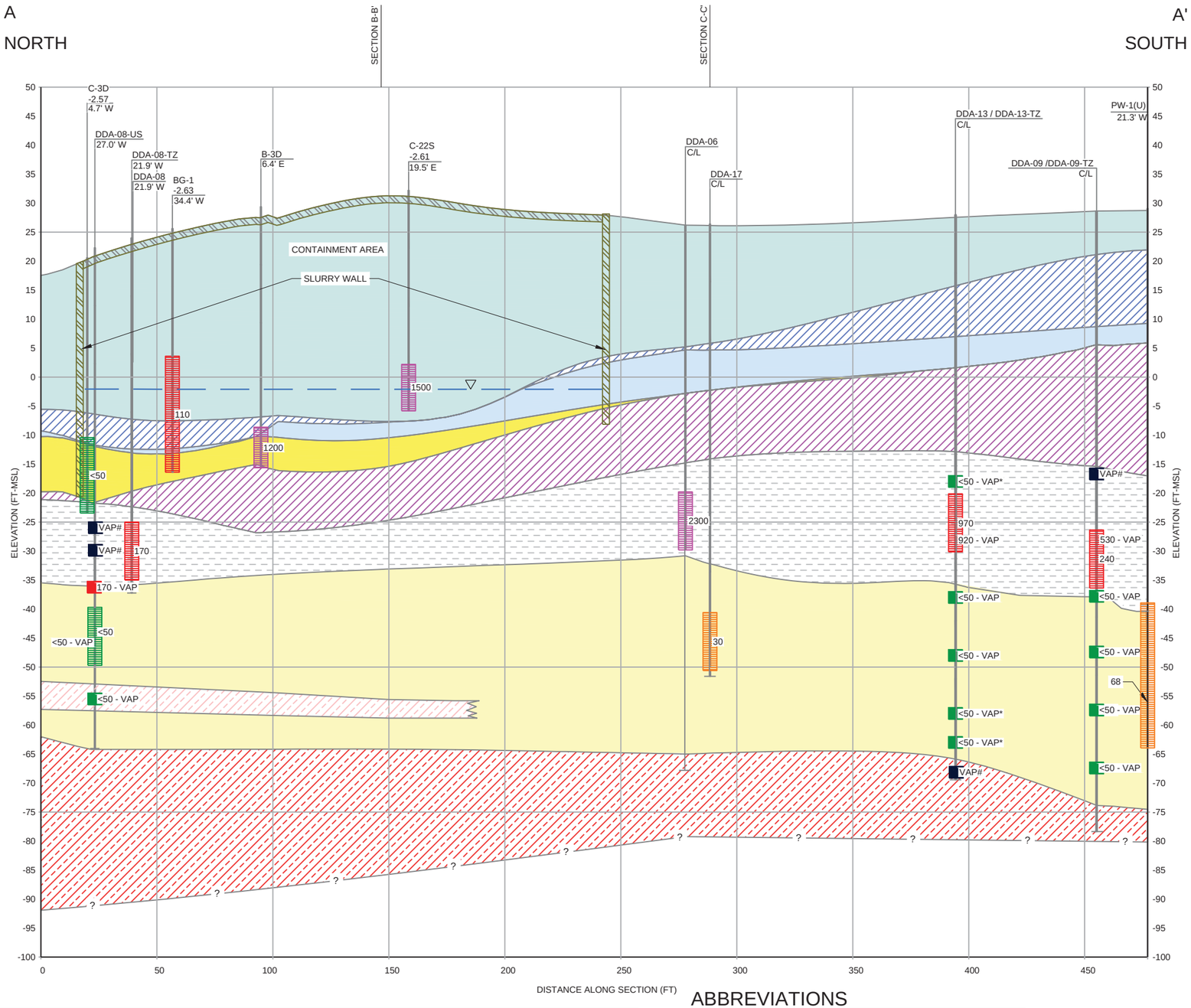

LEGEND

C-22S
-2.61
19.5' E

WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION
AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

1,4-DIOXANE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA SAND 1
- COLUMBIA CLAY
- COLUMBIA SAND 2
- COLUMBIA BASAL GRAVEL
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPDC

0 25 50 75
2.5X VERTICAL EXAGGERATION FEET

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATE DETECTION OF TRIHALOMETHANES ASSOCIATE WITH DRILLING WATER - RESULT LIKELY BIASED LOW.

7.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT
DELAWARE SAND AND GRAVEL SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
CROSS SECTION A-A'
1,4-DIOXANE
DDA TO WELL PW-1(U)

Golder Associates

PROJECT No.		013-6052	FILE No. 0136052ZM002-AA DIOXANE
DESIGN	RWB	2016-1-19	SCALE AS SHOWN
CADD	RWC	2016-1-19	**FIGURE 2.7B**
CHECK	RWB	2016-1-19	
REVIEW	TAM	2016-1-19	

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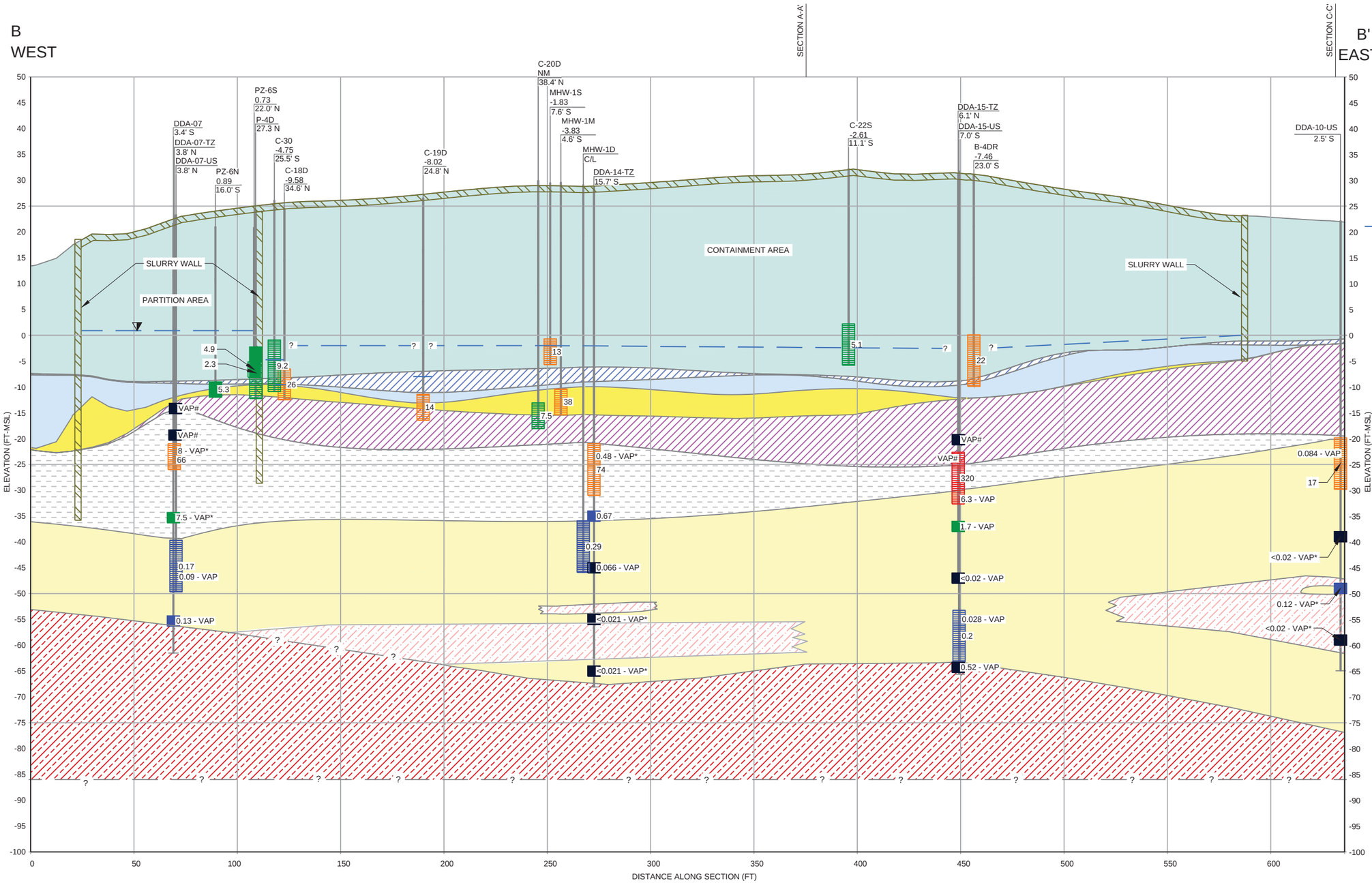

LEGEND

C-22S
-2.61
11.1' S

WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION
AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

BCEE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA SAND 1
- COLUMBIA CLAY
- COLUMBIA SAND 2
- COLUMBIA BASAL GRAVEL
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPDC

0 25 50 75
2.5X VERTICAL EXAGGERATION FEET

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULT LIKELY BIASED LOW.

7.) VAP# INDACTES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

BCEE = BIS-2-CHLOROETHYLETHER

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
CROSS SECTION B-B'
BCEE
DDA TO WELL PW-1(U) VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZM007-BB-BCEE
DESIGN	RWB	2016-1-19	SCALE	AS SHOWN
CADD	RWC	2016-1-19		
CHECK	RWB	2015-12-09	**FIGURE 2.8A**	
REVIEW	RWB	2015-12-09		

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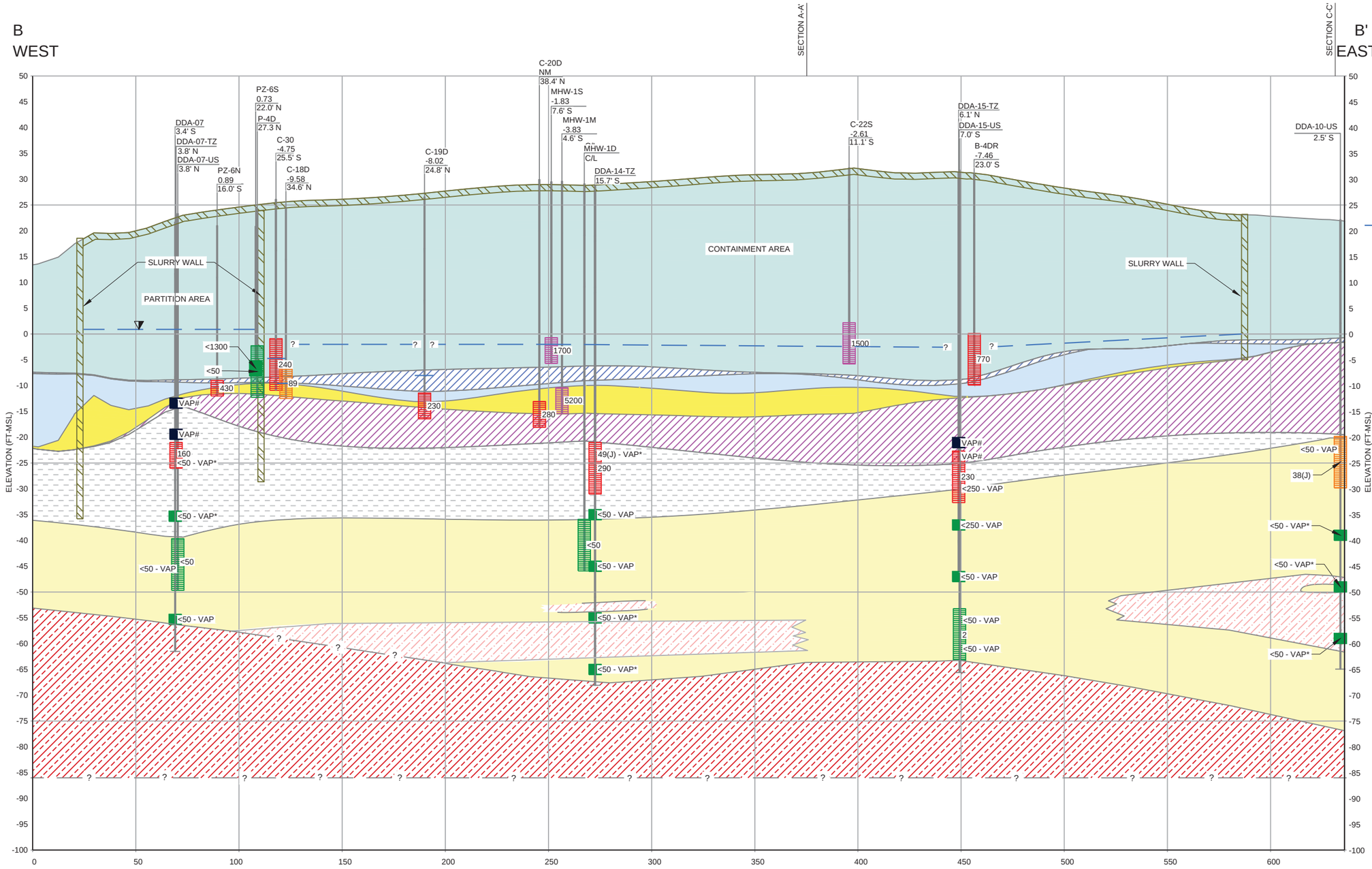

LEGEND

C-22S
-2.61
19.5' E

WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION
AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

1,4-DIOXANE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA SAND 1
- COLUMBIA CLAY
- COLUMBIA SAND 2
- COLUMBIA BASAL GRAVEL
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPDC

0 25 50 75
2.5X VERTICAL EXAGGERATION FEET

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULTS LIKELY BIASED LOW.

7.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

(J) = ESTIMATED CONCENTRATION BELOW REPORTING LIMIT

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT

DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE

CROSS SECTION B-B'
1,4-DIOXANE
DDA TO WELL PW-1(U) VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No0136052ZM003 BB DIOXANE
DESIGN	RWB	2016-1-19	SCALE AS SHOWN
CADD	RWC	2016-1-19	FIGURE 2.8B
CHECK	RWB	2016-1-19	
REVIEW	TAM	2016-1-19	

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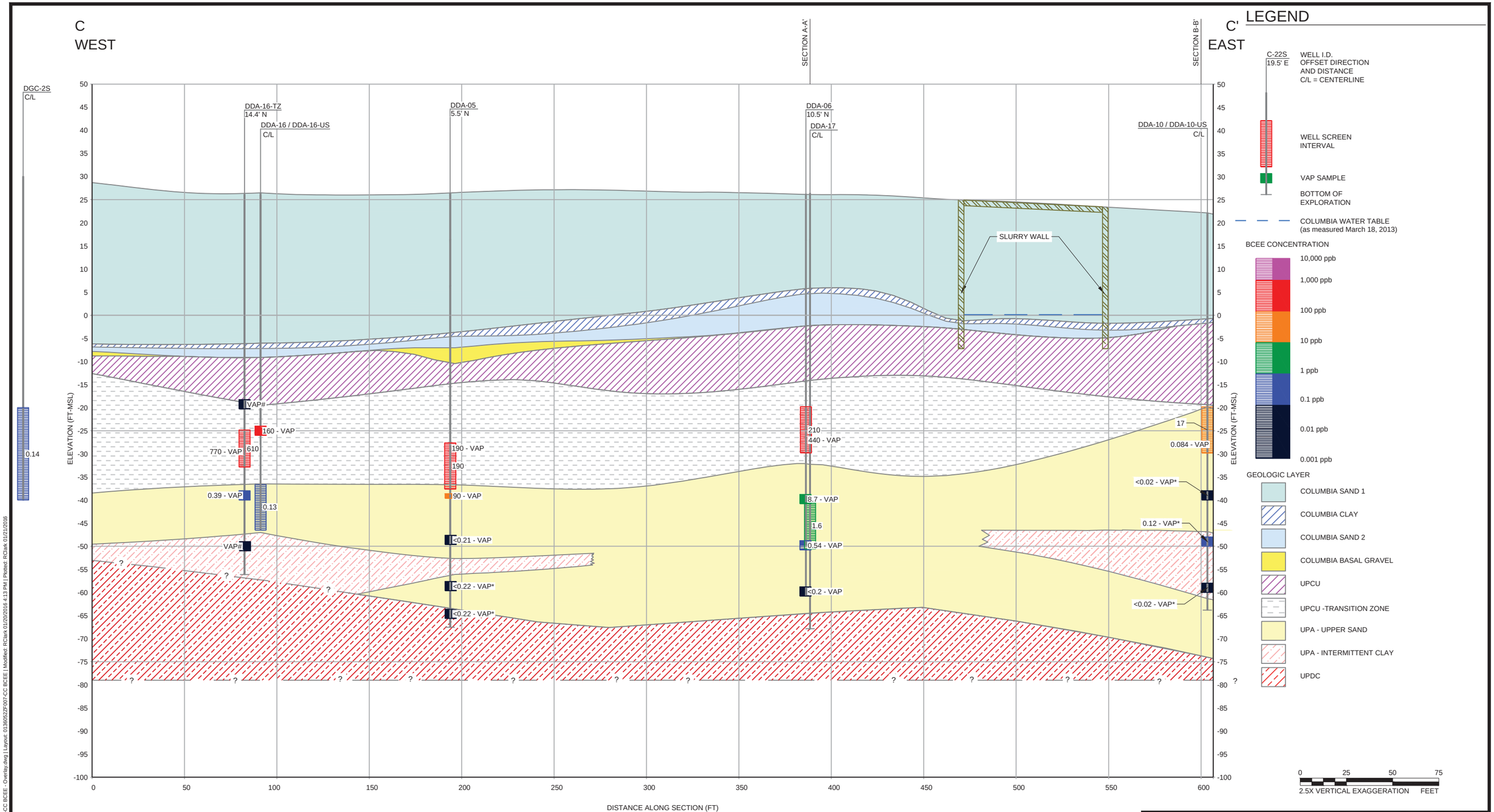

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULTS LIKELY BIASED LOW.

7.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

BCEE = BIS-2-CHLOROETHYLETHER

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT

DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE

CROSS SECTION C-C'
BCEE
DDA TO WELL PW-1(U) VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No.	0136052ZM007-CC-BCEE
DESIGN	RWB	2016-1-19	SCALE	AS SHOWN
CADD	RWC	2016-1-19		
CHECK	RWB	2016-1-19		
REVIEW	TAM	2016-1-19		

FIGURE 2.9A

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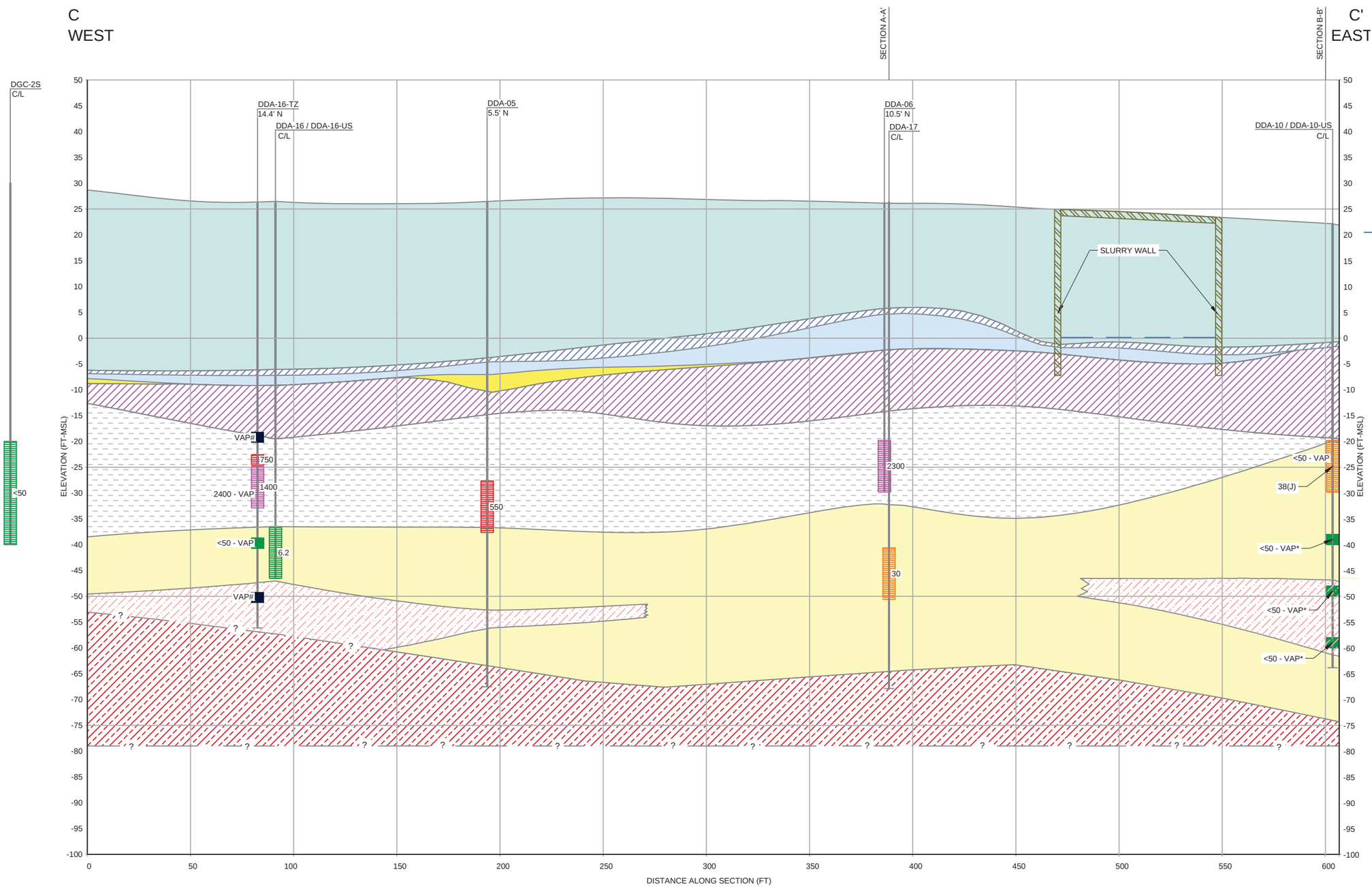

LEGEND

DDA-05 5.5' N — WELL I.D. OFFSET DIRECTION AND DISTANCE C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

1,4-DIOXANE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA SAND 1
- COLUMBIA CLAY
- COLUMBIA SAND 2
- COLUMBIA BASAL GRAVEL
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPDC

0 25 50 75
2.5X VERTICAL EXAGGERATION FEET

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.84) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM OCTOBER AND DECEMBER 2012, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULTS LIKELY BIASED LOW.

7.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

ABBREVIATIONS

(J) = ESTIMATED CONCENTRATION BELOW REPORTING LIMIT

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

PROJECT

DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE

CROSS SECTION C-C'
1,4-DIOXANE
DDA TO WELL PW-1(U) VICINITY

Golder Associates

PROJECT No.		013-6052	FILE No. 0136052ZM004-CC DIOXANE
DESIGN	RWB	2016-1-19	SCALE AS SHOWN
CADD	RWC	2016-1-19	**FIGURE 2.9B**
CHECK	RWB	2016-1-19	
REVIEW	TAM	2016-1-19	

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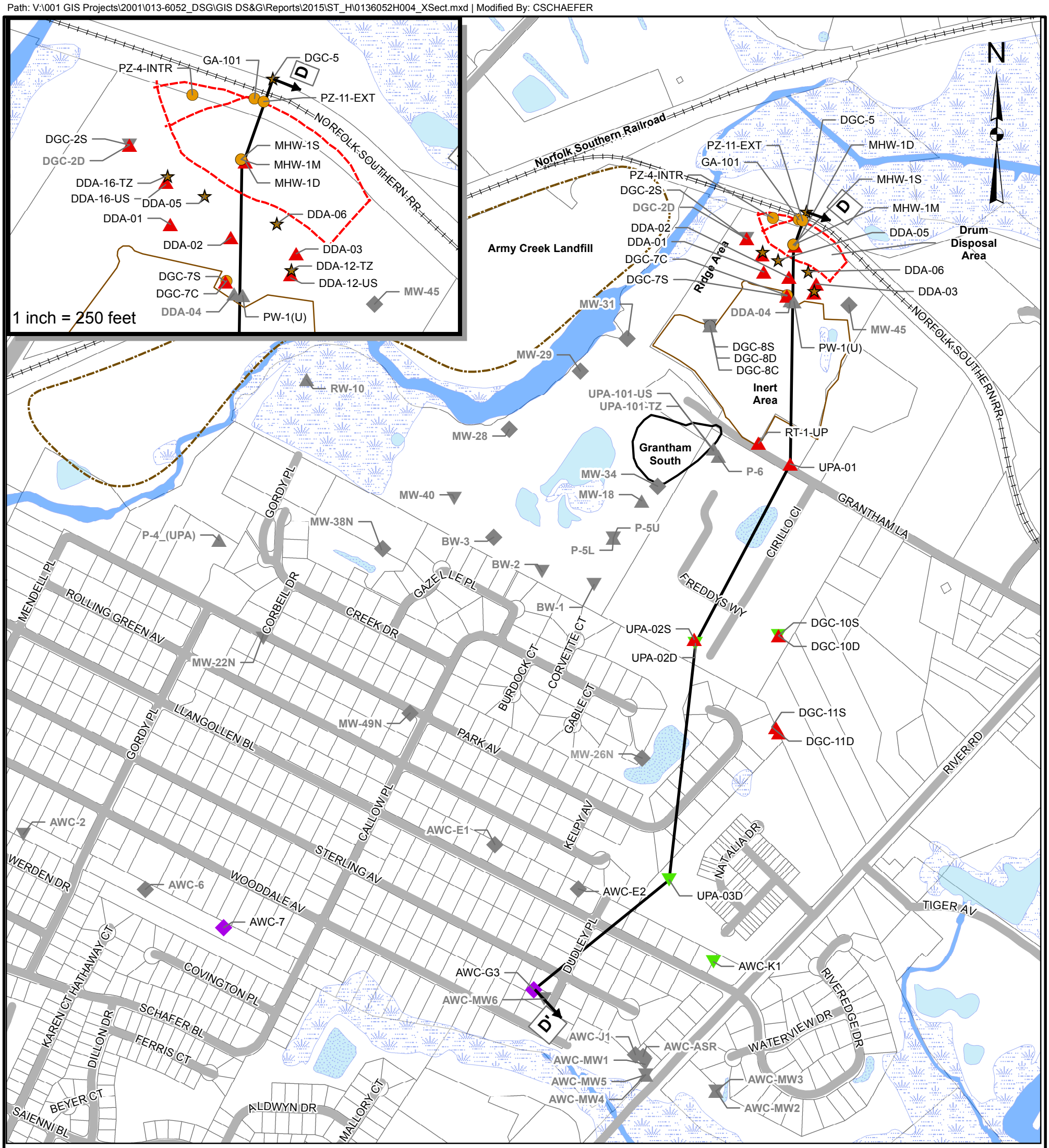


LEGEND

Locations_All

Type_, DownGrad

- Well screened in UPCU Transition Zone included in the current monitoring program
- Well screened in UPA Upper Sand included in the current monitoring program
- Well screened in UPA Upper Sand not included in the current monitoring program
- Well screened in UPA Lower Sand included in the current monitoring program
- Well screened in UPA Lower Sand not included in the current monitoring program
- Well screened across UPA Upper Sand and Lower Sand included in the current monitoring program
- Well screened across UPA Upper Sand and Lower Sand not included in the current monitoring program
- Well screened in Columbia Aquifer included in the current monitoring program
- Well screened in Columbia Aquifer not included in the current monitoring program
- Site-Wide Cross-Section (D-D')

REFERENCE

Base data from New Castle County Delaware, Department of Land Use, "eParcel View Map" web site GIS data download. Data acquired 01/18/2012.

0 300 600 1,200 Feet

PROJECT No. 013-6052.007	TAM	1/29/2016
FILE No. 0136052H004_XSect	REVIEW	
REV. 0 SCALE: AS SHOWN	CHECK	RWB 1/29/2016
DESIGN TAM 01/20/2012	GIS	CDS 1/29/2016

FIGURE 2.10

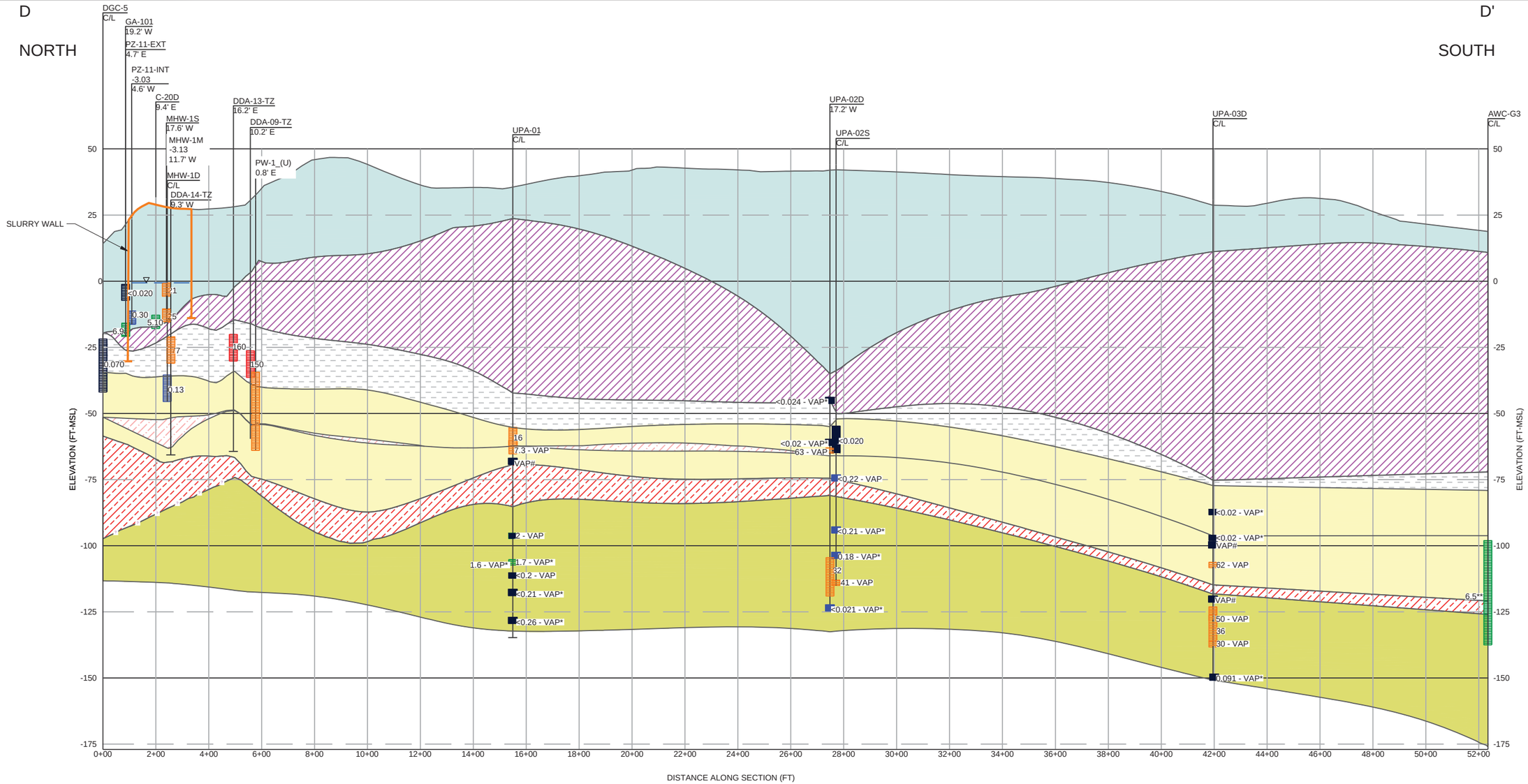
TITLE

SITE-WIDE CROSS SECTION LOCATION MAP

PROJECT

Delaware Sand and Gravel Superfund Site
New Castle, Delaware

Golder Associates
Manchester, New Hampshire



LEGEND

C-22S
-3.03
19.5' E
WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION
AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP SAMPLE*

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

BCEE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA AQUIFER
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPA - LOWER SAND
- UPDC

NOTES

1.) LOCATIONS AND ELEVATIONS ARE BASED ON SURVEY INFORMATION FROM TAYLOR, WISEMAN & TAYLOR (TWT) AND OTHERS AS PROVIDED TO GOLDER BY THE DS&G TRUST.

2.) THE GEOLOGIC CROSS SECTIONS WERE DEVELOPED BY ENVIRONMENTAL VISUALIZATION SYSTEM (EVS) SOFTWARE DEVELOPED BY CTECH CORPORATION (VERSION 9.87) AND HAND ADJUSTED BASED ON PROFESSIONAL JUDGMENT.

3.) GEOLOGIC CONTACTS BETWEEN BORINGS ARE INFERRED AND SHOULD NOT BE INTERPRETED AS EXACT INDICATORS OF GEOLOGIC CONDITIONS AT, BETWEEN OR BELOW BORINGS.

4.) THE PROJECTION OF WELL SCREENS ONTO GEOLOGIC UNITS MAY NOT REFLECT ACTUAL GEOLOGIC CONDITIONS AT THE WELL SCREEN INTERVAL DUE TO VARIATIONS IN THE ELEVATION OF GEOLOGIC LAYERS WITH DISTANCE FROM THE CROSS-SECTION CENTERLINE.

5.) ANALYTICAL DATA DISPLAYED INCLUDES MONITORING WELLS SAMPLES FROM FEBRUARY AND MARCH 2013, VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-05 AND DDA-06 IN DECEMBER 2011, AND VAP DATA COLLECTED DURING BORING ADVANCEMENT OF DDA-07 THROUGH DDA-16 BETWEEN SEPTEMBER AND NOVEMBER 2012.

6.) * * INDICATES AWC-G3 SAMPLED APRIL 2012.

7.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULTS LIKELY BIASED LOW.

8.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

9.) VAP SAMPLES NOT DISPLAYED UPGRADIENT OF WELL PW-1(U). SEE FIGURES 2.7 THROUGH 2.9 FOR VAP DATA UPGRADIENT OF WELL PW1-(U).

ABBREVIATIONS

BCEE = BIS-2-CHLOROETHYLETHER

ppb = PARTS PER BILLION OR MICROGRAMS PER LITER

UPA = UPPER POTOMAC AQUIFER

UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT, DATA FLAGGED WITH *

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

0 200 400 600
10X VERTICAL EXAGGERATION FEET

PROJECT
DELAWARE SAND AND GRAVEL
SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
CROSS SECTION D-D'
BCEE
DDA TO LLANGOLLEN WELL AWC-G3

Golder Associates

PROJECT No.		013-6052	FILE No. 0136052ZM026 D-D BCEE-02
DESIGN	RWB	2016-1-19	SCALE AS SHOWN
CADD	RWC	2016-1-19	**FIGURE 2.11A**
CHECK	RWB	2016-1-19	
REVIEW	RWB	2016-1-19	

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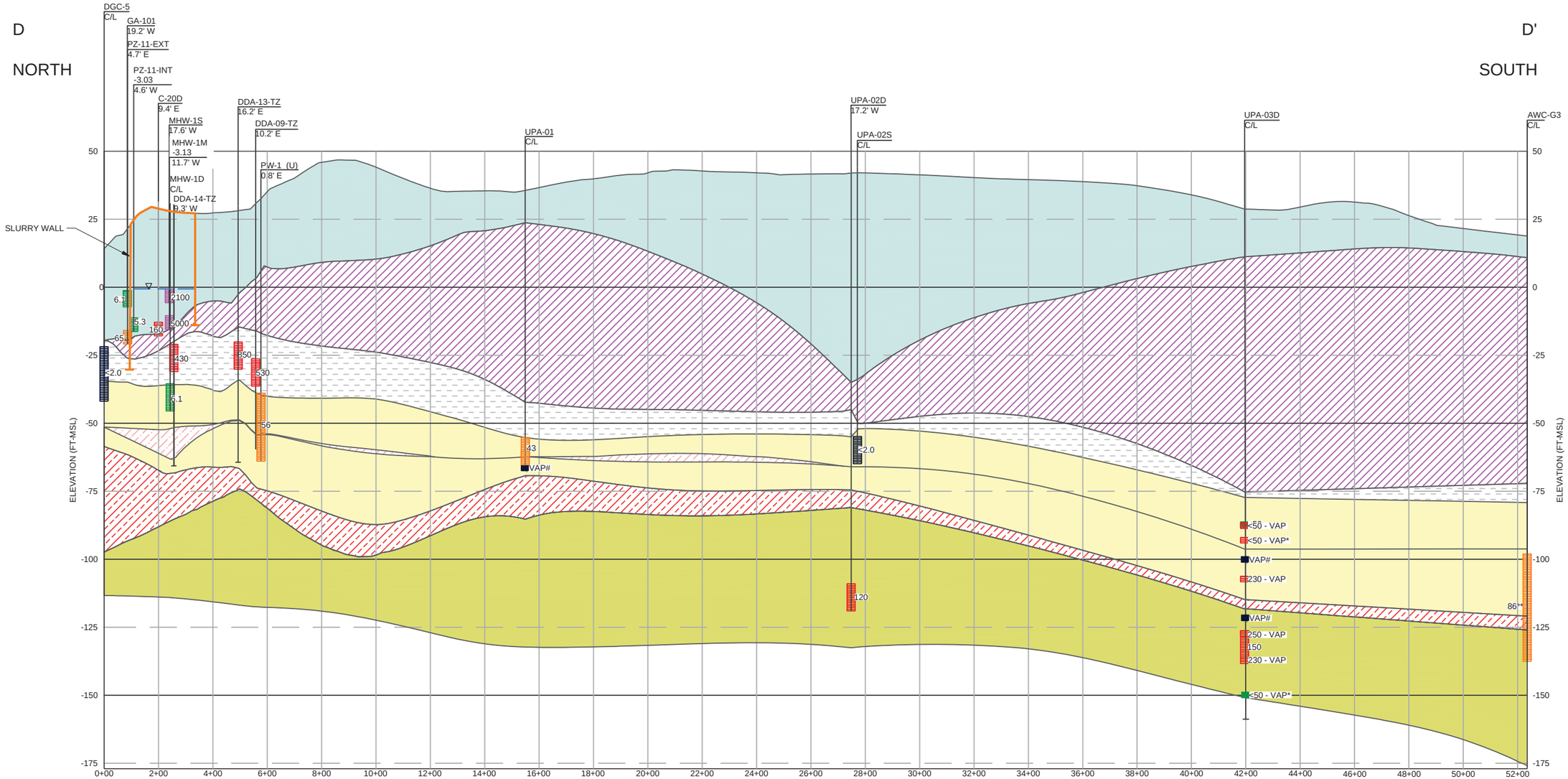

LEGEND

C-22S
-3.03
19.5' E
WELL I.D.
COLUMBIA GROUNDWATER ELEVATION
OFFSET DIRECTION AND DISTANCE
C/L = CENTERLINE

WELL SCREEN INTERVAL

VAP - VAP SAMPLE*

BOTTOM OF EXPLORATION

COLUMBIA WATER TABLE (as measured March 18, 2013)

1, 4-DIOXANE CONCENTRATION

- 10,000 ppb
- 1,000 ppb
- 100 ppb
- 10 ppb
- 1 ppb
- 0.1 ppb
- 0.01 ppb
- 0.001 ppb

GEOLOGIC LAYER

- COLUMBIA AQUIFER
- UPCU
- UPCU -TRANSITION ZONE
- UPA - UPPER SAND
- UPA - INTERMITTENT CLAY
- UPA - LOWER SAND
- UPDC

NOTES

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6.) ** INDICATES DATA PROVIDED BY OTHERS, NOT VALIDATED BY GOLDER.

7.) VAP* INDICATES DETECTION OF TRIHALOMETHANES ASSOCIATED WITH DRILLING WATER - RESULTS LIKELY BIASED LOW.

8.) VAP# INDICATES VAP SAMPLING ATTEMPTED, BUT FORMATION DID NOT PRODUCE SUFFICIENT WATER.

9.) VAP SAMPLES NOT DISPLAYED UPGRADIENT OF WELL PW-1(U). SEE FIGURES 2.7 THROUGH 2.9 FOR VAP DATA UPGRADIENT OF WELL PW-1(U).

ABBREVIATIONS

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UPCU = UPPER POTOMAC CONFINING UNIT

UPDC = UPPER POTOMAC DIVIDING CLAY

VAP = VERTICAL AQUIFER PROFILING SAMPLE COLLECTED DURING BORING ADVANCEMENT, DATA FLAGGED WITH *

<50 = CONCENTRATION NON-DETECT AT INDICATED REPORTING LIMIT

0 200 400 600
10X VERTICAL EXAGGERATION FEET

PROJECT
DELAWARE SAND AND GRAVEL SUPERFUND SITE
NEW CASTLE, DELAWARE

TITLE
CROSS SECTION D-D'
1, 4-DIOXANE
DDA TO LLANGOLLEN WELL AWC-G3

Golder Associates

PROJECT No.		013-6052	FILE No.	01360522M026 D-D DIOXANE
DESIGN	RWB	2016-1-19	SCALE	AS SHOWN
CADD	RWC	2016-1-19		
CHECK	RWB	2016-1-19	**FIGURE 2.11B**	
REVIEW	TAM	2016-1-19		

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GOLDER

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